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RIVETING LIGHT ALLOY STRUCTURES
(Klepka Konstruktsiy Iz Legkikh Splavov)

Author: V. P. Grigor'yev and P. B. Goldovskiy

Source: State Publishing House For The Defense Industry

Moscow

1954

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This book describes the technological processes of riveting metal structures made from light alloys. The methods and means of mechanization and automation of these processes are investigated, and data are given on rivets and on the tools used in riveting.

The content of this book deals chiefly with the basic processes of assembling and riveting, as applied to the particular requirement of making hermetically tight joints, and also with the methods and procedures used in testing as well as with the selection of auxiliary equipment and instruments.

The book is intended for technical personnel, foremen, maintenance supervisors in plants, and may also be used as a manual by students in institutions of higher learning.

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PREFACE

In the manufacture of various structures from light metal alloys, the basic requirement is that the riveted joints must be inseparable. The wide use of riveting was adopted particularly in the construction of aircraft. The increase in the speed of airplanes, the necessity of producing hermetically tight riveted joints and surfaces, the required accurate surface finish of the exterior surfaces of the assembled units, all stepped up the requirements made on riveted joints.

The higher quality requirement of riveted joints, and the large extent to which riveting work is done, necessitates measures to maintain quality and reduce labor costs. In taking such measures, first consideration should be given to the training and improvement of the qualifications of the technical personnel, such as foremen, maintenance supervisors, and riveters; the use of well-built auxiliary equipment, instruments and tools; the utilization of correct technological processes of assembly and riveting; a trained labor organization and a good place in which the work is done.

This book contains data on assembly accessories, riveting tools, rivets, as well as a study on the construction and methods of utilizing to advantage, riveting presses, drilling machines, auxiliary appliances, etc. An important portion of this book consists of a description of the technical processes of assembly of riveted work, both in joining separate parts and in assembling complete units. Data are given on each of the technical processes, on the equipment and tools used, on the organization of the labor crew, and on the location in the plant where the work is

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done.

The technical processes described in connection with the assembly of riveted parts are illustrated with graphs, pointing out the advantages and the deficiencies of the processes applied; in particular, it is shown that press riveting is superior to percussion riveting, and drilling is better than punching of holes. Comparative data are given on the strength of joints made with different types of rivets, on the strength of riveted and welded joints, and also on the technical and economic aspects of standard types of nonseparable joints.

This book is primarily intended for technologists, foremen, maintenance supervisors, and inspectors in industrial plants. It may also be used as a textbook by students in the intermediate and in higher technical institutions of learning.

Chapters I, II, III, VII, XI, XII, XIII, and XVII were written by Candidate of Technical Sciences B.P.Grigor'yev. Chapters IV, V, VI, IX, X, XIV, XV, and XVI were written by Engineer P.B.Goldovskiy.

The data given in this book are based on the experience and work done by the authors on the subjects treated, on the prevailing practice in industrial plants, and on the work done by the Scientific Research Institute. The description of some of the riveting presses was supplied by the Laboratory Institute. In the preparation of this book for publication, the descriptions were made in the form presented by a group of machinery designers, under the leadership of the well-known designer V.G.Gorokhov.

The authors wish to express their deep gratitude to Lecturer S.A.Vigdorchik, who has made many valuable suggestions in reviewing the manuscript of the book, and to Engineer V.I.Tikhonov for the assistance rendered by him in editing the book.

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PART I

GENERAL CONSIDERATIONS ON THE ASSEMBLY OF RIVETED JOINTS

CHAPTER I

PURPOSE AND METHODS OF ASSEMBLY

In the production of structures from light metal alloys, the assembly of parts by riveting represents a considerable proportion of the work. For example, in the manufacture of modern all-metal aircraft, riveting constitutes from 30 to 35% of the labor involved in the production of the craft. The amount of labor involved in the assembly of parts by riveting depends on the availability of proper equipment and on the technical aspects of supervision and the preliminary preparation of the parts.

One of the essential factors in connection with the design and construction of riveted parts is their classification as major assembled units, and of these units into tie components, panels, and sections. The advantage of making this classification is that it permits using highly mechanized equipment for drilling, countersinking, and riveting, thus simplifying the work of assembly. All this results in a reduction of labor, less time of assembly and, consequently, in lower cost of production.

In Figs.1 and 2 are shown a wing and a fuselage, dismantled into their constituent components as ties or connecting parts, panels, and sections.

Depending on the nature of the parts from which the product is made, we may divide them into two basic classes of riveted work (Table 1): namely, 1) frames or tie parts and panels, and 2) assembled units.

The assembly of minor components and of panels represents a comparatively small amount of assembly work and does not require complicated equipment, It permits the

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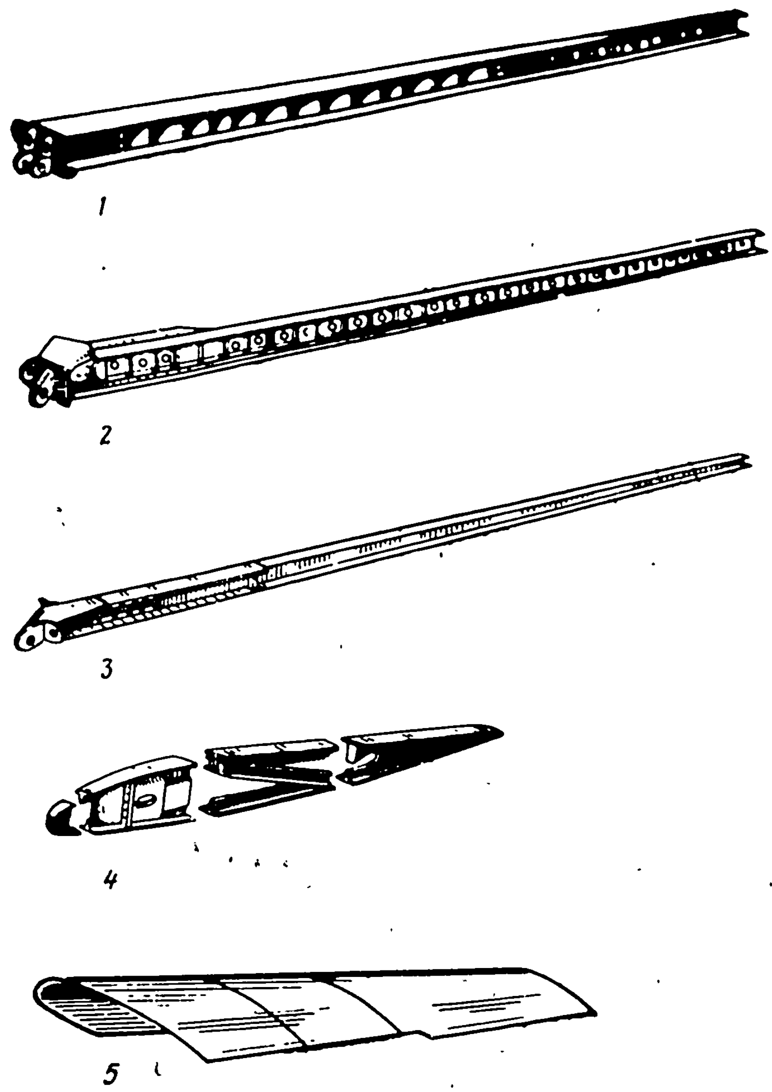

Fig.1 - Examples of Wing Elements

1, 2, 3) Longerons; 4) Wing rib; 5) Top panel; 6) Bottom panel; 7) Tail section; 8) Flap; 9) Tail fairing; 10) Aileron; 11) Wing in assembled view

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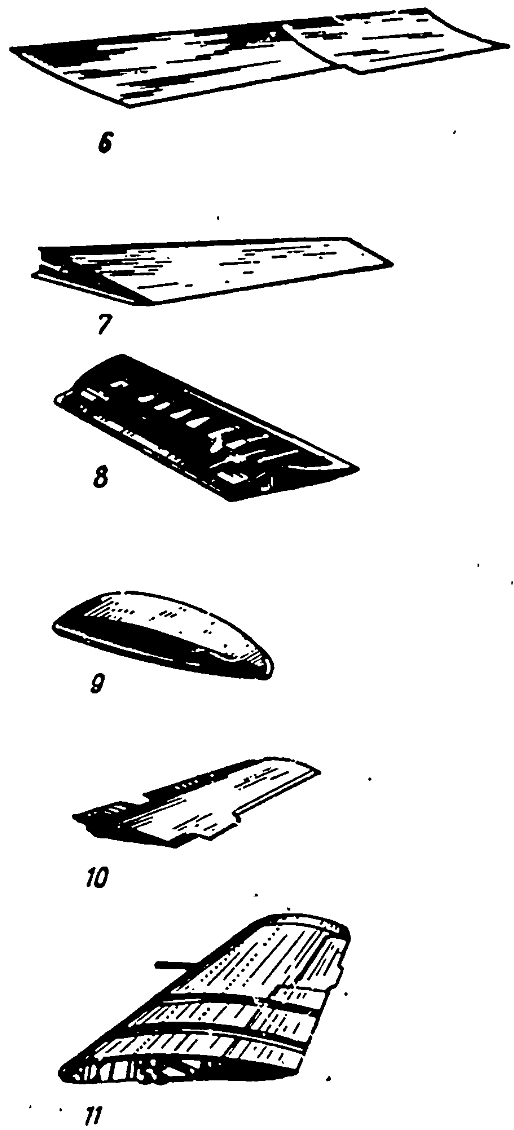

Fig.1 - (continued)

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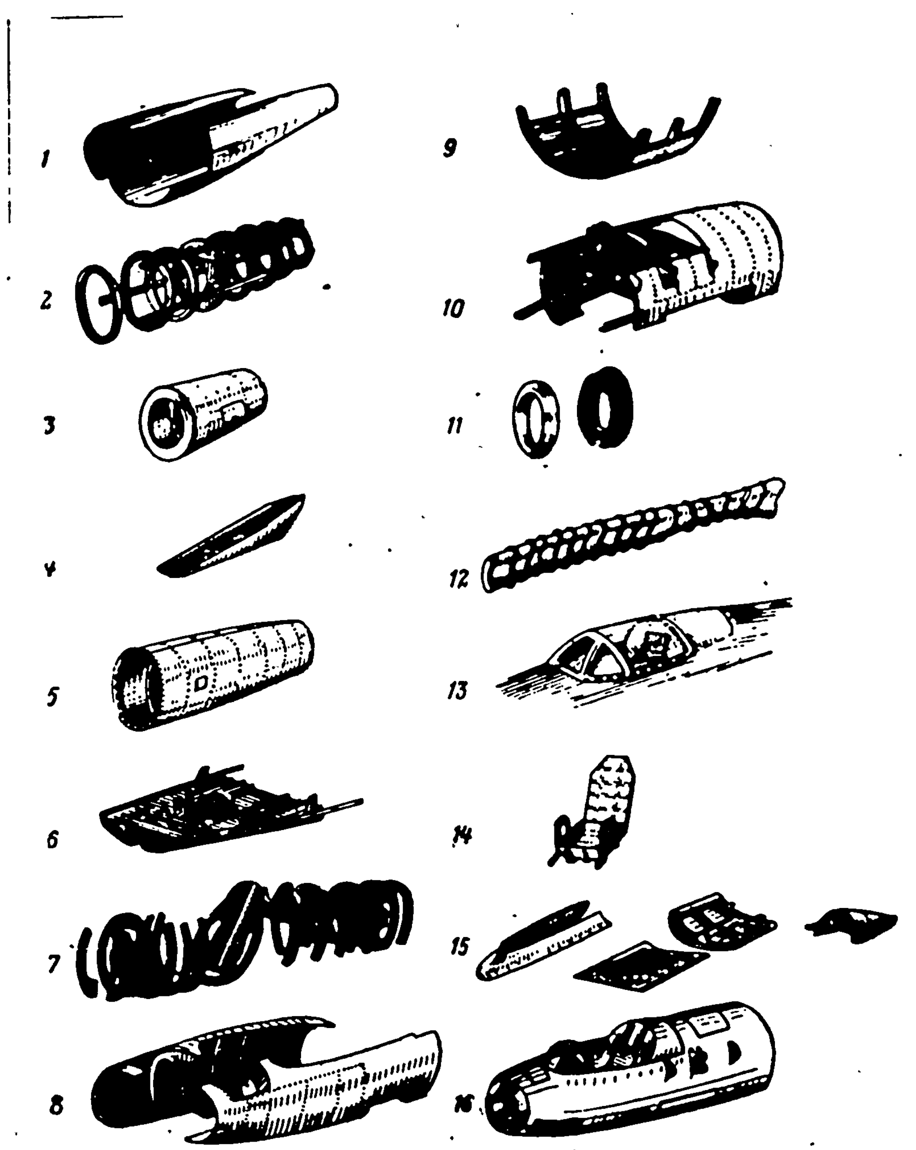

Fig.2 - Examples of the Members of a Fuselage

1) Panel lining of the tail section of the fuselage; 2) Frame ribs of the tail section; 3) Tail faring; 4) False rib; 5) Tail section in assembled view; 6) Framework carcass underneath forward section; 7) Bulkhead of the nose section; 8,9) Panels; 10) Rear part of forward section of fuselage; 11) Suction ring; 12) Suction tube; 13) Cockpit; 14) Seat; 15) Minor assemblies; 16) Front section of the fuselage in assembled view.

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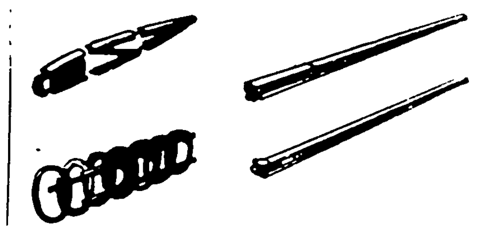
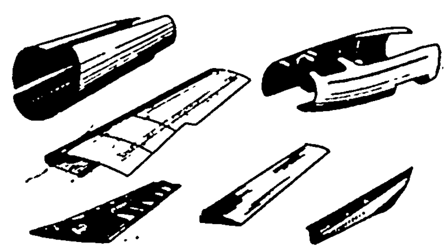
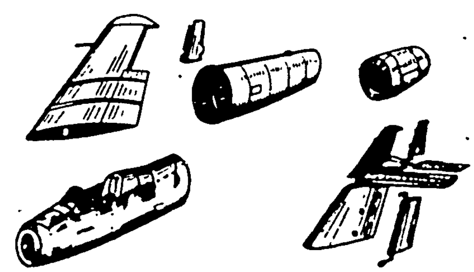
use of highly mechanized means for riveting and for the formation of the holes by drilling and by dimpling, to form a cavity underneath the rivet head; this makes it

Table 1

Examples of Riveted Assembly Work

Riveted components	Nomenclature of minor units, panels, and major assemblies	Sketch
	Ribs, bulkheads, longerons, and other small assemblies	
Minor assemblies and panels	Panel lining of the wing and fuselage, joined from several plates or panels with power tools, flaps, etc.	
Major Assembly units	Front and rear sections of the fuselage, wing, tail group, etc.	

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possible to organize the work on a continuous basis by moving either the workpiece or the equipment.

Major assembled units, in a technical and structural sense, represent finished parts of the main product. They are characterized by requiring a comparatively large amount of assembly work and considerable labor, using specialized equipment for drilling holes and for riveting. Such units are of relatively large size and are characterized by an intricate design.

Depending on the nature of the parts involved in the assembly by riveting, a distinction is made between the assembly of minor and major units. In the assembly of major units, individual minor assemblies and panels are joined by means of specialized rigs, with the result that a larger assembled unit is formed(such as a wing, center section, fuselage, tail group, hermetically-sealed compartment, and so forth).

The minor and the major assemblies then go to the final assembly, where the combination of the separate units takes place along with other components, and with the installation of conduit wiring, instruments, and other necessary parts.

1. Methods of Assembly

Riveting work, by means of which separate parts are united with rivets into minor assemblies and panels, and these assembled as section and major units, may be reduced to two operations; namely, the placing of the parts in the proper position as specified by the drawings, and their joining together by riveting.

Depending, however, on the particular methods of production which prevail in any one plant, there may be more operations in addition to the two basic operations stated. Such additional operations in actual production, as a rule, deal with the lining up and supply of the parts, marking off for drilling, etc. (Fig.3). Much time is lost in the performance of these operations, and, furthermore, highly experienced workmen are needed.

The difficulties mentioned can be eliminated by adopting a method of assembly

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whereby the parts to be assembled are prepared, with the holes drilled by means of templates in special jigs. The schedule on procedure of assembly by this method is shown in Fig.4. By this method, the number of operations is reduced to three.

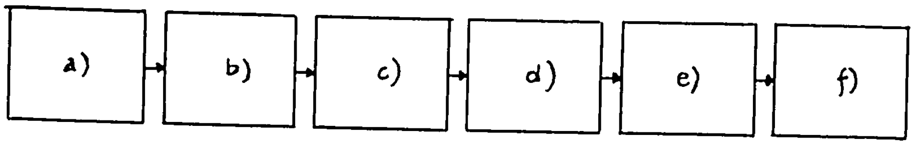

Fig.3 - Schematic Diagram of Sequence of Operations When Using the Procedure of Marking Off and Laying Out Work

a) Layout, dimensioning, and marking; b) Supply and arrangement of parts; c) Arrangement in assembly position and fastening; d) Marking off for drilling; e) Drilling; f) Riveting

The advantage of assembling by previously drilling the holes in the parts while still in the fixtures, and using proper templates as guides, lies in the fact that the parts, when placed together, will fit accurately. To effect a more perfect riveted joint, guide holes are drilled only in one (the inside) mating part, the number of which must be the same as the number of rivets in any particular joint, while in the other mating part (the outside) 2-3 holes are drilled, which must coincide with the 2-3 holes in the inside piece used as guide holes. Increasing the number of guide holes (above 2-3) is of no use since this reduces the probability of coincidence of a larger number of holes in the assembly of the mating parts.

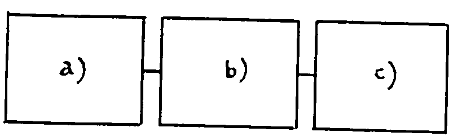

Fig.4 - Sequence of Operations When Assembling from Guide Holes

a) Arrangement in assembly position and fastening; b) Drilling; c) Riveting

During the assembly of minor and major units in suitable fixtures or jigs, the

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parts are arranged in accordance with the guide holes or by means of the holding devices which are a part of such fixtures.

The adoption of the method of assembly on the basis of guide holes is quite rational, since this procedure requires less assembly equipment, simplifies the construction of the equipment, increases the quality of the work, and permits better utilization of labor. However, this method is not sufficiently precise for the correct installation and fitting of linings and assembled components, specified for the exterior of an aircraft. For this reason, it is customary to adopt a method of assembly of such parts in fixtures, taking as a guide the outline of the exterior surface of the lining or the parts of the airframe.

2. Characteristics of Assembly Equipment

Depending on the variety of parts and items used, assembly equipment may be classified as being of the following types:

1) Equipment for the assembly of minor units and panels;

2) Equipment for the assembly of major units and their sections.

Fixtures or jigs of the first group are of comparatively small size, of simple construction, and permit ready access to the workpiece.

Figure 5 shows a typical construction of a fixture for the assembly, drilling, and riveting of minor units such as ribs and bulkheads. In order to make the workpiece accessible from both sides, the fixtures shown are reversible. The fixture is built from standardized units and parts.

In some of the designs the raising and turning of the unit in process of assembly is accomplished by means of pneumatic jacks, incorporated in the design of the fixture. A similar type of fixture for drilling holes in rib joints is shown in Fig.6.

The assembly of the wing panels, center section, fuselage, and other major units is accomplished in fixtures having a more intricate structure.

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Figure 7 shows a fixture for the assembly of wing panels. The sheets and the stringers are placed in the fixture and pinned with control rivets, after which the

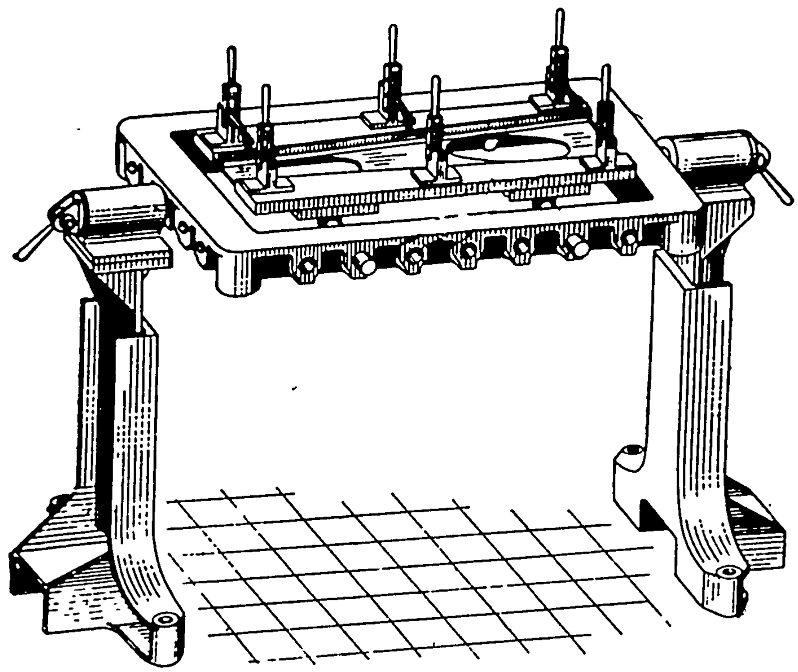

Fig.5 - Typical Construction of a Fixture for Assembling, Drilling and Riveting of Airplane Ribs

work of drilling the holes, countersinking, dimpling, insertion of the rivets and group riveting is carried out. Then, the riveted panel is returned to the same fixture for installation of the transverse elements which impart stiffness.

Fixtures and jigs of the second group for the assembly of major units and their sections have relatively more complicated working parts and are of larger size; they are also more expensive to build. Some of these fixtures, intended for assembling, drilling, and riveting of sections of the fuselage and wings of aircraft are shown in Figs.8,9, and 10. These jigs are used for assemblies of major units from previously assembled minor units and panels, installing supplemental elements to impart

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stiffness; hole drilling, countersinking or dimpling, and riveting.

As a means of correct alignment of the parts in the fixture, either the surface contour of the minor assembly units or the guide holes, which have been previously drilled in accordance with a pattern or template, may be used.

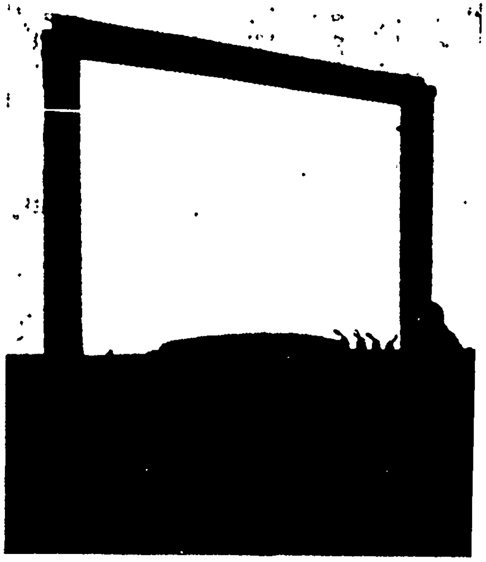

Fig.6 - Double-Sided Swinging Fixture for Drilling Holes in Rib Joints

In aligning the parts in accordance with the contour of the surface, use is made of the holding and clamping devices with which the fixtures are usually provided, some of which are shown in Figs.11 and 12.

The holding devices shown in Fig.12, used for the alignment of components in fixtures, are commonly known as braces, channels, and clamps.

It is obvious, therefore, that in order to do a good job of riveting it is necessary to have many specialized rigs, whose construction consumes much time and requires considerable material. The expense is particularly large when a new type of aircraft is scheduled for production. For this reason, in the construction of assembly jigs standardized parts and components are used as much as possible, and these may be changed around and moved from one location to another to accommodate the requirements of different designs of structures. To attain this objective with a minimum loss of time and at a low cost, is one of the chief problems facing the machine designer and builder.

The following basic principles must be observed in the development, design and construction of jigs:

1) Not to use components made up from parts by welding or riveting, and as far

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Fig.7 - Assembly of a Wing in a Jig

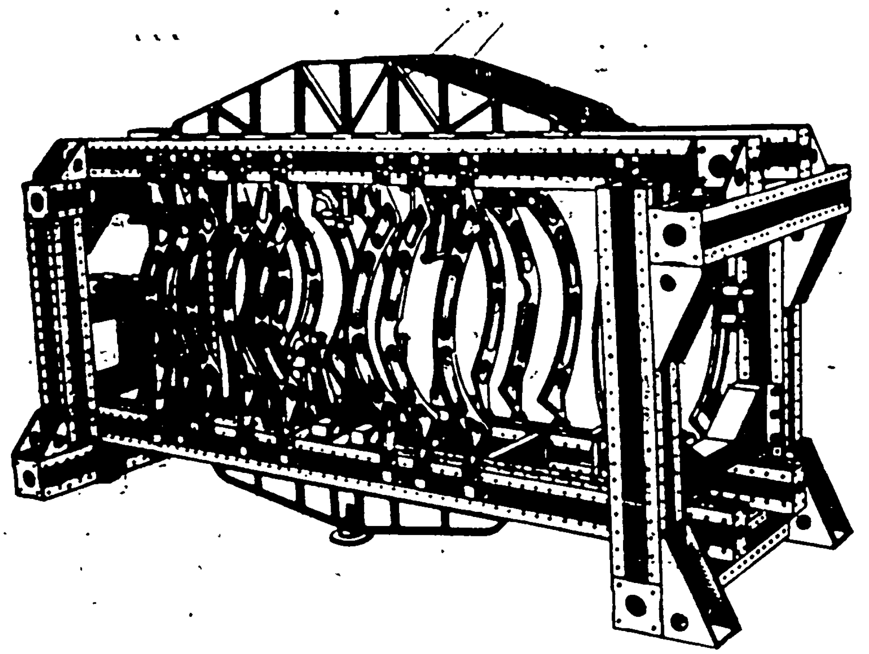

Fig.8 - Typical Design of a Jig for Assembling, Drilling, and Riveting of a Fuselage

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Fig.9 - Jig for the Assembly of Fuselage Sections

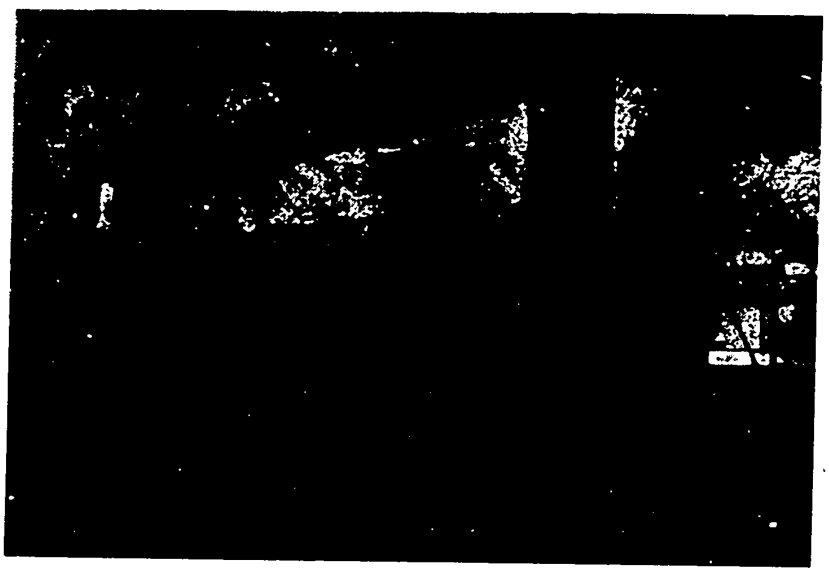

Fig.10 - Jig for the Assembly of the Larger Section of a Wing

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as possible to use components which may be taken apart by removing and replacing bolts and nuts. This permits the repeated use of the components in various types of fixtures for many different purposes.

2) Endeavor to use standard parts which will permit their interchange in different types of fixtures for the assembly of light, medium, and heavy-duty units.

3) Make the component parts of the assembly jig from materials of the lowest cost that will serve the purpose. In particular, make wide use of iron castings and of plastic materials, which results in lower cost as compared with rolled steel products.

Assembly jigs built in accordance with these principles from standard castings are shown in Figs.13, 14, and also in Figs.5 and 8.

The introduction and use of assembly fixtures of standardized construction in industrial plants permits to accomplish the following:

1) Shorten the time and lower the cost of getting set up for the production of new models of structures;

2) Reduce the amount of work involved in the project by means of proper design of the jig;

3) Reduce the amount of work involved in the construction of the fixture.

In order to improve the working conditions in the place where assembling, drilling and riveting is done on large units, platforms are provided for the workmen, along with compressed air lines (Fig.15) and electric current for extension lights. Every fixture is provided with valves for connecting the compressed-air hose to the various pneumatic tools (such as drills, hammers, portable presses, tapping tools, etc). Several valves are located at various points of the fixtures, so that the movements of the workmen will not be hampered by hose lines of greater length than necessary. Usually in fixtures of large size, compressed air is available at the upper as well as at the lower levels of the fixture.

Large assembly jigs are provided with working platforms and ladders to permit

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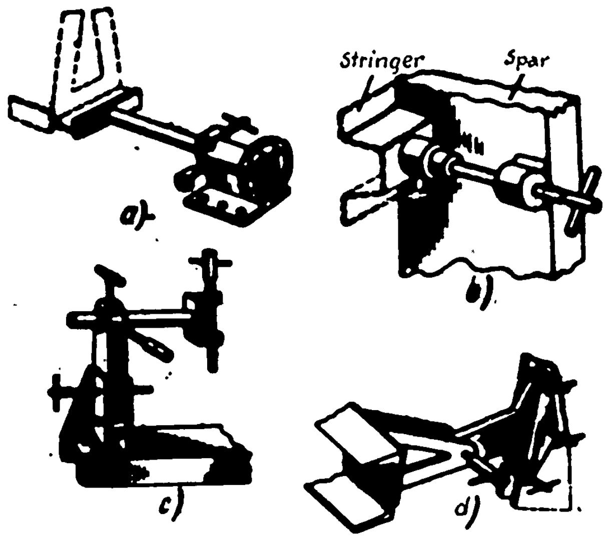

Fig.11 - Some of the Holding Devices for Mounting to Assembly Fixtures

a) Extension-type clamp; b) Screw-type support; c) Adjustable and reversible clamp; d) Swivel clamp

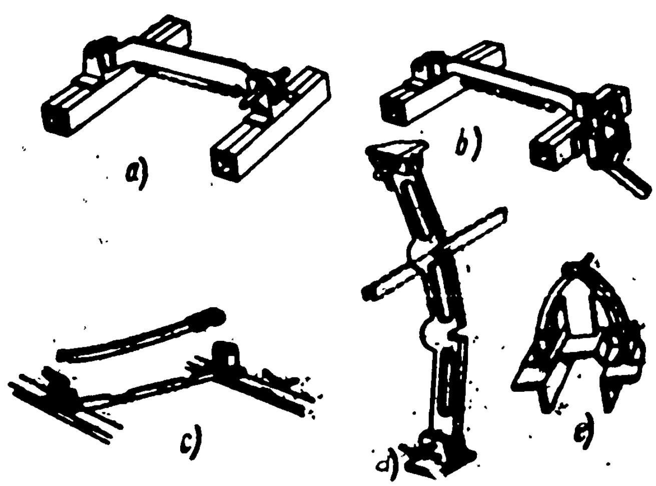

Fig.12 - Several Types of Holders for Mounting to Assembly Fixtures

a) Clamp with lock pin; b) Clamp with eccentric cam lock; c) Removable clamp with eccentric lock; d) Removable brace with lock pin; e) Collapsible double-flap brace

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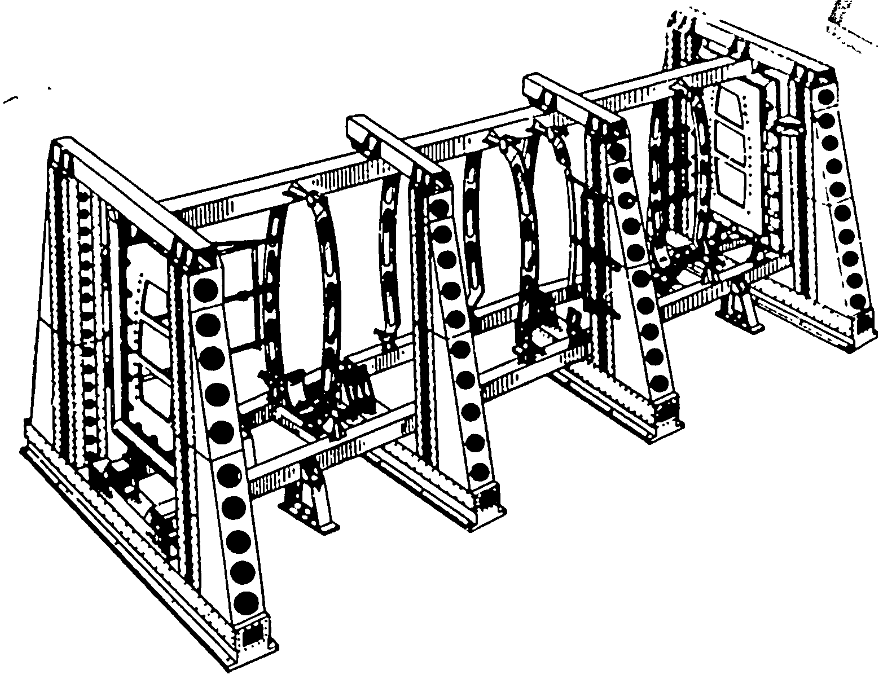

Fig.13 - Jig Made of Standardized Components for the Assembly of Wing Center Sections

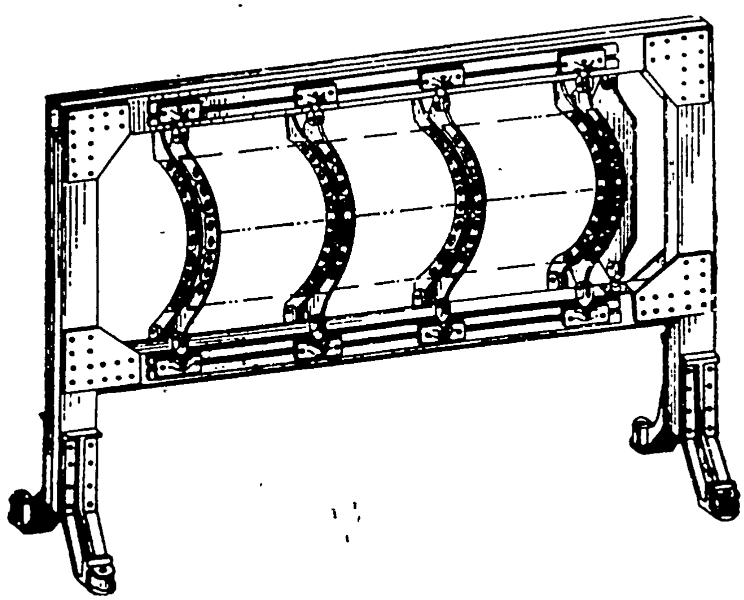

Fig.14 - Jig Made of Standardized Components for the Assembly of Panel Sections

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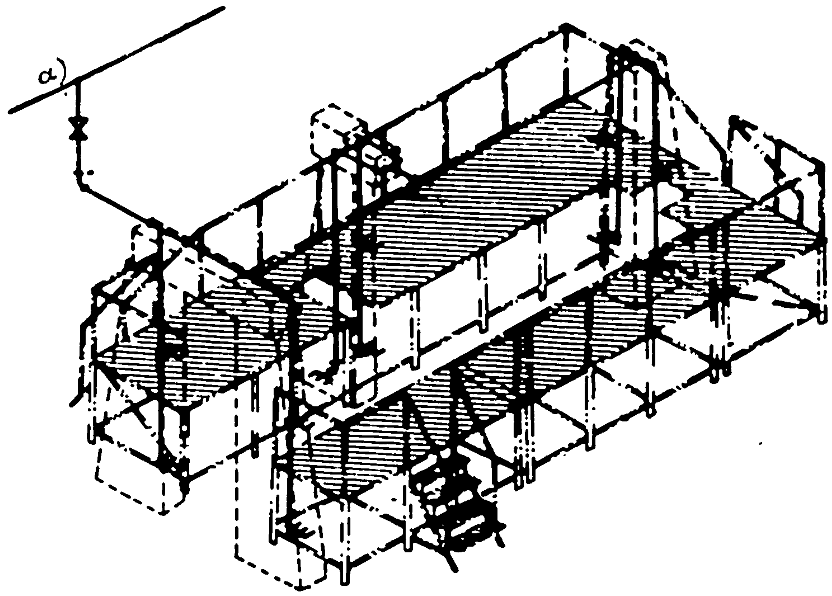

Fig.15 - Outline of a Typical Compressed-Air Installation on Assembly Jigs

a) Compressed-air line

Fig.16 - Jig for the Assembly of Wings, Equipped with Platforms to Facilitate Work on the Higher Levels of the Structure

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work on the elevated parts of the structure (Fig.16). Figure 17 shows a typical design of a movable platform. In this design standard parts are used, which may be

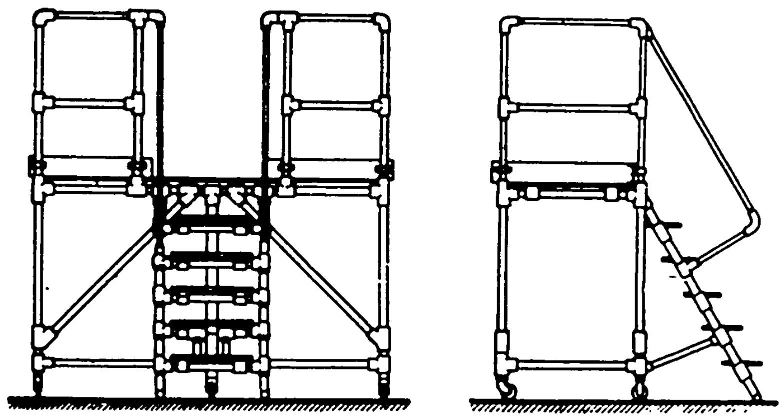

Fig.17 - Movable Working Platform

readily joined together and permit the rapid assembly and disassembly of the platform, adapting it to the requirements of various fixtures.

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Chapter II

MEANS FOR OBTAINING SURFACE SMOOTHNESS OF MAJOR UNITS

1. Stretching of the Planking

A high degree of surface smoothness is required for the streamlined parts of aircraft, exposed to the air flow. Defects in the form of peeling and buckling, produced by improper work during the technical process of assembly and riveting, decrease the aerodynamic quality of aircraft to a considerable degree.

To prevent the development of peeling and buckling of the planking, which may arise as a result of loose contact with the airframe, special tightening methods are used during the assembly in fixtures. For sheets of light gage (thickness less than 0.8 mm), mechanical or thermal stretching of the planking is used, which is done before drilling the holes and riveting.

The mechanical stretching of the skin of the airframe is accomplished by using stretchers and rubber buffer strips. The sheets are fastened on one end to the airframe, the shock absorbers are placed on the upper surface, and this is followed by tightening the stretching device. After that the holes are drilled and the clamps and braces adjusted, so that the sheets are in intimate contact with the airframe.

An effective method of preventing peeling after riveting, is to stretch the sheets on the airframe before riveting, by using the thermal method.

In the thermal method of stretching, the sheets are heated in a special electric heating device to a temperature of 70 - 80°C. On heating, the sheets increase in length and width in accordance with the coefficient of expansion. During the

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subsequent cooling to ambient temperature, the sheets contract and thus become stretched tightly on the airframe.

Stretching by means of electrical heating is effected in the following manner: The prepared sheet is first placed on the airframe and is fastened either on the

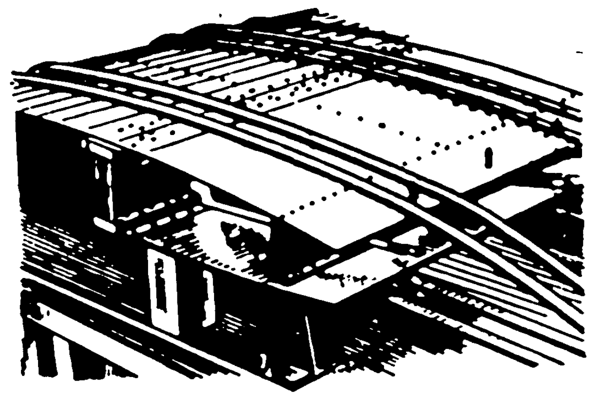

Fig.18 - Stretching of the Planking on the Airframe by Means of Shock Absorbers

upper or lower end with three to four rivets. Then the heating device is installed and the current turned on. On reaching 80°C (usually in 4 - 5 min) the sheet is tightened on the opposite end with six to seven rivets, thus fixing the sheet in the proper position. During all the time of fastening the ends of the sheet, it is necessary to maintain the temperature of the sheet constant, with a variation of not more than ± 5°C. Having riveted the sheet on the ends, the heating device is disconnected and the sheet allowed to cool to the ambient temperature. Next, the holes are drilled and dimpled for the rivet heads, and the riveting is done.

When it becomes necessary to dimple the holes for the rivet heads, additional operations become necessary, namely,

1) After the sheet is cooled, it is removed for the purpose of dimpling by

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2) After stamping of the recesses is completed, the sheet is again installed on the airframe, during which time it is once more heated electrically in accordance with the procedure described above.

Heating devices are available in two types: devices with nichrome spiral elements and devices with bulb panels.

Nichrome spirals wound on spiral tubes are placed at the focal point of a reflector (Fig.19). The inside of the reflector is coated with aluminum, which has a high coefficient of reflection. The number of required reflectors is determined by the size of the sheet to be heated. All reflectors are mounted on one panel, so that the shape of the panel must correspond to the configuration of the sheet exposed to heating. The heating panel is fed with alternating current from transformers at a potential of 20-30 v. The basic wiring of the electric heating device is shown in Fig.20. The panel containing the heating device is mounted near the assembly jig.

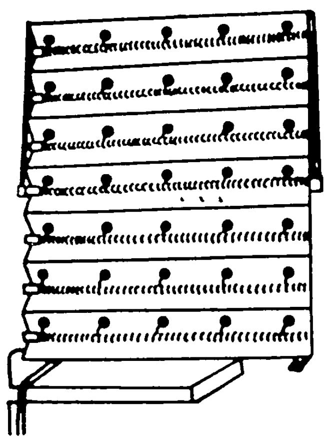

Fig.19 - Interior View of the Device for Heating the Sheets with Nichrome Spiral Wire as Heating Elements

The panel is moved from one place to another as may be needed, by means of a suitable movable carriage suspended from a monorail which forms a part of the jig (Fig.21). The spacing between the panel and the sheet is regulated by suitable props.

Measurement of the temperature during heating is done on the opposite side of the sheet, i.e., from the airframe side, by means of a thermocouple.

It should be noted that in the process of heating, the lower part of the sheets heats somewhat slower than the middle and upper parts (Fig.22). This is caus STAT

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the fact that the lower section of the sheet is being cooled by the current of cold air from below (according to investigations by A.N.Belikov). In order to eliminate this undesirable effect, it is necessary to take it into consideration in calculating the design of the heating device, and to provide for a higher output of heat energy for the lower part than for the upper. Nonuniformity of heating the sheet may be avoided by regulating the spacing of the reflectors from the exposed sheets.

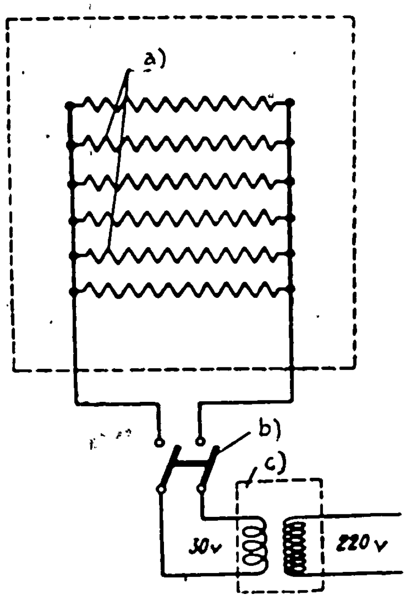

Fig.20 - Basic Electrical Wiring Diagram of the Heating Device

a) Heating wires; b) Knife switch; c) Transformer

When the sheets are heated by means of bulbs, and not by spiral resistance elements, the bulbs are arranged in checkerboard order, thus ensuring uniform heating of the surface of the sheets.

The thermal method of stretching is used in parts of the plant for the assembly and riveting of the wing center section, stabilizers, tail fin, and other sections which require thin sheet covering. The application of this method has a wider significance in connection with the investigation of the influence of the temperature factor on the surface, on the mechanical properties of the materials of the skin and airframe, the degree of deformation of the airframe, and the susceptibility of the materials to intercrystalline corrosion. Wider application of the thermal method of stretching is tied in also with the research work being done on finding more perfect means of exposure of the components to heat, to shorten the time of heating, and also on the development of more precise technical processes for obtaining a higher quality of product at a lower cost.

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A more effective method, which ensures the required aerodynamic smoothness of surface, is the assembly from the outline (of the planking), applying the correct engineering design principles of compensation.

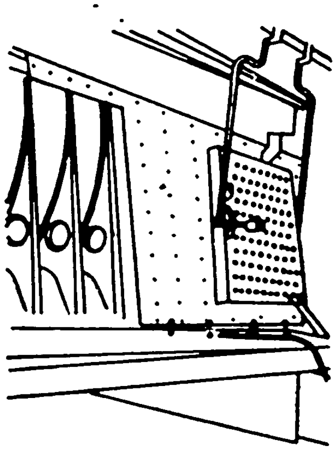

Fig.21 - Heating Device, Transported Along the Fixture on a Monorail

2. Means for Temporary Fastening of Parts

After the parts are arranged in the required position and the sheets are stretched on, and before the holes are drilled for riveting, the adjoining parts are fastened by means of spring clamps, clamps with hooks, adjustable bolts, screw clamps, glue, or other means.

Of all available means for temporary fastening, the most widely used and the

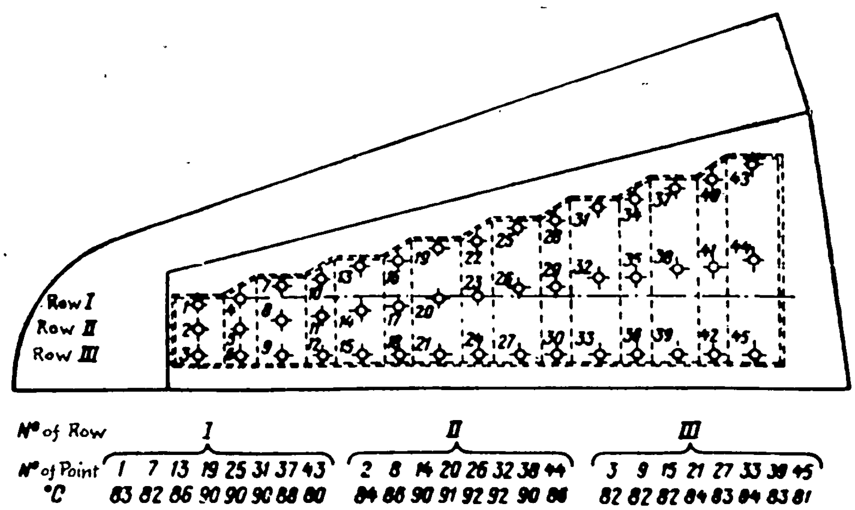

Fig.22 - Temperature at Different Points on the Sheet After Heating for Four Minutes with Infra-red Rays

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most effective, is the spring-type fastener, type PF (Fig.23). Assuring a tight contact of adjoining parts, they can be moved quickly and easily in place and as quickly and easily removed.

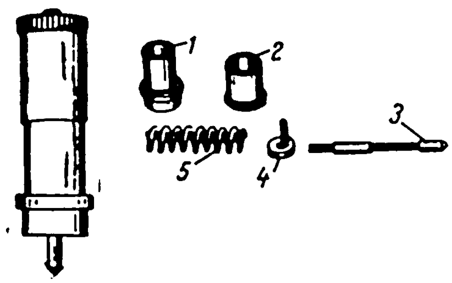

Fig.23 - Spring Clamp of Type PF and Its Parts

1) Body; 2) Cover; 3) Guide pin; 4) Wedge; 5) Spring

Spring clamps are installed in holes drilled simultaneously through two or more parts which are to be joined together. The number of clamps required is determined according to the shape and size of the parts on which the work is done.

Installation and removal of the clamps is done by means of the type K-1 pullers (Fig.24).

Due to the rather low compressive force of spring clamps of the PF type, it is recommended that they be used only in clamping sheets which do not exceed 2 mm in total thickness. When the combined

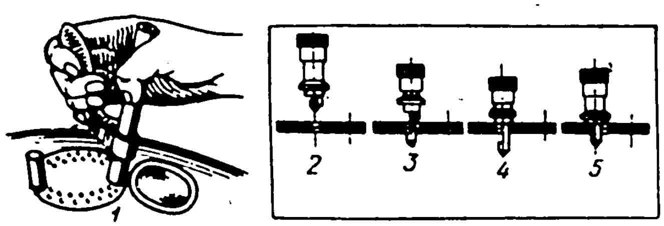

Fig.24 - Installation of a Spring Clamp by Means of Pullers Type K-1

1) Installation of clamp by means of pullers type K-1; 2) Original position of clamp; 3) Extended position of the guide pin and its entry in the hole (puller in compressed position); 4) Wedge of guide pin in position for fastening; 5) Working position of clamp with puller in released position

thickness is greater, and also in the case of cambered surfaces, adjustable bolts and adjustable control rivets are used at a spacing of 150-300 mm. In cases where

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the parts joined together are not to be taken apart again, the control rivets should have the finished-size diameter, in accordance with the specifications on the techni-

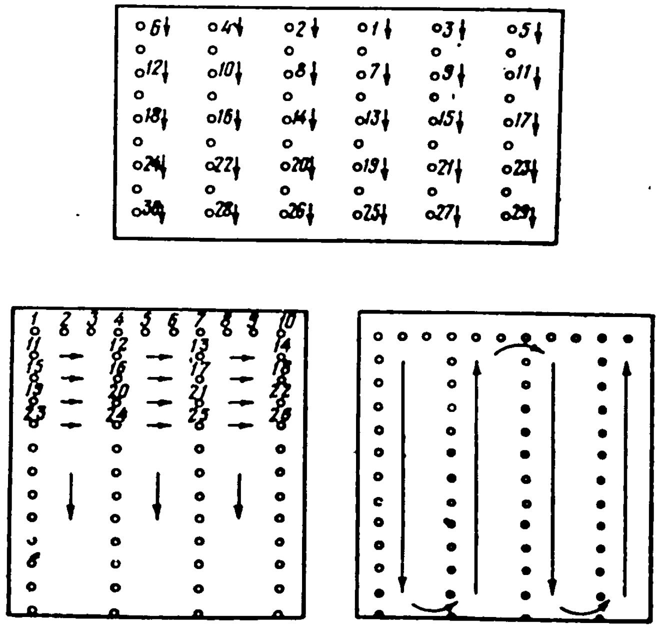

Fig.25 - Outline of the Sequence of Drilling the Holes, Installation of Clamps, and Riveting by the Terminal Method

cal drawings.

For the protection of surfaces of the parts, especially of the planking, from possible damage while installing the adjustable bolts, it is advisable to use washers made from nonmetallic materials.

3. Order of Clamp Installation and Sequence of Drilling Holes and of Riveting

Peeling and buckling of the surface of riveted parts may develop as the result of the improper sequence of installing clamps, holders, and control bolts, or of wrong procedure in drilling holes and in riveting. For this reason, in the execution of the mechanical operations it is imperative that the order in which the job is done

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is in accordance with the speci...

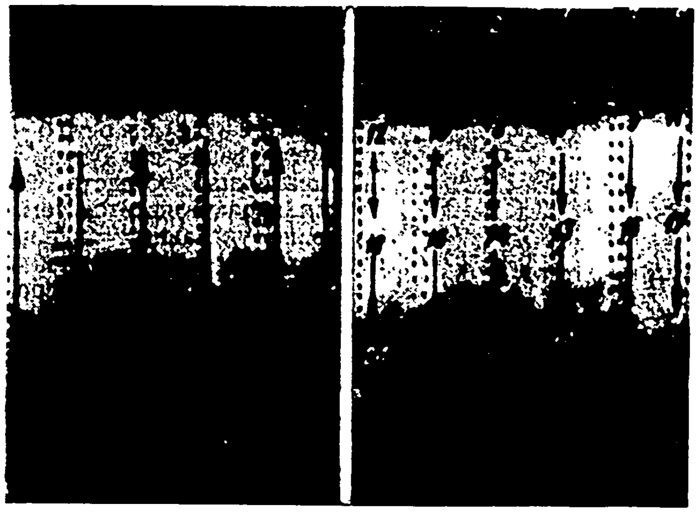

Fig.26 - Example of the Sequence of Riveting of Planking by the Terminal Method

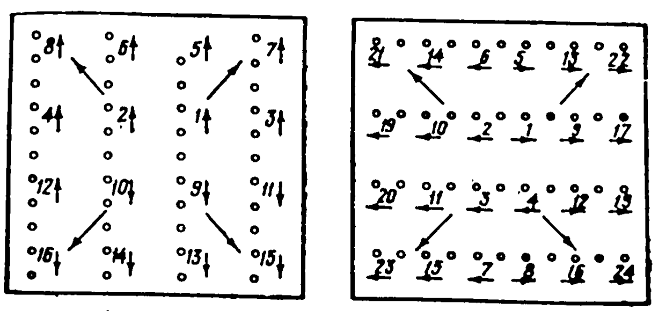

Fig.27 - Outline of the Sequence of Drilling of Holes, Installation of Clamps, and Riveting by the Central Method

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is in accordance with the specifications.

In order to ensure smoothness of the surfaces, the installation of the clamps and holders as well as the riveting operation should be carried out either by the "central" or the "terminal" method.

Fig.28 - Example of the Sequence of Riveting by the Central Method

The terminal method (Figs.25 and 26) of drilling holes, fixing of clamping devices, and riveting is characterized by the fact that the assigned job is done from the fastened end or side of the sheet toward the free end.

The central method (Figs.27 and 28) of drilling holes, fixing of clamping devices and riveting, is characterized by the fact that the operation is carried out from the center toward the periphery.

The application of the described methods results in better stretching of the sheets and prevents possible buckling on the surface of the planking.

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CHAPTER III

COMPARISON OF RIVETING WITH OTHER MEANS OF JOINTING

Structural elements which are intended to be fastened together in assembly jigs may be joined by means of riveting, welding, or cementing. To evaluate these different means of jointing, some of the most important characteristics of each will be described below.

The wide application of riveting of light metal alloys involves a number of inherent disadvantages, among which the following are of importance: increase in weight of the structure due to the weight of the protruding head of the rivet; weakening of the material being riveted due to the necessary drilling of the rivet holes, which may be as much as 25%; large number of operations necessary in the preparation of the materials for jointing, such as the procurement of rivets, drilling of holes, and countersinking or stamping of recesses, insertion of the rivets, and the riveting itself; the objectional noise of the pneumatic riveting hammers, and other disadvantages.

In order to avoid these disadvantages, efforts are being made as the first step to improve the process of riveting, and secondly to replace riveting by other methods of making permanent joints, such as electric spot or roller welding, cementing, soldering, etc.

In the present state of technical development of making nonseparable joints, only spot and roller welding may be considered as being comparable to riveting. The introduction of these methods is facilitated by the fact that welded joints ca[illegible] STAT

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considered as equivalent to riveted joints with a large number of riveted seams, with respect to the appearance of the seam itself and to the character of the welded spots.

However, in the manufacture of aircraft, spot welding has not been widely adopted, which is explained by the lack of reliable analytical and experimental data on the materials thus welded, from the viewpoint of strength and reliability as well as of the technical performance of the job of welding the joints.

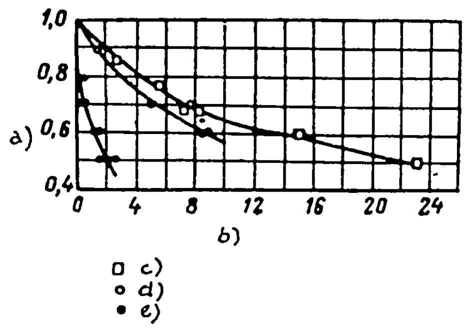

Fig.29 - Performance of Joints at Cyclic Static Loading

a) Coefficient of Loading Stress; b) Number of Repeated Loads in Thousands; c) Joints with Rivets of Type 3K; d) Joints with Rivets of Type 3Y-90°; e) Spot-Welded Joints

Fundamental properties characterizing riveted and welded joints, include relative strength, quality of the surface, and also technical and economic considerations.

The strength of a spot weld, as is well known, is determined by the dimensions and by the mechanical properties of its molten central core. If the welding time is too short or the current too low, no molten core may form. The strength of a weld that is thus insufficiently heated is low. By comparison, the strength of a riveted joint is determined by the mechanical properties of the material from which it is made and by the quality of riveting.

Thus, the strength of a spot weld and of a rivet in its original condition, is a function of the technical process of welding or riveting.

Furthermore, the strength of welded and riveted joints is determined not only by the strength of the spot welds or of the rivets, but also by the mechanical properties of the materials being joined, the distribution and arrangement of the points where the joint is made, the number of points, and also by a series of other STAT

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structional and engineering factors.

Investigations carried out by V.P.Grigor'yev on the strength of welded joints with static, vibration and with cyclic stress loading, show the following;

1. Under conditions of static and vibration stress, structures of welded and of riveted joints have equal strength.

2. Under conditions of cyclic static loading, welded joints do not stand up under service conditions as well as riveted joints (Fig.29).

3. The slip or displacement in shear, during the transition from the elastic to the ductile condition, is lower in riveted than in welded joints (Fig.30).

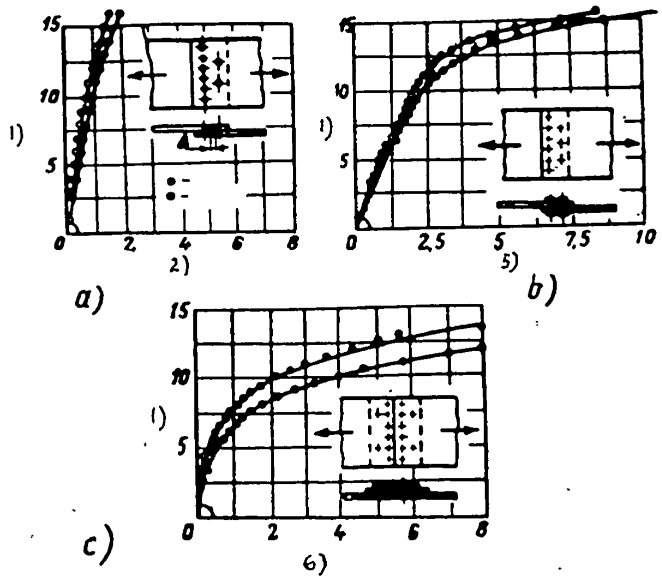

Fig.30 - Slip in Welded and in Riveted Joints

a) Welded joint; b) Riveted joint with rivets of 4 mm and with protruding heads; c) Riveted joint with counter-sunk heads having a diameter of 5 mm and a conical angle of 90°. The rupture takes place along the dots.

1) Stress in kg/mm^2; 2) Slip Δ in % of diameter from the spot weld; 3) Strong joint; 4) Extra strong joint; 5) Slip Δ in % of diameter of rivet; 6) Slip Δ in % of diameter of rivet

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The low ductility of welded joints causes unequal strain distribution on the row of spot welds. The first row, at the extreme edge, absorbs most of the load, with the result that on stressing the seam or joint with equal or with greater loading of 0.7 P_1, cracks appear in the first row, which leads to a rupture of the joint. Under similar conditions, when the load is applied on rows of a riveted joint, the first row of rivets absorbs the stresses and relieves the tension throughout the sheet. On the whole, a greater amount of work is involved in making joints that are subjected to stresses on cyclic load application.

Fig.31 - View of Investigated Panel

The quality and condition of the surface of riveted and of welded joints is characterized by the extent to which the heads of the countersunk rivets protrude or by the depression of the spot welds in relation to the surface of the part, and by the degree of warping of a portion of the joint or of the assembled unit on completion of the joint.

It should be noted that the smoothness of the surface of an assembled unit depends not only on the proper riveting or welding operation, but also on the accuracy of the contour of the airframe. A comparatively thin planking will follow the depressions and roughnesses in the airframe so that the smoothness of the surface is disrupted on some parts of the assembled unit. Therefore, the quality of the finish of the airframe, the corresponding supply of separate parts, and the proper execution of the technical process of riveting or welding contribute to the quality of the surface of individual units as well as of the aircraft as a whole.

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Considerable expenditure of labor is involved in meeting the quality requirement of surface smoothness in connection with riveting.

In the riveting of structures it is possible to limit the protrusion of the rivet heads to one tenth of a millimeter, due to the close correspondence of the dimensions of the head of countersunk rivets with the dimensions of the countersunk or stamped recesses of the hole. In the case of welding light metal alloys, the cavities formed by spot welding may vary from 0.05 to 0.3 mm.

For the purpose of investigating the technical economic aspects of riveted and welded joints on a comparative basis, a study was made of the panel shown in Fig.31, which was produced by riveting and also by welding. The panel is covered with a planking of 1.2 mm thickness of D16T alloy, and a frame consisting of stamped ribs of the same material. In all, the panel contains 1363 rivets (or spot welds).

The data given in Fig.32 show that the time consumed in making the panel by welding is less than that needed for riveting. The number of auxiliary units of equipment used in a working shift to make up these panels was 12 in the case of riveting each unit separately, and 15 in the case of welding. The space occupied by the welding machine was larger by 15-20% than that required by the riveting press. The power consumed by the welding machine to weld 100 panels in one shift was equal to 1300 kw, as compared with 35-46 kw required for riveting by pneumatic riveting hammers or presses. The considerable cost of welding machines and the larger maintenance expense involved result in higher cost of unit production.

These statements yield the following conclusions:

1. In assembled units subjected to static loads, welding may be considered as being equivalent to riveting.

2. Welded joints are not suitable for use in structures subjected to cyclic stress loads.

3. The degree of surface smoothness of riveted and of welded joints should be approximately the same.

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4. Spot welding results in a higher rate of production than riveting with pneumatic hammers or individual press riveting.

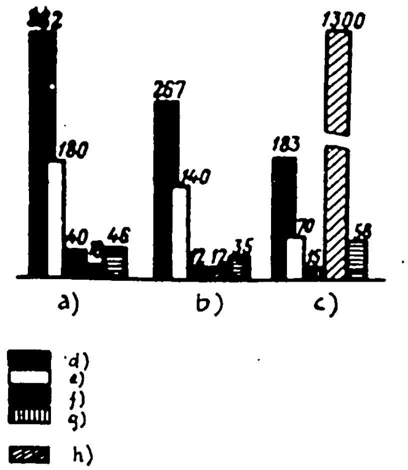

Fig.32 - Technical-Economic Aspects in the Manufacture of Panels by Riveting and Welding

a) Riveting with pneumatic riveting hammers; b) Press riveting (single units; c) Electric (spot) welding; d) Piecework time for one panel, in min; e) Machine-work time for one panel, in min; f) Cost of one panel, in rubles; g) Number of auxiliary equipment to produce 100 panels during one shift; h) Power required by the machine tools, in kilowatts, to produce 100 panels during one shift

In order to make welding more advantageous economically, it is necessary to reduce the power consumption and the size of the welding machines, while further improvements and refinements in the technology of welding may permit joints of higher strength and smoother surface finish of the assembled units.

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PART II

PREPARATION OF THE HOLES AND COUNTERSINKING BEFORE RIVETING. PLACING OF THE RIVETS

CHAPTER IV

FORMATION OF THE HOLES

1. Method of Producing the Holes

The production of holes is a preliminary operation to riveting. The quality of the riveted joints depends much on how well the operation of preparing the holes was carried out. In the performance of this operation the following conditions are necessary: clean inside of the hole (freedom from graininess, burrs, scratches, etc.), perfect roundness, no skewing, and absence of other defects.

Holes in parts intended for riveting are made by two methods: drilling or punching.

Punched holes are widely employed in assembly work of sheets, plates, and other profiles, and are made in special instruments (punching presses) by means of punches and dies.

Holes made by punching possess a number of disadvantages, the principal ones being as follows: buckling of the material, hardening by cold-working, cracking, torn edges, etc. Cracks and torn edges cause additional stresses in the joint. For this reason, the strength of structural elements with punched holes is lower than that of the same elements with drilled holes. Depending on the material of the structural elements, the reduction in strength is from 2 to 8% (Table 2).

The strength in fatigue tests of structural elements with punched holes is from 3 to 8% lower than with drilled holes (Fig.33).

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The difference in the strength of plates with punched and with drilled holes is particularly noticeable on repeated static loading tests. The strength of a plate

Table 2

Strength of Plates with Holes Made by Different Methods

Method of forming the hole	Strength of plate in %		
	V95	MA-1	D16T
Drilling to size	100	100	100
Punching to size	88	96	92
Punching holes to 0.75 diameter followed by drilling to size	100	102	99

with punched holes is 1.5 times less than that of the same plate with drilled holes, when subjected to repeated static loading. For this reason, the punching of holes to

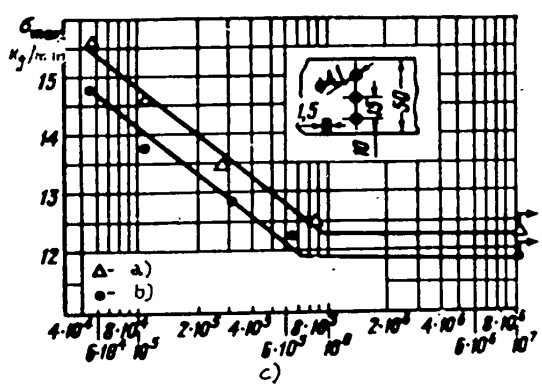

Fig.33 - Effect of the Manner in Which the Holes are Made on the Strength of the Plate in Fatigue Tests

a) Drilled holes; b) Punched holes; c) Number of cycles

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the exact final diameter is not good practice. The preliminary punching of holes to

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a smaller diameter for use as guide holes or for assembly, should be done in sections of the plant that are properly equipped with punching and stamping equipment. Before the final assembly of parts, components, or major units, the punched holes are drilled to size to correspond with the diameter of the rivets used.

Standard equipment is used for punching holes, utilizing punches and dies and punch presses. One of these presses is shown in Fig.34. In setting up the press for punching, templates or patterns with markers are used, the distance between the markers corresponding to the position of the holes in the part being punched.

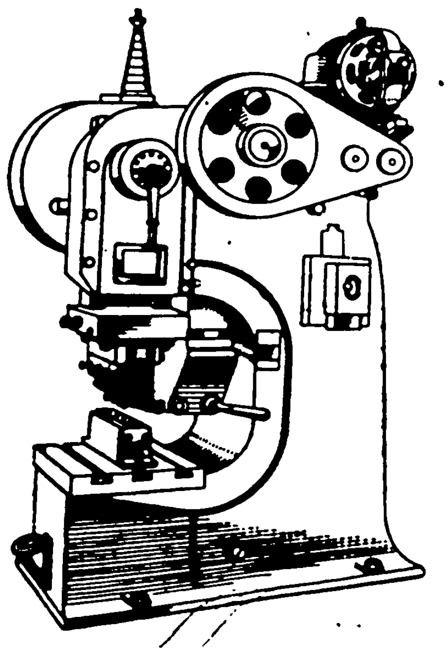

Fig.34 - Press for Punching Holes

The punching of the holes may be done in devices, such as the one shown in Fig.35, in which the frame has the shape of the letter C.

The holes are made by the punch (1) and the mating die (2) (Fig.36), between which the work to be punched is placed in position.

Drilled holes assure a stronger and more stable joint, due to the cleanliness and greater precision in the drilling operation.

Depending on the construction of the components and the thickness of the parts being riveted, drilling may be done (a) in one, or (b) in two operations:

a) Drilling to final dimensions from the side of the planking or the airframe;

b) Preliminary drilling to a smaller size from the side of the airframe, followed by drilling to exact size from the side of the planking.

Drilling of the holes for riveting from the planking side to finished size is done by means of templates or in special jigs through guide bushings or according to

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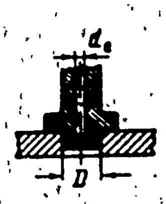
layout marks.

In the construction of aircraft the most widely used method is to drill holes with the aid of templates made of steel.

Table 3

Dimensions d_c abd D when Using Guide Bushings

Sketch	Diameter d_c of hole	Nominal	2.7	3.1	3.6	4.1	5.1	6.1	8.1	9.6	10.1
		Permissible deviation	+0.1		+0.15			+0.2			
	Outside diameter D	Nominal	5	6	7	8	10	12	16	18	20
		Permissible deviation	-0.2					-0.3			

To preserve the templates and prevent wear and tear, the guide holes consist of hardened steel bushings which are inserted at the proper places in the template, with the drill passing through them. These inserted bushings, however, may loosen and shift, or even drop out. For this reason it is worthwhile to use patterns without inserted bushings and to rely on special fittings or bushings placed on the drill (Fig.37).

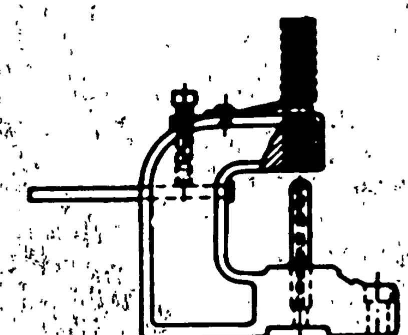


Fig.35 - Punch Press

Such special drill bushings are interchangeable. Depending on the diameter of the drill they have specific dimensions (Table 3).

Drilling of holes with the aid of templates may be done as bench work or in special fixtures which permit placing a STAT

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fastening of the template to the part being drilled. Should difficulties be encountered in applying the template when drilling is done in fixtures, special guides are used, which may be laid over the workpiece or mounted to the part before drilling (Fig.38). The special guide usually consists of a steel plate in which bushings are inserted with force fit. After assembly and fastening of the parts in the fixture, the special guide is put in place, fastened, and the holes are drilled (Fig.39).

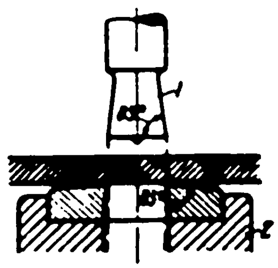

Fig.36 - Jig Used on Presses for Punching Holes

a) Punch; b) Die

When drilling in accordance with preliminary prepared guide holes (Fig.40), the work involved is reduced by approximately 30% as compared with drilling when the holes are merely marked on layout. When a template is prepared with guide holes for drilling a particular part, it is obvious that it may be used for drilling other similar parts.

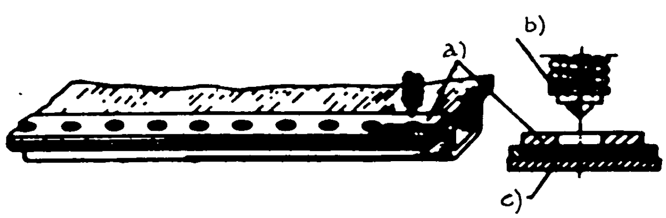

Fig.37 - Drilling Holes by a Template

a) Template; b) Bushing; c) Parts being drilled

Drilling of holes by marking (Fig.41), is used only in exceptional cases, since it results in a low rate of production, and is justified only in experimental work.

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The laying out of spots can be done as follows:

a) Using a template and a center punch;

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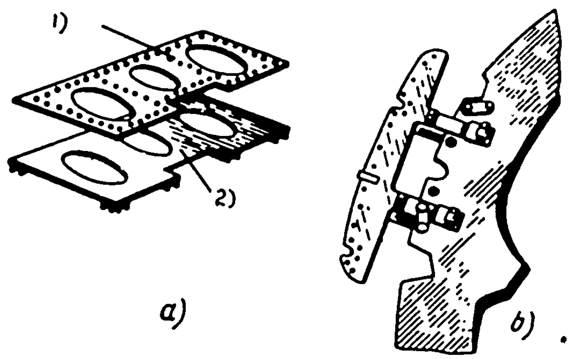

Fig.38 - Examples of Guide Templates

a) Layout; b) Flap, mounted on parts of the fixture

1) Guide template; 2) Part

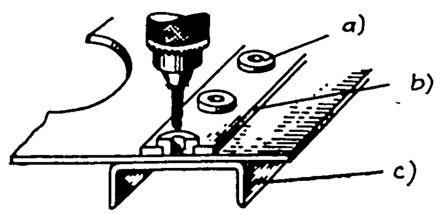

Fig.39 - Drilling with Guide Templates

a) Guide bushing; b) Plate; c) Part being drilled

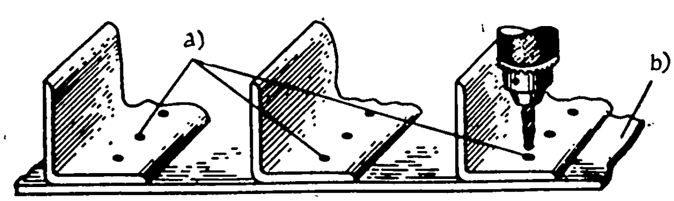

Fig.40 - Drilling with Previously Prepared Guide Holes

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a) Guide holes; b) Planking

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b) Using a template and spraying paint in the holes;

c) Using marking and measuring tools (such as an ordinary rule and pencil).

The following procedure is used in marking by means of a template and center punch: The template is placed on the top of the part to be drilled, the holes are punch-marked, the template is removed, and the holes are drilled.

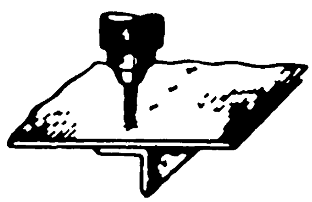

Fig.41 - Drilling for Marking

When the marking is done by means of a template and application of paint, the placing of the template is the same as described above, but instead of using a center punch, the holes are marked by a colored powder applied by spray gun.

The marking of holes by means of an ordinary rule and pencil is done on aluminum alloy parts. The marking of duralumin parts with scribing tools or center punches is not permitted, since the protective surface film of the metal is destroyed when it is scratched or punched, and there is a possibility that corrosion may develop.

Drilling of holes for rivets is carried out in either stationary or portable drill stands or by pneumatic and electric hand drills.

2. Cutting Tool

The cutting tool used for drilling holes consists of a spiral drill. Drills are manufactured of carbon and of high speed steel. In drilling chromium-silicon steel alloys, drills with hard-metal tips are used, which permits a cutting speed twice that of the cutting speed obtained with drills of carbon steel.

The angle 2φ shown in the plan view of Fig.42 is of great importance and affects the efficiency of drilling. This angle is chosen to correspond with the requirements of the type of material being drilled (Table 4).

Improper grinding of the drill, such as unequal bevel of the cutting edge STAT

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a difference in their length, interfere with the correct performance of the drilling and causes enlargement of the hole (Fig.43). Holes of an enlarged diameter aggravate

Table 4

Significance of the Angle 2φ, Depending on the Type of Material Worked

Material worked	2φ in degrees
Steel, cast iron, hard bronze, duralumin	116-118
Silumin, babbitt	140
Brass, soft bronze	130
Magnesium, ebonite, celluloid	85-90

the working conditions of riveting and cause breaking of the rivet heads. In addition, when the holes are larger than necessary they are not filled with the body of the rivet, which, in turn, leads to looseness (slipping) of the seam. For this reason, drill grinding should be done by experienced grinders at a centralized location, with systematic observance of the geometry of the cutting parts of the drill and cleanliness of the grinding work.

The quality of the work done in drilling is affected to a marked degree by the lack of rigidity of the spindle and the chuck as well as by the wobble of the drill itself if it is not properly held in the chuck.

Actual practice as well as experimental investigations show that, to maintain the quality of the drilled holes, the lack of rigidity of the drill, or its tendency to wobble in the chuck, must not exceed 0.1 to 0.2 mm. The lower limit relates to holes up to 10 mm, while the upper limit refers to holes of a diameter above 10 mm.

Holes for rivets of various sizes are made with drills, whose dimensions are given in Table 5.

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This relationship of the diameter of the rivet to the diameter of the drill, as shown in Table 5, permits proper insertion of the rivets in the holes and assures

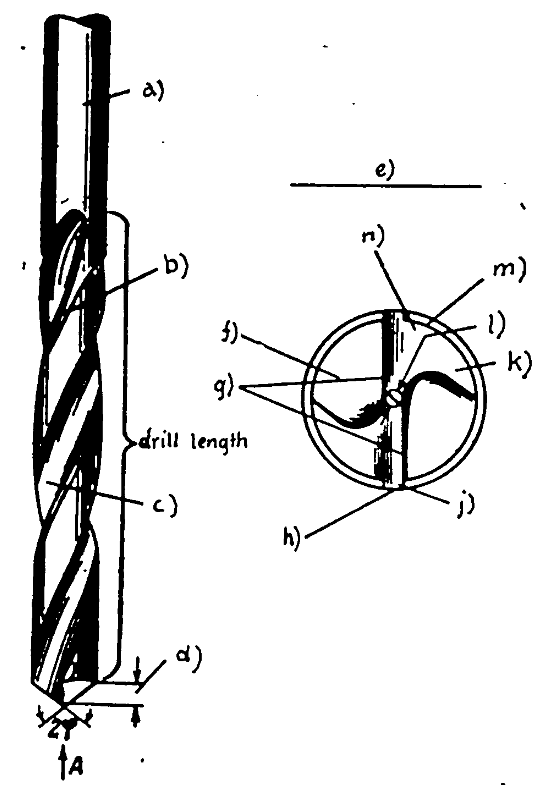

Fig.42 - Spiral Drill

a) Shank; b) Guide face (land); c) Flute; d) Cutting part; e) View indicated by arrow A; f) Flute; g) Cutting edges; h) Margin; j) Edge of margin; k) Rib; l) Chisel edge; m) Land clearance; n) Lip clearance surface

that, in riveting, the hole will be completely filled with the metal from the core of the rivet. The correct selection of the drill size is therefore of great importance. If the hole is smaller, the rivet will not go in and will have to be forced in, with damage to the parts being riveted and with an unnecessary loss of working time.

In places of limited access, where drilling of the holes is difficult with ordinary drills, use is made of extra long drills in accordance with Specifications GOST 886-41, or special extension and angular types of fittings are used, a descrip-

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tion of which is given below.

3. Drilling Machines

Vertical drill presses of the general-purpose type are used for drilling the holes along the length of longerons, ribs, and other parts and junctions. Their use results in a high rate of production and in a higher quality of work, as compared with pneumatic hand drills.

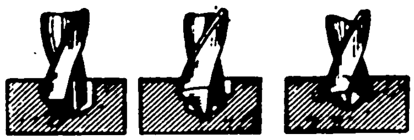


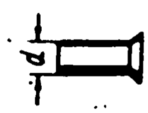
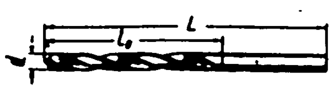
Fig.43

For drilling straight-line holes in minor and major units of an aircraft it is advantageous to use drill presses equipped with multiple-spindle drill heads. Drilling a number

Table 5

Dimensions of Spiral Drills for Drilling Riveted Holes

(Dimensions are in accordance with Russian Specifications GOST 887-43)

Diameter of rivet, d, in mm		2.6	3.0	3.5	4.0	5.0	6.0	8.0	9.5	10.0
Diameter of drill, d, in mm		2.7	3.15	3.6	4.1	5.2	6.2	8.2	9.7	10.2
Over-all length of drill, L, in mm		65	70	75	82	95	105	125	135	140
Flute length, l_o, of drill in mm		35	40	45	50	60	68	85	95	95

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of holes at the same time in group sequence results in an increase of production several times greater than with single hole drilling.

Technical data on the characteristics of multiple-spindle drilling machines are given in Table 6.

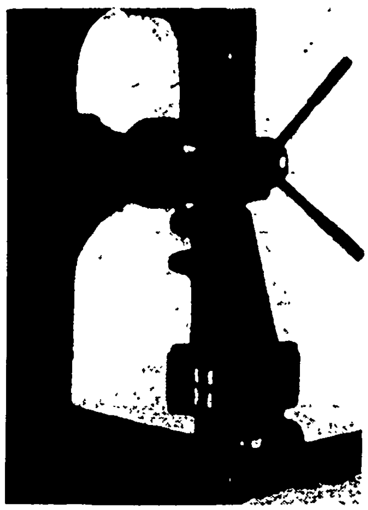

Fig.44 - Drill Stand with a Four-Spindle Drill Head

Figure 44 shows a drill press equipped with a special four-spindle drill head for drilling junctions of relatively small size. The head of the drill stand has a row of gears which impart a rotary motion to the drills held by the jaws of the checks. A roller conveyor is attached to the base of the stand for supporting the workpiece during the drilling operation and permitting to move the work, for drilling the next group of holes in a successive manner.

Figure 45 shows a drill stand with a twelve-spindle drill head. The head is fastened to the stationary part of the stand on the spindle end (1). From the electric motor the rotary motion is transmitted over the driven tapered block (2) and the clutch (3) to the crankshaft (4) and dog (5). The dog (5) then imparts a rotary motion to the spindles (7) of the head. In order to prevent dynamic unbalancing, the dog is provided with a counterweight (6) on the crankshaft. This kind of a head makes it possible to drill holes in components and in parts at a continuous pace.

In cases where it is inconvenient to move the work over the drill stand table because of the large size of the workpieces, (such as heavy longerons, wing panels, and center sections) stands with drill heads are used that can be moved from one place to another across the part which is being drilled.

A drill stand of this type is shown in Fig.47, intended for group drilling of holes in parts of considerable length. The bedplate (1) carries the carriage (2),

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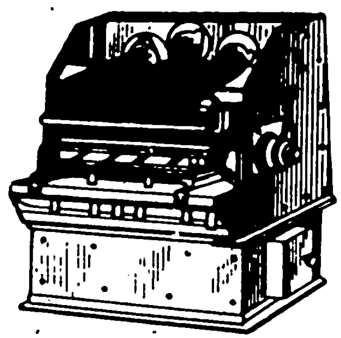
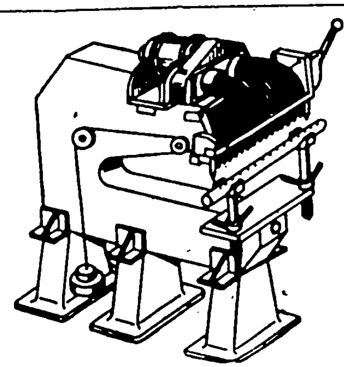
Table 6

Drilling Data for Multiple-Spindle Drill Heads

a)	b)	c)	d)	e)	f)	g)	h)	i)	j)			n)	
									k)	l)	m)	o)	p)
MC-1		30	4	2800	40	18	3,2	650	1650	1400	950	25	25
MC-84		20	4	2800	24	30	3,0	—	1800	1750	1000	—	1220

a) Type of drill press; b) Sketch of press; c) Number of spindles; d) Greatest diameter of holes in mm; e) Number of revolutions of spindle in rpm; f) Maximum torque permitted per spindle in kg-mm; g) Shortest distance between spindles in mm; h) Rating of electric motor in kw; i) Maximum permitted force of feed when working all spindles, in kg; j) Dimensions of sections, in mm; k) Height; l) Length; m) Width; n) Opening in press, in mm; o) Jaw; p) Sweep; q) Twelve-spindle drill-head press; r) Four-spindle drill head press; s) Four-spindle combination drill and milling head press

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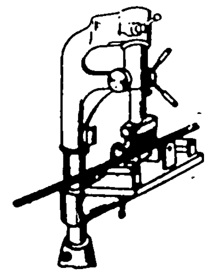
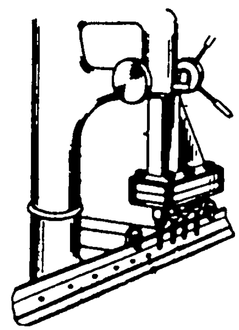
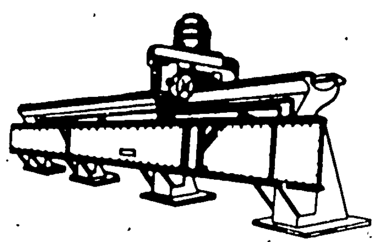
Table 6 (continued)

q)		12	4	1250	—	12,7	1,5	—	2100	650	330	120	350
r)		4	4	1250	—	12,5	1,5	—	2100	650	330	120	350
s)		4	5	1400	—	50	—	—	1830	7000	1000	200	—

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which carries the electric motor and the four-spindle drill head (3). The longeron (4) is placed on the tracks (5), which permit regulating the height of the workpiece.

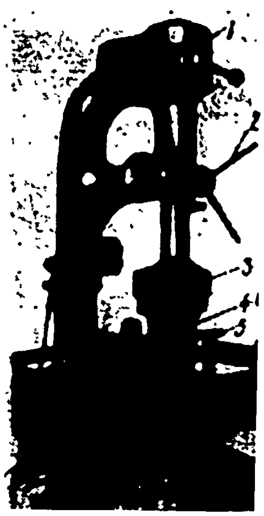

Fig.45 - Drill Stand with a Twelve-Spindle Drill Head

1) Electric motor; 2) Hand levers for feeding; 3) Body of the twelve-spindle drill head; 4) Drill; 5) Workpiece (edging of a longeron); 6) Table with supporting device

For the purpose of fastening the longeron, the drill stand is equipped with a number of pneumatic gripping devices (6), operated by an air valve connected to the compressed-air system. The displacement of the carriage, together with the drill head, after one group of holes is drilled to another, is accomplished by means of the hand wheel (8).

Specialized drill presses of portable or radial types are used for drilling holes in components and major units of large size in continuous production.

Figure 48 shows a stand for drilling the panels of a wing. The overhead trolley (1) with the radial drill heads can be moved while in a perpendicular position in two directions over the monorail (2) which is attached to the uprights (3). The rotary arm (9) with the drill heads can be rotated about the column (6) through 360°. At the end of the arm is the electric motor (7), which transmits rotary motion to the spindle (4). The feed of the drill is effected by means of manual lever (8).

On such stands it is customary to have several radial drill heads, for use by a corresponding number of drill operators. Drilling is done in accordance with the marked guide holes in stringers, but templates and patterns may also be used. Further improvements in such drill stands should be along the lines of automation for

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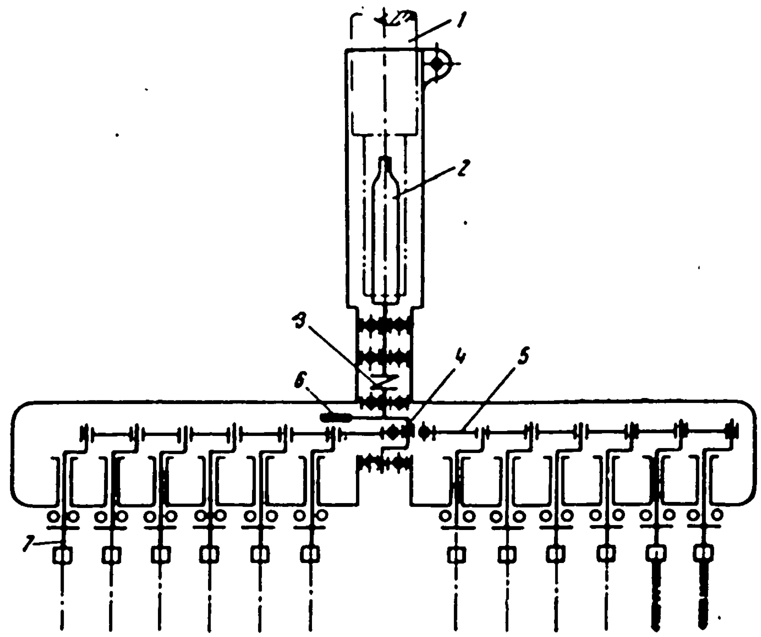

Fig.46 - Kinematic Diagram of a Twelve-Spindle Drill Head

1) Spindle of drill press; 2) Driven shaft; 3) Clutch; 4) Crankshaft; 5) Block; 6) Counterweight; 7) Spindle

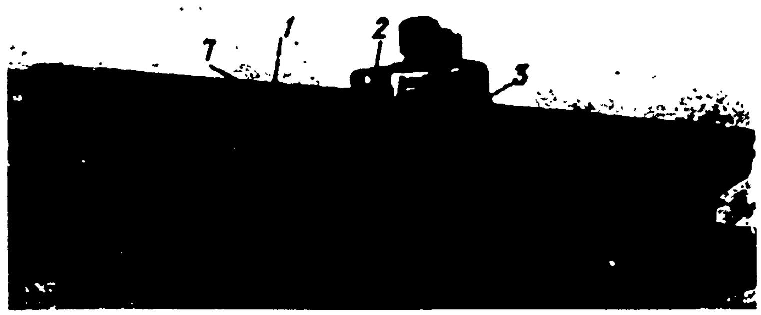

Fig.47 - Drilling the Border Holes of a Longeron on a Drill Press with a Movable Multiple-Spindle Drill Head

1) Base; 2) Carriage; 3) Four-spindle drill head; 4) Longeron in which the holes are drilled; 5) Runways on which the longeron is placed; 6) Pneumatic clamping devices; 7) Hand wheel for relocating the drill head; 8) Manual feed lever

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shifting the part being drilled or the drill heads.

Radial drill heads may also be used for drilling holes directly in parts mounted in assembly jigs. A suitable arrangement is shown in Fig.49.

The flexible arm, consisting of two steel castings, permits drilling holes over the entire area covered by the radius of the arm. When it is necessary to drill holes lengthwise over the entire longeron, the drill head, together with the column and its base, are shifted to the desired place on runways.

Several radial drill heads are used at the same time for drilling holes in longerons of considerable length (Fig.50), which are installed on trucks that run on monorails. Such installations permit to work on large panels of wings, center sections, and fuselage, longerons of various sizes, ribs, and other major units of an aircraft.

Considering that the major units of an aircraft consist of separate minor units and panels in shapes that permit ready access to the part on which work is being done, the application of group drilling by a crew of drillers is feasible, and the following advantages are realized:

1) The amount of labor is reduced and the workmanship of the holes is improved;

2) An assembly line on the principle of continuous production can be organized, with the riveting also being done by the group method, thus improving the entire system of work in the assembly sections of the plant with a rhythmic output of production.

Figure 51 shows a diagram of a stand with which it is possible to assemble, drill, and countersink panels over the entire surface. The drill heads are so arranged that the holes can be drilled perpendicularly to the surface of workpieces. Rotation of the drills is effected by means of flexible spindles from a common drive mechanism which is part of the stand.

4. Manually Operated Mechanical Drilling Tool

Manually operated hand drills are also widely used on assembly jigs in air STAT t

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Fig.48 - Stand for Radial Drill Head for Drilling Large-Size Panels

a - Overall view; b - Radial drill head

1 - Trolley; 2 - Monorail; 3 - Pedestal; 4 - Spindle; 5 - Radial drill head; 6 - Column; 7 - Electric motor; 8 - Hand lever; 9 - Bracket

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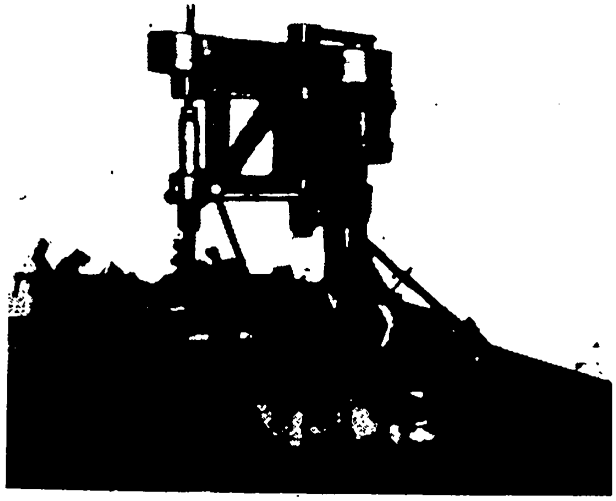

Fig.49 - Radial Drill Head for Drilling Holes into Longerons, Fixed in the Assembly Jig

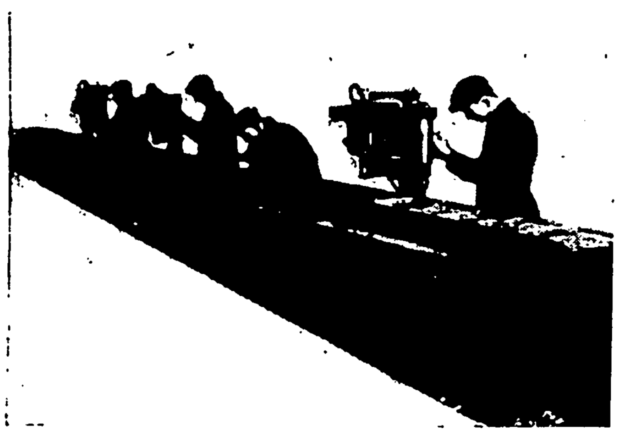

Fig.50 - Aligning of Radial Drill Head for Drilling Holes in Longerons

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construction along with other power tools. These are pneumatic and electric drills.

In present day production, pneumatic hand drills are in wider use, which have the following comparative merits: Pneumatic hand drills are of small size and weight; a feature of the power drive is that it permits a gradual and smooth increase in the speed of the drill, by controlling the pressure on the lever connected with the air valve. When the drill is overloaded by excessive feed pressure, the motion stops and breakage of the drill is avoided, while in the case of electric hand drills their windings may burn out and the drill itself may be damaged. It is cheaper to operate pneumatic hand drills than electric, notwithstanding that it is necessary to go to considerable expense in providing auxiliary equipment of compressors and air distribution lines. Furthermore, pneumatic hand drills are safer to use than electric drills.

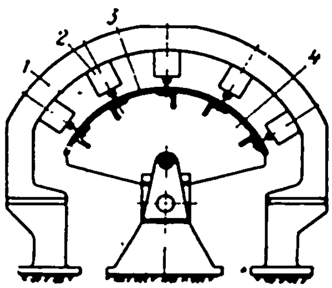

Fig.51 - Schematic Diagram of a Stand for Assembling, Drilling, and Riveting Panels

1 - Base; 2 - Drill head; 3 - Panel being worked; 4 - Rocking cradle bed

According to the construction of the power drive mechanism, pneumatic hand drills are of two types: rotary and reciprocating.

Drills with rotary motors have the following main advantages over piston-type motors;

1. The power of rotary motors per unit weight is considerably greater than that of piston types. For this reason, for the same power output, the weight of rotary motors is considerably less as compared with piston types.

2. The absence of slide valve mechanisms, crankshafts, and connecting rods in rotary motors simplifies their construction as compared with piston-type motors, thus facilitating their manufacture and lowering the cost.

3. The operation of rotary motors is much quieter, due to the absence of recip-

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rocating parts, and the mass of the moving parts is well balanced. This is of considerable importance in connection with the drilling and countersinking of holes which make rigid requirements as to accuracy of the diameter and quality of the surface of the parts worked.

A drawback of rotary motors is that their efficiency is somewhat lower than that of piston motors, which results in a high consumption of compressed air. However, the design and construction of rotary motors is being constantly improved, so that the better grades of such motors have an efficiency almost approaching that of piston-type motors.

Outside of the condition mentioned, in the selection of a particular type of a pneumatic drill, it is advisable to give preference to the rotary motor type.

Table 7 gives the technical characteristics of pneumatic hand drills in general use, in connection with the drilling of light-alloy structural elements.

In drilling holes in parts of aluminum and magnesium alloys and also of mild steel, drills operated at speeds up to 3500 rpm are used. For drilling in parts of alloy steel (such as edges of longerons, tie components, etc.), use is made of slow-speed drills at a speed up to 1000 rpm. Pneumatic drills, whose rpm exceeds 3500 and approaches 13,000, are used only in drilling preliminary holes of a smaller diameter than specified in parts made of mild steel and duralumin.

Figure 52 shows the construction of the pneumatic hand drill type D-2 for drilling holes up to 8 mm in diameter, in parts made of aluminum and magnesium alloys.

The hand drill D-2 has a pistol-type grip with a starting mechanism, and consists of a motor, reduction gear, and three-jawed chuck. The air hose is connected to the male coupling (1) for the supply of compressed air from the system. When pressure is applied to the lever of the cock (3), the air by-passes the check valve (2) and is admitted to the motor through the channel (4) in the grip handle.

The motor in the hand drill D-2 is of the rotary type and consists of rotor (6) to which movable vanes (7) are mounted. The rotor, together with the vanes, is STAT

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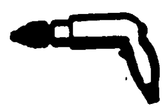
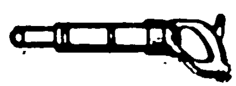
Table 7

Technical Characteristics of Pneumatic Drills

a)	b)	c)	d)	e)	f)	g)	h)	i)	j)	k)
D-1				125×125	5	3500	0.20	5	0.3	0.8
D-10	l		m	200×170	6	13000	0.20	5	0.5	1.6
D-2				235×140	8	2500	0.25	5	0.4	2.0
SD-8				250×140	8	2000	0.15	5	0.6	1.8
DZ-1200				390×150	15	1200	0.75	5	0.75	3.5

a) Type of hand drill; b) Job application; c) Sketch; d) Purpose; e) Dimensions of part worked; f) Maximum diameter of drill, in mm; g) Revolutions per minute; h) Power, in hp; i) Pressure of compressed air in atmospheres; j) Air consumption in m^3/min; k) Weight in kg; l) In open places; m) For drilling soft steel and nonferrous alloys; n) For drilling alloy steel; o) In crowded places; p) In places of limited access

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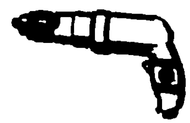
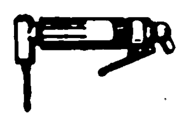
Table 7 (continued)

DZ-450	l		n	390×150	15	450	0.75	5	0.75	3.6
D-11				240×170	10	1000	0.25	5	0.5	2.0
SDT-10				220×130	10	850	0.15	5	0.6	2.5
SDA-8	o		m	230×50	8	2100	0.15	5	0.6	1.4
SDU-8	p			205×100	8	2100	0.15	5	0.6	1.5
UD-2				200×62	10	2000	0.3	5	0.5	1.6
D2-U				240×110	8	2300	0.25	5	0.4	1.5

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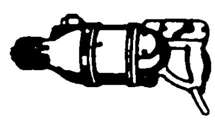
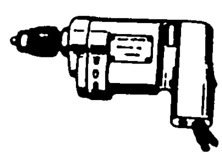
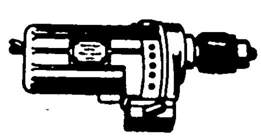
cated in the stationary part of the motor, the stator (10), on ball bearings. The rotor is in an eccentric position with respect to the stator, forming thus a crescent-shaped chamber (8). From the channel (9), compressed air enters the chamber (8) between the rotor and stator and exerts a pressure on the vane (7), forcing the rotor to rotate. As the motor revolves, the compressed air travels along the chamber (8) to the exhaust ports (5), through which it is exhausted into the atmosphere.

Table 8

Types of Electric Hand Drills and Their Characteristics

a)	b)	c)	d)	e)	f)
FD-5		15	1200	220 or 120	4,9
FD-8		8	2200	220 or 120	2,8
FD-9		6	3600	220 or 120	1,5

a) Type of hand drill; b) Sketch; c) Maximum diameter of hole, in mm; d) Number of revolutions per minute in idle running, in rpm; e) Current voltage, in volts; f) Weight in kg

At an air pressure of 5 atm and higher the motor starts up readily. At some-

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what lower pressures, the drill can be started only by depressing the lever of the cock to admit air and manually turn the motor by means of the chuck, after which the motor quickly reaches its speed.

At normal pressure of the compressed air in the system (5 atm), the rotor of the drill develops 12,000 rpm, which is reduced to 2500 rpm by means of the reduction gear (11).

In many cases, in place of, or in addition to pneumatic hand drills, electric hand drills are employed. The technical characteristics of electric hand drills are given in Table 8.

An important characteristic of electric hand drills is that they may be used on jobs and in places where compressed air installations are not available, due to the lack of air compressor and related equipment.

Figure 53 shows the construction of the electric hand drill FD-8. The hand drill is equipped with a universal motor that has a commutator, which may be operated on either alternating or direct current as available in the power line. The body of the hand drill consists of three main parts: the upper cover (7), body part (5), and the lower part (4). Two electromagnetic poles are pressed in the body. The armature of the motor revolves on two ball bearings. The rotary motion is transmitted from the armature shaft to the drill, which is held in a chuck, through the reduction gear (2) which consists of two gears. The spindle (3) also revolves in two ball bearings. For the purpose of cooling the windings of the motor, a blower is mounted on the motor shaft which sucks in air through the ports in the body of the drill.

Electric current is supplied to the motor through the rubber-insulated three-wire cable (8). Two of the wires are live, carrying current to the motor, while the third is for grounding the drill while in operation.

The choice of the kind of drill used depends on the diameter of the hole, the nature of the material being worked, and the accessibility of the work.

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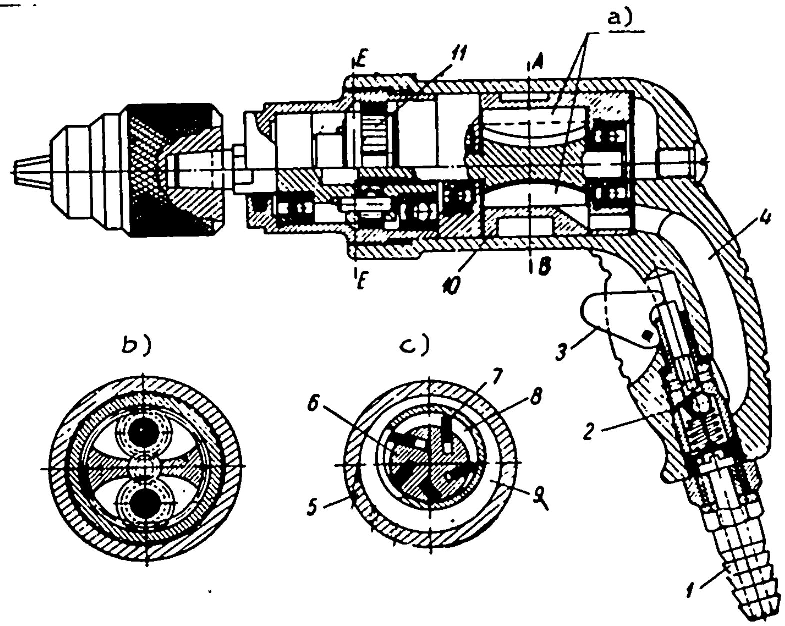

Fig.52 - Pneumatic Hand Drill of Type D-2

a) Vanes are shown in their normal position; b) Cross-section through EE; c) Cross-section through AB

1 - Air plug; 2 - Valve; 3 - Valve lever handle; 4 - Drill handle; 5 - Exhaust openings; 6 - Rotor; 7 - Vanes; 8 - Air chamber; 9 - Air channels; 10 - Stator; 11 - Gear reducer

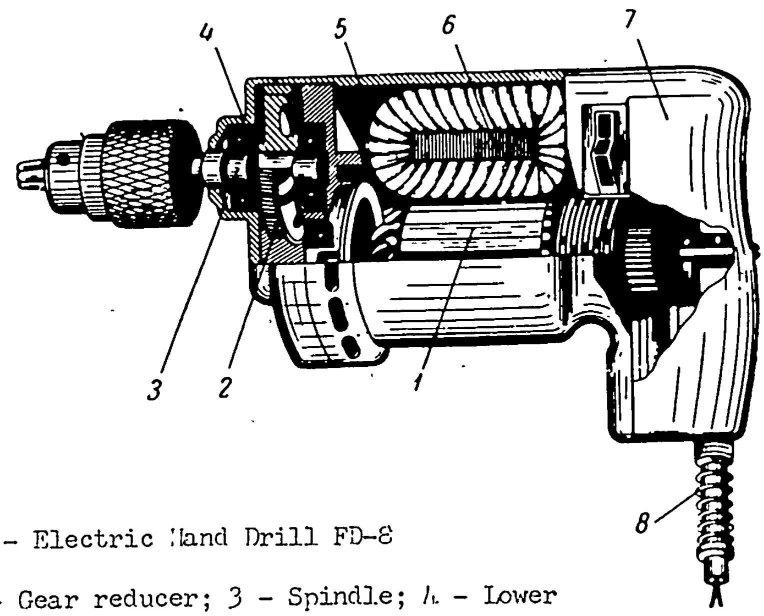

Fig.53 - Electric Hand Drill FD-8

1 - Armature; 2 - Gear reducer; 3 - Spindle; 4 - Lower cap; 5 - Body; 6 - Electromagnetic poles; 7 - Top cover; 8 - 3-wire electric cable

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The range of work that may be done with electric hand drills can be increased considerably by using specialized tools and fittings in the form of extension couplings, angular fittings, and jig bushings which are attached to the body of the hand

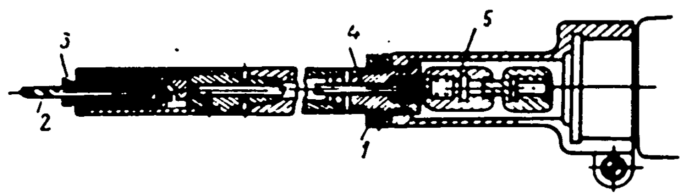

Fig.54 - Extension Fitting of Type SNP-4, Attached to Hand Drill

1 - Lock nut; 2 - Drill; 3 - Bushing; 4 - Shaft; 5 - Clutch

drill. Extension and angular types of fittings are used for drilling holes in places which cannot be reached with ordinary pneumatic or electric hand drills, such as when far-removed or obstructed holes.

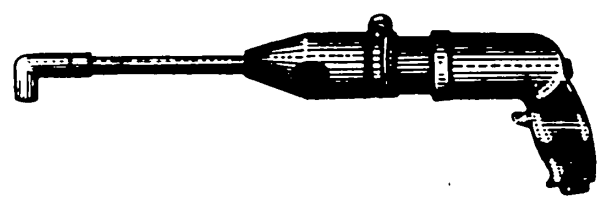

Fig.55 - Angular Type Extension Fitting, SNU-5, Attached to Hand Drill

Figure 54 shows an extension fitting of the type SNP-4, attached to the hand drill. The body of the fitting is rigidly attached to the front part of the hand drill. A coupling is screwed on the spindle. The rotation of the spindle is transmitted to the shaft (4) over the coupling (5). The end of the extended shaft carries the bushing (3), which corresponds to the diameter of the drill used.

For drilling holes in places located close to vertical obstructions, fittings of the angular extension type are used with the drill. Figure 55 shows an angular extension fitting of the type SNU-5 for drilling holes at a corner angle of 90°.

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Fittings of the type SNU-5 are also available for drilling at angles of 45°. The design of angular fittings is similar to that of the extension type, with the only difference that the rotation of the drill point at an angle is transmitted from the shaft over a pair of conical gears or over a universal joint.

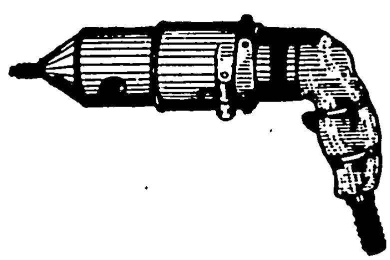

Fig.56 - Guiding Device of Type KN-1, Attached on Hand Drill

For drilling duralumin, and using simplified patterns made from thin sheet steel which are not provided with inserted guide bushings, use is made of guide bushings attached to the body of the drill tool. One of such attachments of the type KN-1 is shown in Figs.56 and 57. The housing of this device (5) is put on the cylindrical part of the hand drill, and has an adapter (4) at its lower end, in which the cylinder (3) is held. Inside this cylinder is the guide bushing (2), held in its extended position by the coiled spring (1), so that the drill point is flush with the bushing. During the drilling operation the guide bushing must be inserted in the holes of the pattern or template, making sure that the position of the drill is in the correct position with respect to the surface being drilled; then, the power is turned on, and drilling is started by applying pressure on the tool. This compresses the spring, causing the drill point to go through the guide bushing and properly drilling the hole.

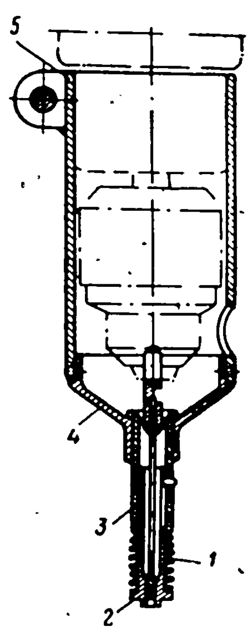

Fig.57 - Construction of the Guide Device

1 - Spring; 2 - Guide bushing; 3 - Cylinder; 4 - Adapter; 5 - Housing

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5. Operation of Drill Presses and Hand Drills

The accuracy with which holes are drilled for riveting has an effective influence on the quality of the work done on the joined seam as a whole. The following basic factors influence the quality of drill work:

1) Quality of grinding of the drill point;

2) Pressure exerted in the drill feed;

3) Diameter and length of the drill;

4) Wobble of the spindle of the drilling tool;

5) Wobble of the chuck;

6) Wobble of the drill in the chuck;

7) Available facilities and skill of the drillers.

The center line of drilled holes must be perpendicular to the plane of the part worked. To meet this requirement in stacked parts which have a total thickness of more than 3 mm, special attachments are used on the hand drill (Fig.58).

The attachment device consists of the body (2) which is fitted to the cylindrical portion of the hand drill and made fast with the screw (1). The support bushing (5) is fitted to the body of the device and is held in its normal position by the tension of the spring (3). Rubber strips (6) are cemented to the legs of the bushing in order to protect the surface of the parts drilled. When force is applied to the drill tool, the spring is compressed and the body of the device slides over the guide bushing with the result that the drill point comes in contact with the surface of the part worked and the hole is drilled.

The procedure in drilling holes with a similar attachment is illustrated in Fig.59.

The operation of pneumatic and electric hand drills requires much attention and skill. Before starting the work, the parts to be drilled must be checked for proper fastening. The part being drilled must be held tight in the assembly fixture or on the bench. Then the drill is inserted in the chuck up to about 3/4 of the shank

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length, and is tightened by means of a wrench (Fig.60). To verify how well the drill is held in the chuck, it is tested for wobble at slow speeds by locking and unlocking the drill in the chuck several times. The causes of wobble and remedies are shown in Table 9.

Table 9

Causes of Drill Wobble and Remedies

Cause of wobble	Means of eliminating wobble
Drill is crooked	Change the drill
Burrs and nicks on the shank of the drill	Change the drill
Worn out jaws in chuck	Change the chuck
Spindle of drill is tapered (causing the chuck to wobble)	Replace hand drill
Improper position of drill in the chuck	Loosen the jaws in the chuck, turn the drill, and lock it again in place

Having checked and eliminated drill wobbling, the power is turned on, and the drill is aligned at right angles to the surface of the part worked. At the start of drilling, the operator places his left hand on the body of the hand drill as a support and bends the index finger of this hand around the drill. The drill point is thus properly directed to the center of the hole, which also helps in determining the required depth of the hole (Fig.61).

When holes are drilled in thin sheet plankings, a wooden support must be placed at the outlet side of the drill, which protects the sheet from sagging and buckling; while at the same time protecting the hands of the driller's helper from inju STAT the drill point.

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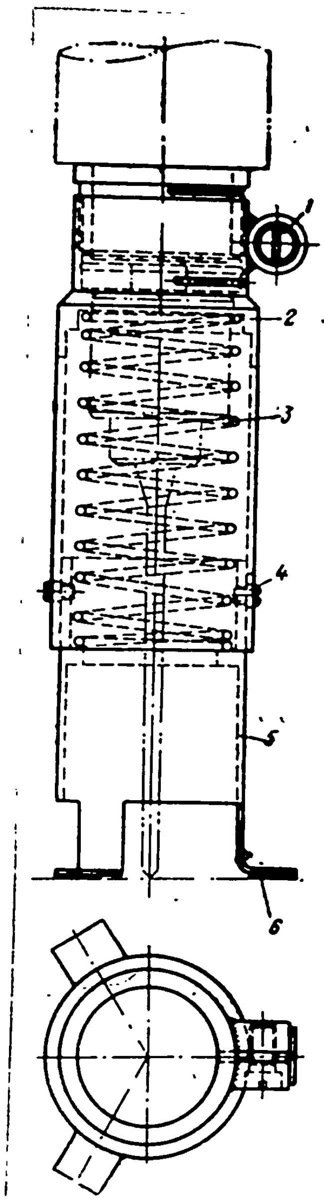

Fig.58 - Attachment on Hand Drill to Ensure Perpendicularity of the Holes

1,4 - Screws; 2 - Body; 3 - Spring; 5 - Support bushing; 6 - Rubber Strip

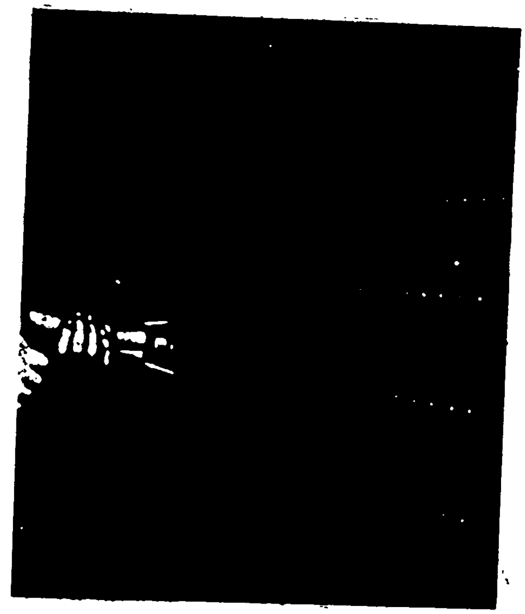

Fig.59 - Drilling Holes with an Attachment Device to Ensure Perpendicularity to the Surface of the Part Drilled

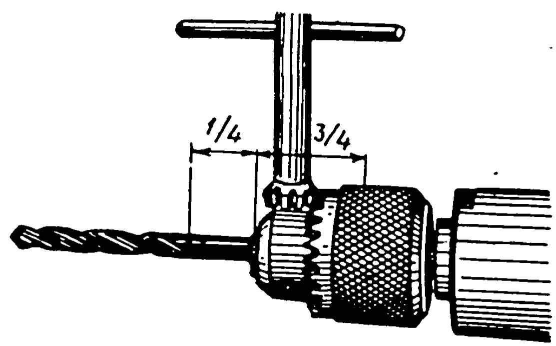

Fig.60 - Tightening of the Drill in the Chuck

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When drill presses are used, it is advisable to start up the press before inserting the part to be drilled. Setting the drill point on the workpiece must be done carefully, without abrupt jerks or sudden impact, to prevent chipping of the drill point which would ruin the surface finish of the material. When the hole is about finished, it is advisable to reduce the feed. If the feed is not reduced, the drill has a tendency to grip a chip of sufficient size to develop burrs in the metal, and in some cases also to cause breakage of the drill.

When drilling deep holes it is advisable from time to time to remove the drill from the hole, without stopping either the drill press or the hand drill, the object being to remove the accumulated chips. Stopping the drill press or the hand drill while the drill point is still in the hole causes seizing of the drill in the workpiece and breakage of the drill.

Fig.61 - Position of the Hand While Drilling

When drilling deep holes in steel parts a cooling fluid must be used, which serves at the same time as a lubricant and a rust preventive. Table 10 gives suggestions for cooling and lubricating fluids for use in drilling steel, cast iron, and bronze.

Table 10

Coolants and Lubricants Used in Drilling

Materials Drilled	Recommended Fluid
Carbon steel, alloy steel, tool steel, and cast steel	Emulsion
Cast iron, bronze	Kerosene; mixture of borax and water with glycerol

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In drilling holes into stacks consisting of a combination of steel and duralumin

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the drilling should be started from the side of the steel part. In cases when the hole in one part has to serve as a guide for the hole in the other part, the guide

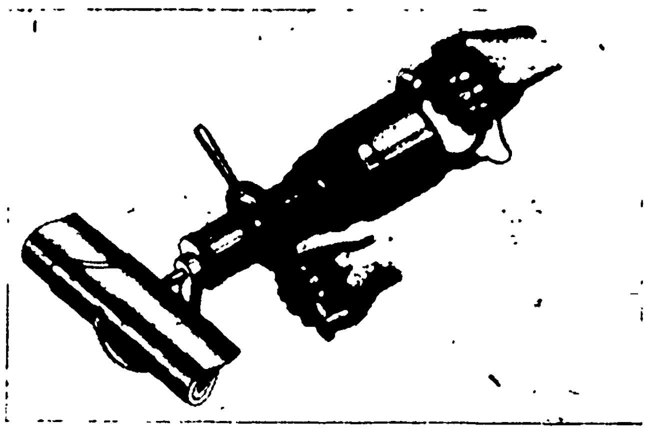

Fig.62 - Drilling Holes in Steel Tubes with a Pneumatic Hand Drill Equipped with a Mechanical Feed of the Drill Point

holes should be drilled in the part made of the tougher material. If the material of both parts is the same, the guide holes should be drilled in the part with the greatest thickness.

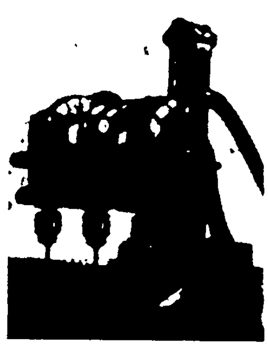

Fig.63 - Device for Using Three Drills Simultaneously for Drilling Holes in Components and Panels of Great Length

For drilling holes of comparatively large diameter (up to 32 mm) in steel parts, heavy-duty hand drills are used which are equipped with a mechanical feed mechanism, an example of which is shown in Fig.62. The pneumatic hand drill shown, designed by N.F.Yegorov, has a power rating of 1.4 hp, weighs 4.6 kg, and permits a spindle speed adjustment in the range of 600 to 180 rpm, which is quite important when drilling in metals of various degrees of STAT-ness. The availability of a mechanical feed

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permits shifting the drill smoothly and evenly from one place to another and removing the drill from the workpiece quickly after the hole is drilled. The clamp which serves as a support for the hand drill and to absorb the thrust of the mechanical feed, also absorbs the torsional moment which always develops on the spindle when a drill tool is in operation, since the body of the hand tool is clamped to the part drilled.

The rate of production in the assembly sections of a plant can be increased

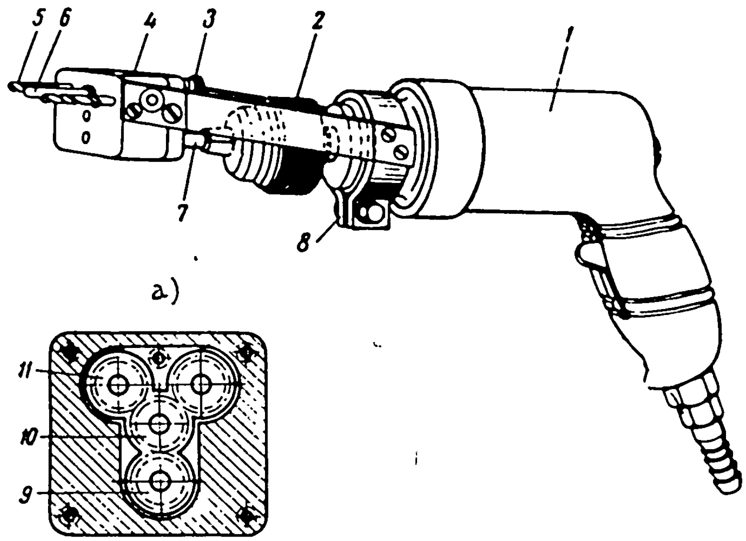

Fig.64 - A Two-Spindle Attachment

a) View of the reduction gear, with cover plate removed

1 - Pneumatic hand drill; 2 - Chuck; 3 - Oil cup; 4 - Body of attachment; 5 - Drill point; 6 - Holding pin; 7 - Driven shaft; 8 - Collar; 9 - Drive gear; 10 - Intermediate idling gear; 11 - Working gears

considerably by using mechanical contrivances to allow simultaneous use of several hand drills.

Figure 63 shows a device for the installation of three hand drills, for us STAT drilling holes into longerons and panels of large length. When combined with means

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of support and with provisions for shifting the drills from one place to another, the use of such a device results in a considerable increase of production and more efficient utilization of labor. All three drills are started at the same time by opening a valve connected with the compressed-air main line. A foot paddle is provided for feeding the drill points into the workpiece.

Another means of increasing labor output when working with hand drills is to use multispindle attachments fastened to the body of the hand drill.

The attachment shown in Fig.64 is used for simultaneous drilling of two rivet holes and for holding parts together during assembly by means of bolts and wing nuts. This attachment is mounted to the body of the hand drill (1) by means of the collar (8) and the driven shaft (7) which is locked in the chuck (2) of the hand drill. The gear (9) is attached to the shaft (7), and rotation is transmitted to the working gears (11) over the intermediate gear (10). Lubrication of the gears is effected through oil cups (3). The adoption of this attachment facilitates putting the wing nuts on the bolts, as well as slipping the nuts over the extension pin (6).

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CHAPTER V

FORMATION OF RECESSES UNDER THE HEADS OF FLUSH RIVETS

1. Means for Forming Recesses

The formation of recesses under the heads of rivets for flush riveting is done by countersinking and dimpling.

Countersinking is done when the thickness δ_1 of the exterior part, such as the skin, is equal or more than the height h of the inserted head of the rivet (Fig.65a). If, however, the thickness δ_1 of the planking is less than the height h of the inserted rivet head, and the total thickness of the stack of joined pieces S is not greater than the diameter of the rivet, dimpling is used (Fig.65b).

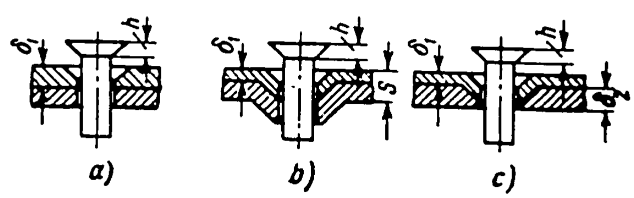

Fig.65 - Methods of Forming Recesses

a - Countersinking; b - Dimpling; c - Countersinking and dimpling

Countersinking of the inner part, such as the airframe, and stamping of the outer part, such as the skin or planking, is done whenever the thickness δ_2 of the airframe does not permit a dimpling operation and when the thickness δ_1 of the planking is less than the height of the head of the inserted rivet (Fig.65c). STAT

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2. Countersinking

The quality of the work in flush-riveting depends basically on the geometric correspondence of the contour of the rivet head with the contour of the recess. Consequently, the operation of countersinking is one of the most important processes in the art of flush-riveting. The accuracy with which this is done influences the degree of smoothness of the surfaces and the strength of the flush-riveted joint.

The quality of countersinking work depends basically on the following factors:

1. Design and geometry of the cutting edge of the countersink;
2. Design of the countersink attachment;
3. Wobble of the countersink and the pilot pin;
4. Dimensions of the drilled hole;
5. Skill of the operator.

Countersinking is done by two methods: simultaneously with or independently of drilling.

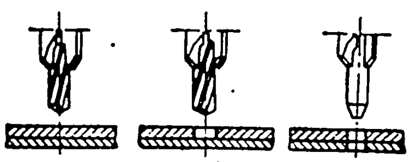

Fig.66 - Methods of Countersinking
a - Countersinking done simultaneously with drilling on layout; b - Countersinking done simultaneously with drilling through guide holes; c - Countersinking of a pre-drilled hole with a pilot point

Countersinking while drilling may be done by laying-out with a pencil, by laying-out and center-punching, and by using guide holes (Fig.66). Drilling and countersinking in the same operation, according to guide holes, result in a considerable reduction of labor, in an increase in production, and in an improvement in the quality of the work done.

Countersinking Tools and Attachments. Tools with pilot stems are used for countersinking holes which have been previously drilled (Fig.67a). Such tools may be an integral combination of drill and countersink or a countersink attachment on the drill. The use of a countersink attachment on the drill (Fig.67b) appears to be more rational than

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the use of a combination drill and countersink tool, since in the first instance, if the drill breaks, which is usually more frequent than breakage of the countersink, the drill may be changed and the work continued with the same countersink.

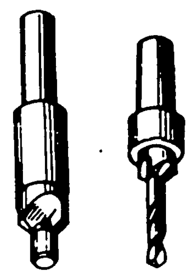

Fig.67 - Shapes of Countersinks

a - Countersink with a pilot stem;

b - Drill with countersink attachment

In selecting a countersink, the dimensions and type of rivets used on any one job should be taken into consideration, along with the material of the part on which work is done. Countersinking tools must have a diameter somewhat larger than the diameter of the rivet heads.

Countersinks with three cutting edges are used for making recesses in duralumin and in steel, while countersinks with only two cutting edges are used for parts made of magnesium alloys.

The cutting edges of the countersinks must be ground to a sharp edge and the grooves must be polished. When working with dull cutting edges the surface of the recess becomes filled with metal filings, while the cut chips of metal adhere to the working surfaces of the countersink, thus interfering with proper performance of the operation. Grinding of the cutting edge of countersinks is done in centralized workshops.

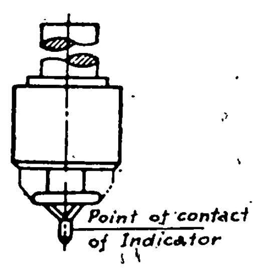

Fig.68 - Schematic Diagram for Checking a Countersink with a Wobble Indicator

Wobbling of the working part of the countersink should not exceed 0.02–0.03 mm to prevent wrong dimensioning of the diameter of the recess.

The amount of wobble in a countersink is determined by an indicating device, the tip of which is brought in contact with the surface of the driven shaft of

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countersink (Fig.68).

Adjustable attachments on the body of pneumatic hand drills or on countersinking and drilling presses are used for determining the correct depth of the recess to match the shape of the specified rivet head.

Countersinking attachments must meet the following basic requirements:

1) The wobble of the countersink, when installed in the attachment device, must not exceed 0.02-0.03 mm;

2) The attachments must be provided with adjustable supports for regulating the depth of the recesses with an accuracy up to ± 0.02 mm;

3) The attachments must have an accessory mechanism for the disposal of chips while it is in operation, and the thrust support which comes in contact with the work must not damage the surface of the part worked;

4) The attachments should be of relatively small size and weight;

5) The thrust support should be of such construction that it will not obstruct the visual range of the recess;

6) After the attachment is installed and adjusted for the depth of the recess, it must be able to make a recess that will be properly filled by the rivet head;

7) The body of the attachment must be permanently and tightly attached either to the body of the hand drill or the countersinking and drilling press.

Various types of countersink attachments are used for riveting of light alloy structures, and these may be grouped as follows according to their design and application:

a) Attachments fastened on hand drills or drill and countersink presses provided with chip-discharge means;

b) Attachments fastened to the body of hand drills and presses without a blower for chip discharge;

c) Attachments fastened to the chuck of the hand drill or press;

d) Attachments fastened to the spindle or shank of the drill in hand drills

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or drill and countersink presses.

The type ZN-2 attachment (Fig.69) ensure accuracy of depth of the recess to ±0.03 mm. The body of the attachment (1) is slipped over the cylindrical part of the hand drill D-2, and the spindle of the attachment thus becomes fitted to the spindle of the hand drill. Rotation of the countersink (6) is transmitted from the drive shaft (4) over the tapered bushing (7). The depth of the recess is limited by the thrust support (5), which is shown together with the spring (9) in the extended position. The adjustment for the specified depth of countersinking is effected by the sleeve (3), which is regulated and held in place by the screw (10). After adjusting for the required depth setting, the ring (2) is fitted and permanently sealed in position with the seal (13).

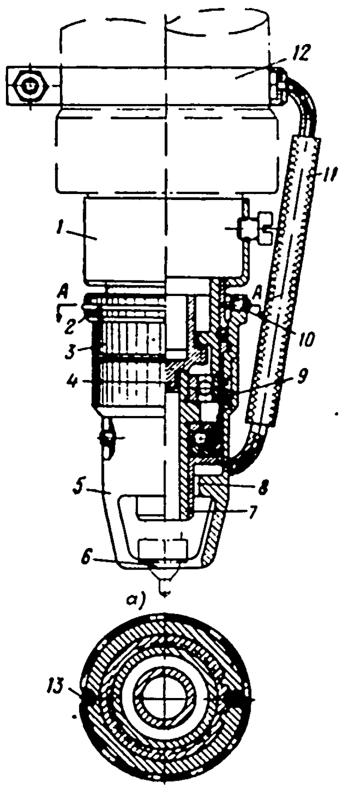

Fig.69 - Countersink Attachment of Type ZN-2

a) Cross-section through AA

1 - Body; 2 - Ring; 3 - Bushing; 4)- Drive shaft; 5 - Thrust support; 6 - Countersink; 7 - Bushing; 8 - Grooves; 9 - Spring; 10 - Screw; 11 - Tubing; 12 - Hollow collar; 13 - Seal

The surface of the thrust support is chromium-plated and polished in order to protect the surfaces of the parts being countersunk from damage. A hollow collar (12), together with rubber tubing and packing is provided for the removal of the chips formed in the countersinking operation. In operation of the hand drill, the exhausted air from the blower in the drill goes from the exhaust ports into the hollow collar (12), into the tubing (11), from which the air current is directed to the space between

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the body of the attachment and the thrust, and thence through the grooves (8) into the hole being countersunk, thus blowing away the chips.

The loose coupling of the drive eliminates the possibility of transmitting any wobble of the hand drill spindle to the countersink.

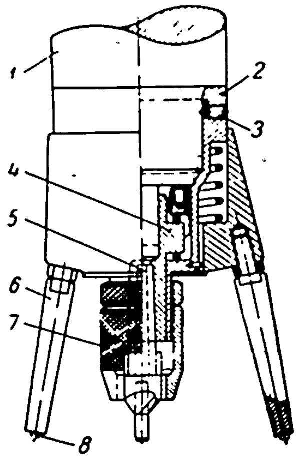

Fig.70 - Countersinking Attachment of Type ZN-1

1 - Pneumatic hand drill; 2 - Body of attachment; 3 - Screw for mounting the attachment to the hand drill; 4 - Spindle; 5 - Interchangeable countersink; 6 - Tripod; 7 - Adjustable prop; 8 - Ball rest of fabric laminate to prevent damage to the surface of the workpiece

Figure 70 shows a countersinking attachment of the type ZN-1. The body of the attachment (2) is fitted to the hand drill, while the spindle (4) is mounted to the tapered spindle of the hand drill. The threaded end of the body carries the thrust support (7) with its locknut, for adjusting the depth of the recess. The body is slipped into a tripod (6), with the three equidistant screwed-in legs at the same distance from the center.

The tripod is used for aligning the hand drill with the attachment perpendicularly to the surface of the part, Bakelite or similar laminated balls (8) are fitted into the ends of the legs to prevent damage to the plated surface. The attachment is supported on the tripod by means of a spring, shown in its extended position.

The use of this attachment has certain drawbacks. The countersink is rigidly connected with the spindle of the hand drill over the reducing bushing and thus is subject to any wobble of the drill spindle. Also the absence of an air blower in this device causes the chips to fall in the space between

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the panels being dimpled. An obvious advantage of this device is its simplicity of design and its correct position with respect to the outer surface of the lining or other part being worked.

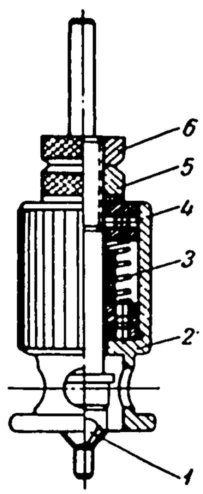

Fig.71 - Countersinking Attachment Inserted in the Chuck of a Hand Drill or Drill
1 - Countersink with pilot stem; 2 - Bushing; 3 - Spring; 4 - Thrust ball bearings; 5 - Support nut; 6 - Lock nut

Figure 71 shows an attachment mounted to the chuck of a hand drill or of a drill and countersinking press. It consists of the countersink (1) with a pilot stem. The bushing (2) is fitted to the countersink over the thrust ball bearing (4). The spring (3) is within the bushing (2). The lock nut (6) is used for fixing the countersink in its adjusted position. Regulation of the depth of the recess is obtained by screwing in the countersink or screwing out the support nut (5).

Countersinking with the aid of this attachment is performed in the following manner: After adjusting the device for the specified depth of the recess, the shank of the countersink is inserted in the hand-drill chuck, and the power is turned on. The hand drill is held in the right hand while the bushing is held in the left hand with which the pilot stem of the countersink is inserted into the drilled hole. As pressure is applied on the hand drill the hole is countersunk to specifications.

This attachment is simple in construction but, at the same time, is not a sensitive device; for this reason, its use is limited to countersinking in parts for which a high degree of surface smoothness is not required. Since this attachment is inserted directly into the chuck of the hand drill or drill press, it is obvious that any wobble will be transmitted to the countersink. The body of the attachment

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must be held by hand while in operation to prevent the support from scratching the surface of the part worked. The advantage of this device is its light weight and small size, which facilitates the work.

Figure 72 shows an attachment mounted directly to the spindle of a hand drill or a drill-countersink press (countersink chuck). This device permits an accuracy of ±0.04 mm, and its small size and weight contribute to better utilization of labor.

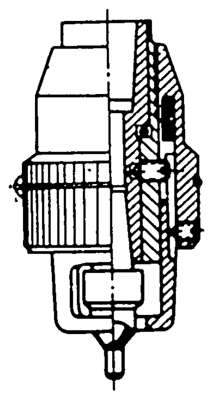

Fig.72 - Countersinking Attachment Mounted Directly to the Spindle of Hand Drills or Drill Presses (Countersinking Chuck)

Of all described countersinking attachments used for flush-riveting work, preference should be given to the types ZN-2 and ZN-1, which give greater accuracy of work. These attachments are for use in places where a high degree of smoothness of the riveted joint is necessary (wings, center sections, etc.). In spots where the technical specifications do not require a high degree of smoothness, it is rational to use the attachments shown in Figs.71 and 72.

As already stated, before countersinking is started, the attachments used should be adjusted for the specified depth of the recess and fixed in that position to prevent misalignment.

The adjusting of the attachments is done by mounting on a test rig with calibrated recesses, and is further checked by countersinking not less than five holes in specimens which must be the same as the material of the parts to be countersunk.

The mounting on the test rig is carried out in the following sequence (cf. Fig.73):

1) Place the support of the attachment so that the countersink fits the calibrated recesses, which are of dimensions corresponding to the minimum dimensions of the heads of the rivets to be used (Fig.73a);

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2) Countersink not less than five recesses in specimens (Fig.73b);

3) Measure the depth of the recess with a calibrated rivet and an indicating instrument. (Complete data on the dimensions of calibrated rivets are given in Table 11).

In case inaccuracies of the setting are revealed, the necessary corrections in the setup are made, followed by repeat countersinking tests and measurements of the recess dimensions. The setting of a countersinking attachment is considered correct only if, after inserting the calibrated rivets into the recessed holes, the rivet heads protrude by not more than the minimum height permitted by the design specifications for the finished structure.

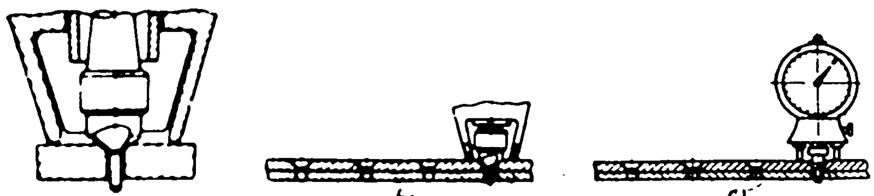

Fig.73 - Sequence for Adjusting and Checking Countersinking Attachments
a - Position of support in a calibrated recess; b - Sample of countersinking of not less than five holes; c - Checking the depth of the recess

When the countersinking attachments are fully tested, they must be sealed with lead seals. Only sealed attachments may be issued to the workmen.

It is forbidden to work with attachments with broken seals (since this indicates tampering with the setting) which may lead to imperfect countersinking (that is, excess or inadequate countersinking of the recesses).

Depth of Countersinking. The depth of the recesses greatly influences the surface quality of the work done in flush-riveting of joints. Insufficient countersinking leads to protrusion of the rivet heads, while excessive countersinking results in a depression of the rivet heads below the surface. Investigations have

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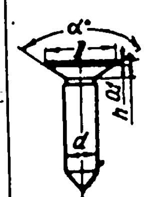
Table 11

Dimensions of Calibrated Rivets in mm

a)	α° b)	90° ± 1° d c)	90° ± 1° d d)	90° ± 1° D c)	90° ± 1° D d)	90° ± 1° h c)	90° ± 1° h d)	120° ± 1° d c)	120° ± 1° d d)	120° ± 1° D c)	120° ± 1° D d)	120° ± 1° h c)	120° ± 1° h d)
	2,6	2,6		4,6		1,1		2,6		5,35		0,9	
	3	3		5,2		1,2		3		6,10		1,0	
	3,5	3,5		6,1		1,4		3,5		6,90		1,1	
	4	4		7		1,6		4		7,80		1,2	
	5	5	+0,02	8,8	−0,05	2	−0,01	5	+0,02	9,50	−0,05	1,4	−0,01
	6	6		10,6		2,4		6		11,50		1,7	
	8	8		14,2		3,2		—		—		—	
	9,5	9,5		16,8		3,8		—		—		—	
	10	10		17,7		4		—		—		—	

Notes: 1 – The material for the rivets is a brand of steel of the type U-12-A.

2 – Heat treatment: quenching and annealing R_C = 56-64.

a) Sketch; b) Diameter of rivet; c) Minimum dimension; d) Tolerance; e) Nominal dimension

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shown that these defects are due principally to a variation in fit or the noncoincidence of the rivet heads with the recesses.

The curve slope (Fig.74) indicates that, if the holes are not sufficiently countersunk, i.e., if the height of the rivet head is more than the depth of the recess, then the left part of the experimental curve approaches the theoretical curve. The observed discrepancy between the experimental and theoretical curves is explained by the fact that, after the riveting is completed, the rivet head becomes upset under the pressure, but still protrudes over the surface of the planking.

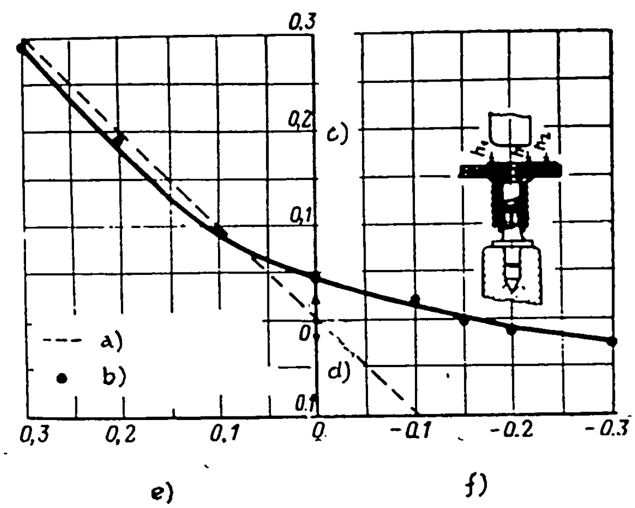

Fig.74 - Correlation of Protrusion of Rivet Heads and Depth of Countersunk Recess
a) Theoretical curve; b) Experimental curve; c) Protrusion of the rivet head, Δh; d) Depression of the rivet head; e) Difference between height of rivet head and depth of countersink recess ($h_1 - h_2$), in mm; f) Difference between depth of recess and height of rivet head ($h_2 - h_1$), in mm

The opposite characteristic of the curve segments occurs when the depth of the recess is greater than the height of the rivet heads, i.e., when the recess is excessively countersunk. In such cases, the experimental curve deviates sharply from

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the theoretical curve. This is explained by the fact that, in the process of riveting, the rivet head abuts the flat surface of the set die so that, after riveting, the top of the rivet head is only slightly below the surface of the planking, while in some cases it is either flush with the surface or protrudes slightly.

In cases where the depth of the recess is significantly greater than the height of the rivet head, (e.g., over 0.1 mm), the rivet head does not fill the recess adequately, leaving a clearance between the surface of the recess and the rivet head (Fig.75). This reduces the strength of the joint when subjected to stresses and lowers the corrosion resistance of the seam.

The strength of flush-riveted joints with various depths of countersunk recesses was investigated on specimens in shear and tensile test with static, vibration, and repeated static loading.

Table 12 and Fig.76 show that, in shear with static loading, the strength of the joint increases as the depth of the recess is increased. This is due to the fact that the cross-sectional area under shear is increased because of the conical shape of the rivet head which penetrates into the mating sheet. Macrographs of the specimens are shown in Fig.75.

Another characteristic of the curve in the graph is shown in that portion of it where the depth of the recess is less than the height of the rivet head, that is, when the countersinking is insufficient. In such cases, since the stem of the rivet is of uniform area in shear, the failure load or the ultimate strength is nearly constant, regardless of the depth of the countersunk recess. This is shown in Table 12.

Tension tests with static loads on specimens, as shown in Table 13 and Fig.77, have demonstrated that as the depth of the recesses is increased, the strength of the joint is lowered. The reduction in the strength of the joint, corresponding to the increase in the depth of the recess, is due to the fact that the area of intimate contact of the conical surface of the rivet with the material of the riveted STAT is

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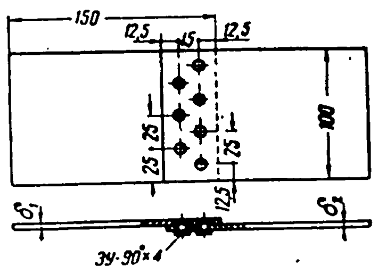
Table 12

Strength of Joints in Shear as a Function of Depth of the Countersunk Recess



a)		b)					
		$\delta_1=1,5$ mm, $\delta_2=2,0$ mm			$\delta_1=\delta_2=2$ mm		
		c)					
		$P_{failure}$ in Kg	τ in Kg/mm²	in %	$P_{failure}$ in Kg	τ in Kg/mm²	in %
d)	0,3	1815	20,6	93	1960	22,3	105,3
	0,2	1815	20,6	93	1937	22,0	104,0
	0,1	1900	21,6	97	1947	22,1	104,6
e)		1958	22,3	100	1860	21,1	100
f)	0,1	1983	22,5	101	1832	20,8	98
	0,15	2010	22,9	103	—	—	—
	0,2	2226	25,3	114	1885	21,4	101
	0,3	2291	26,1	117	1830	20,8	98

τ – ultimate shear strength of rivets

a) Deviation of depth of recess from normal, in mm; b) Characteristics of joint; c) Strength; d) Depth of recess less than normal by; e) Recesses made to normal dimensions; f) Depth of recesses greater than normal by

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less.

It should be noted that seams in which the rivet heads protrude above the surface of the planking are deformed less when subjected to static loads (Fig.76).

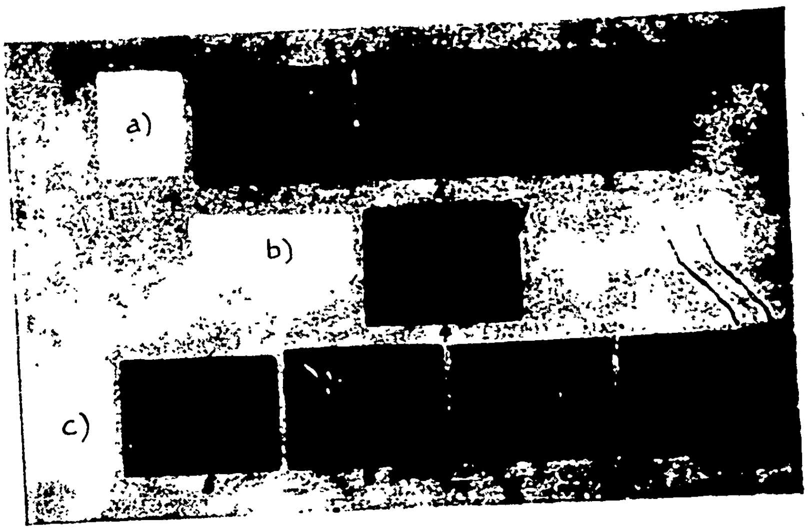

Fig.75 - Macrograph of Specimens Used for Investigating the Effect of Recess Depth on the Quality of Riveted Joints

1 - Depth of recess less than normal dimensions by 0.1 mm

2 - same by 0.2 mm

3 - same by 0.3 mm

4 - Countersunk recess made to normal dimensions

5 - Depth of recess greater than normal dimensions by 0.1 mm

6 - same by 0.15 mm

7 - same by 0.2 mm

8 - same by 0.3 mm

a) Depth of recess less than height of rivet head; b) Depth of recess equal to height of rivet head; c) Depth of recess greater than height of rivet h STAT

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For example, on stressing the seam to a tension of $\sigma^* = 6$ kg/mm^2, the slip which takes place in the parts joined, as a function of the depth of the countersunk recess, is as follows:

a) 1.3% of the diameter of the rivets, in seams where the depth of the recess is less than the height of the rivet heads;

b) 2.1% of the diameter of the rivets, in seams where the depth of the recess is the same as the height of the rivet heads;

c) 4.4% of the diameter of the rivets, in seams where the depth of the recess is greater by 0.2 mm than the height of the rivet heads;

d) 15% of the diameter of the rivets, in seams where the recess is greater by 0.3 mm than the height of the rivet heads.

The results of the vibration tests, as given in Table 14, show that joints in which the countersunk recesses were made smaller than the specified normal dimensions, have a higher fatigue strength under all test conditions. On the other hand, joints in which the recesses were made larger than the required normal dimensions, have a lower fatigue strength under all test conditions. However, where the recesses are either over-countersunk or under-countersunk by 0.1 mm, and also in joints where the depth of the recesses is the same as the height of the rivet heads (since here the recesses were made to the specified dimensions), the fatigue limit remains constant at the value of unit stress $\sigma = 4.7$ kg/mm^2. Compared with the case when the recesses are made to specified dimensions, joints made with over-countersunk recesses by 0.2 mm, have their strength lowered by 4%, while the strength of joints in which the recesses are under-countersunk by 0.2 mm, is higher by 10%.

This may be explained by the fact that the rupture of the plates under vibration loads takes place in the weakened cross section of the specimens along the first

*The tensile stress σ was determined as the ratio of total load applied at the joint to the area F of the entire cross section of the specimen sheets tested.

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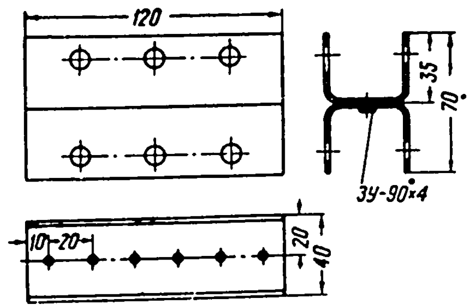
Table 13

Strength of Joints in Tension as a Function of Depth of Countersinking



a)		b)					
		$\delta_1=1,5$ mm, $\delta_2=2,0$ mm			$\delta_1=\delta_2=2$ mm		
		c)					
		d)	e)	in %	d)	e)	in %
f)	0,3	1368	18,2	112	1970	26,1	110,6
	0,2	1330	17,6	109	1900	25,2	106,8
	0,1	1280	17,0	105	1820	24,1	102,1
g)		1223	16,2	100	1780	23,6	100
h)	0,1	1160	15,4	95	1755	23,2	98,3
	0,15	1140	15,1	93	—	—	—
	0,2	1080	14,3	88	1740	21,8	92,3
	0,3	1083	14,3	88	1660	22	93,2

i)

a) Amount of deviation of the depth of the recess from normal, in mm; b) Characteristics of the joint; c) Strength; d) $P_{failure}$ in kg; e) σ in kg/mm^2; f) Depth of recess less than normal by; g) Recesses made to normal dimensions; h) Depth of recess greater than normal by; i) σ = ultimate tensile strength of the riveted joint with the rivets in tension

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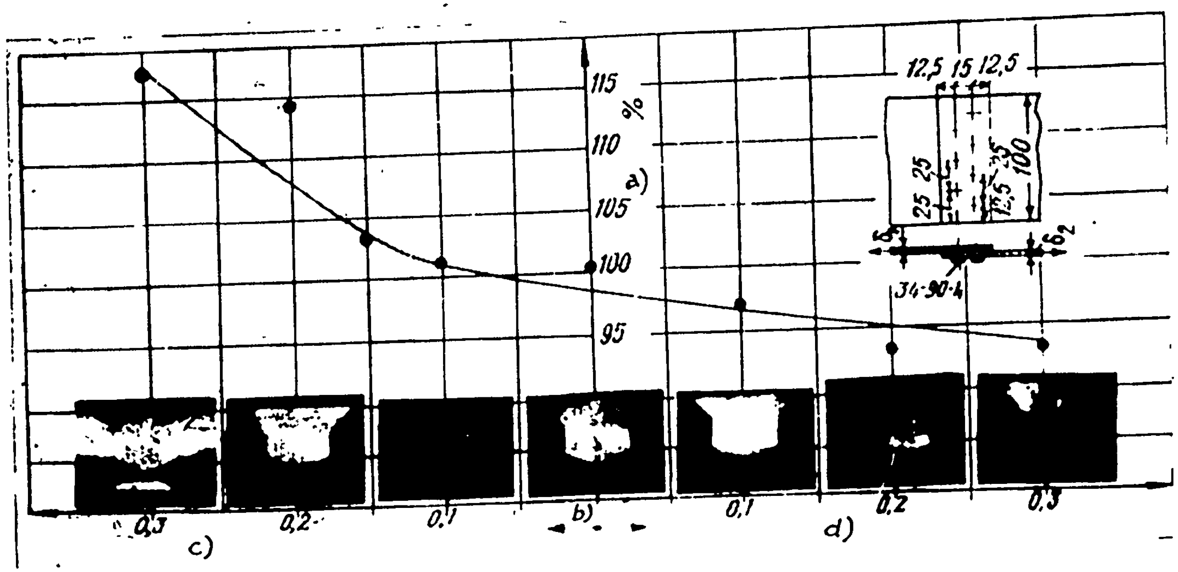

Fig.76 - Effect of Depth of Countersunk Recess on Strength of the Joint. Thickness δ_1 of the Countersunk Plate Less than Height h of the Inserted Rivet Head (The Rivets in the Joint are Subjected to Shearing Action)

a) Strength in %; b) Rating; c) Depth of recess greater than specified normal; d) Depth of recess less than specified normal

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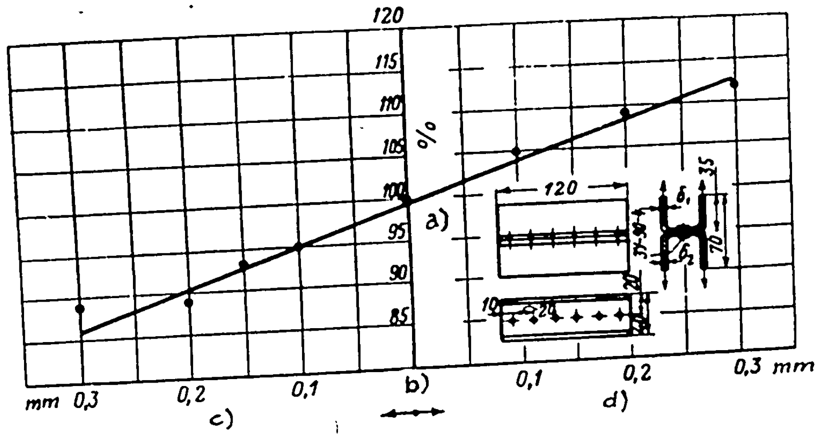

Fig.77 - Effect of Depth of Countersunk Recesses on Strength of the Joint with the Rivets Subjected to Stress in Tension, and with the Height of the Rivet Heads Greater than the Thickness δ of the Upper Plate

a) Strength in %; b) Rating; c) Depth of recess greater than specified normal; d) Depth of recess less than specified normal

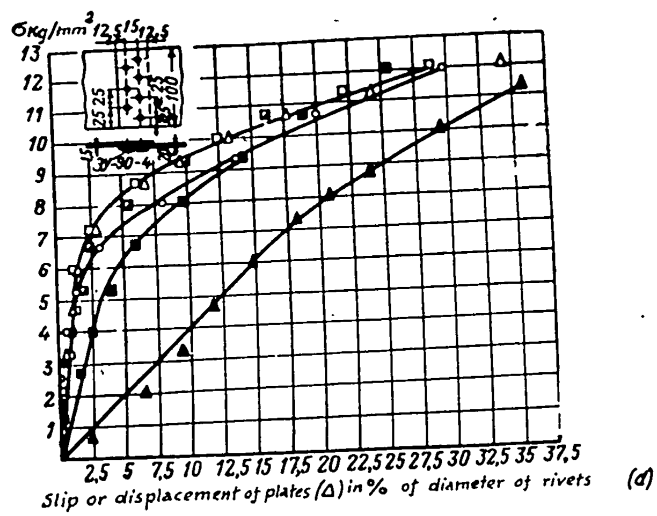

Fig.78 - Deformation of the Joint as a Function of the Depth of the Countersunk Recess Under the Inserted Rivet Heads

- ◘ Recess under inserted rivet head, 0.1 mm below specification
- □ Recess under inserted rivet head, 0.2 mm below specification
- △ Recess under inserted rivet head, 0.3 mm below specification
- o Recess made to specified normal dimensions
- ■ Recess under inserted rivet head, 0.2 mm above specification
- ▲ Recess under inserted rivet head, 0.3 mm above specification

$\sigma = \frac{P}{F}$ (F is the area of the entire cross section of the plate)

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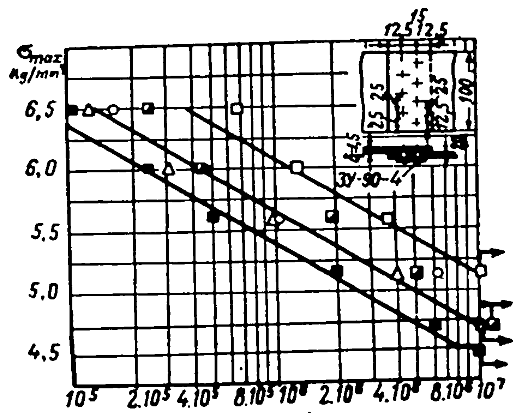
Table 14

Strength of Joints with the Rivets under Shearing Stress

(The tests were carried out under conditions of vibration loading)

Deviation of the depth of recess from specified normal in mm	Depth of recess less than specified normal		Recesses made to normal specified dimensions	Depth of recess greater than specified normal	
	0.2	0.1		0.1	0.2
Fatigue point of the seam as unit stress $\sigma_{\omega\ sh}$, in kg/mm²	5.2	4.7	4.7	4.7	4.5
in %	110	100	100	100	96

Note: The vibration tests were made on the basis of 10^7 cycles.



a)

Fig.79 - Fatigue Strength of the Joint as a Function of the Depth of Countersunk Recess, with the Rivets Subjected to Shear and the Plate to Tension Stresses

- o – Recess made to specified normal dimensions
- ◘ – Recess made less than normal by 0.1 mm
- □ – Recess made less than normal by 0.2 mm
- △ – Recess made greater than normal by 0.1 mm
- ■ – Recess made greater than normal by 0.2 mm

a) Number of cycles. $\sigma = \frac{P}{F}$ (F is the area of the entire cross-section of the plate, in mm²)

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row of rivets, along the line of the three holes in the plate δ_1. Also to the extent that the depth of the recesses is made greater, the area of contact between the rivets and the plate in the first row becomes less, which contributes to the lowering of the fatigue strength of the joint.

Table 15

Strength of Joints on Tests with Rivets in Tension

Deviation of the depth of recess from specified normal in mm	Depth of recess less than specified normal		Recesses made to normal specified dimensions	Depth of recess greater than specified normal	
	0.2	0.1		0.1	0.2
Fatigue point of the seam as unit stress $\sigma_{\omega\ sh}$, in kg/mm²	4.5	4.5	4.5	4.5	4.5
in %	100	100	100	100	100

Note: The tests were made on the basis of 5 to 10^5 vibration cycles.

The indicated results are confirmed by tests with the rivets in tension on vibrational loads (Table 15 and Fig.80). Under the conditions of these tests, the strength of the joint decreases at the higher rates of loading as the depth of the recesses is increased, but the fatigue limit does not change.

In this manner, the tests made in shear and in tension with vibration loads show that a variation in the depth of the recesses, within the limits of ± 0.1 mm, does not affect the fatigue strength of the joint. A deviation from the tolerance given in the direction of over-countersinking (+) leads to a lowering of the strength of riveted joints.

On the basis of the results obtained on the specimens in shear and in tension under repeated static loads, made with various depth of the recesses, Table 16 shows that in the case of testing the specimens in shear, their strength remains STAT

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Table 16

Number of Repetitions of Load on Specimens Tested in Shear and in Tension with Various Depth of Countersunk Recesses

a)		b)	
		c)	d)
		e)	
		$\sigma_{max}=9{,}1$ Kg/mm² $\sigma_{min}=0{,}91$ Kg/mm²	$\sigma_{max}=11{,}3$ Kg/mm² $\sigma_{min}=1{,}13$ Kg/mm²
f	0,2	10117	366
		11872	349
		9580	325
		i) 10529	346
	0,1	9495	431
		9410	285
		9790	331
		i) 9565	349
g)		11330	434
		10892	395
		11189	311
		i) 11137	380
h)	0,1	10220	426
		11700	407
		12700	454
		i) 11542	429
	0,2	14302	524
		15914	438
		11816	515
		i) 14010	492

a) Deviation of the depth of recess from normal dimensions, in mm; b) Kind of test; c) Shear; d) Tension; e) Stress in specimens; f) Depth of recess greater than specified normal dimensions by mm; g) Depth of recess made to normal dimensions; h) Depth of recess less than normal dimensions by; i) Average value

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unchanged, regardless of the depth of the recess. Some increase in strength is observed in specimens in which the inserted flush rivet heads protrude above the surface of the plate.

When subjecting the rivets in a joint to a tensile strain, under repeated static loads, their strength increases to the extent to which the depth of the countersinking of the recesses is reduced.

The following conclusions may be derived from what was stated above:

1. In order to obtain the required degree of surface smoothness and strength in flush-riveted joints, the shape and dimensions of the recesses must correspond to the shape and form of the inserted heads of the rivets used in making the joint.

2. Protrusion of the rivet heads in flush-riveting over the surface of the sheet lining contributes to an increase in strength of the joint under all types of load application (with static, vibration, and cyclic loads).

3. Joints in which the recess underneath the inserted rivet heads has a depth exceeding the specified normal dimensions by 0.1 mm and more, have a lower strength under all types of load. An exception is the case where the thickness of the upper countersunk plate is less than the inserted rivet heads, when tested in shear on static loading.

4. The deformation of joints in which the inserted heads of the flush-type rivets protrude above the surface or are flush with the surface, is considerably less than the deformation which takes place in joints where the inserted rivet heads are depressed relative to the surface of the planking.

For these reasons, it is necessary in the process of countersinking recesses to check systematically the quality of the work and the accuracy of the recesses. In case there is a deviation from the technical instructions and specifications that are in effect governing the countersinking of recesses in any given major unit or component, further work should be discontinued until the defects and causes of the deviation from specifications have been eliminated.

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The material from which it is made and the cleanliness of the surface of the pilot stem of the countersinking tool has a considerable effect on the quality of the countersunk recesses. Proper quality of work and a reduction in the deviation

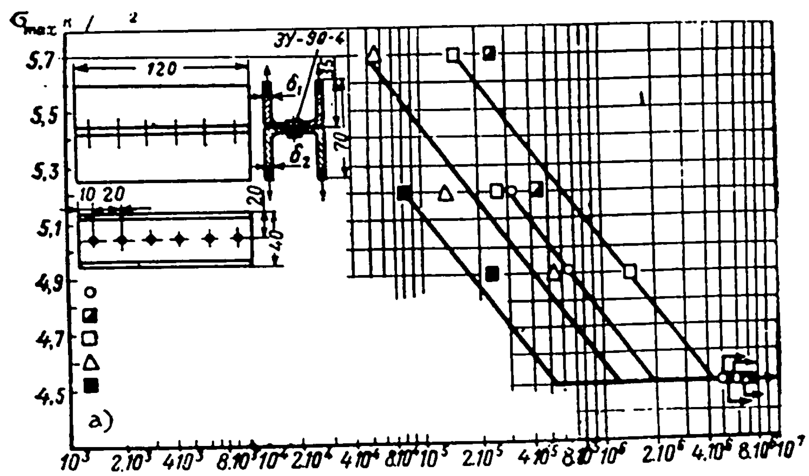

Fig.80 - Fatigue Strength of Joints as a Function of the Depth of Countersunk Recesses (with the Rivets Subjected to Elongation in Tension; Plate Thickness are δ_1 = 1.5 mm, δ_2 = 2.0 mm)

- ○ - Recess made to specified normal
- ◪ - Recess made less than specified normal by 0.1 mm
- □ - Recess made less than specified normal by 0.2 mm
- △ - Recess made greater than specified normal by 0.1 mm
- ■ - Recess made greater than specified normal by 0.2 mm

a) $\sigma_{max} = \frac{P}{nf_3}$ (f_3 is the area of a cross section of the rivet stem in mm^2. n is the number of rivets in the seam).

from correct dimensions is obtained by making the pilot stems from steel tempered at red heat and well polished, and of the same diameter as that of the drill used for the hole.

In countersinking recesses, it often becomes necessary for the workman and the inspector to check the depth of the recess. The checking is usually done by visual

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inspection of the fit of the rivet or by using indicating instruments. In such cases, the inspection of the rivet must be followed by pushing it out from the opposite side, i.e., from the side of the airframe, which involves a loss of production time since two workmen are needed to perform this operation. At the suggestion of Engineer M.V.Feofanov, a device known as a vacuum extractor (Fig.81) was adopted at one of the industrial plants for the purpose of removing the rivet from the side of the planking after inspection of the recess. This device consists of a cap (1) which is screwed into the body (2). The tube (3) is held in the extended position by the coil spring (4). The screw (7) fits into the lower part of the tube (3), with its head in the center of the piston (6) which, on the upper part, carries the washer (5). The piston fits and slides in the tube (8), which has a rubber gasket (9) at its lower end.

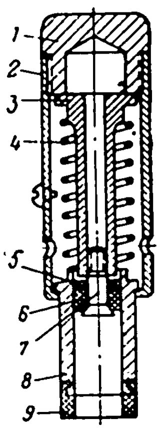

Fig.81 - Vacuum Extractor for Rivets

1 - Cap; 2 - Body; 3 - Tube; 4 - Spring; 5 - Washer; 6 - Piston; 7 - Screw; 8 - Tube; 9 - Rubber gasket

As shown in Fig.82, this device is used in the following manner: The vacuum extractor is placed on the surface of the planking over the place where the fit of the rivet with the recess is being checked. Pressing down by hand on the cap (1) causes the movable mechanism to move down, while the air under the piston is expelled through the clearance between the screw (7) and the piston to the atmosphere. As shown in Fig.82, after the piston is in its lowest position and the pressure on the cap is removed, the action of the spring rapidly returns the piston to its upper position, while the head of the screw (7) closes the clearance passage for air, thus creating a vacuum in the chamber underneath. Due to the difference in pressure acting on the head of the inserted rivet and on its stem, the rivet is expelled and is caught inside the chamber of the tube (9). A hermetical seal between the planking and the device is provided by the

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rubber ring (8).

3. Dimpling

The recesses under heads of flush rivets may also be made by dimpling. Dimpling can be done individually on each sheet or part of the joint or on two or three parts

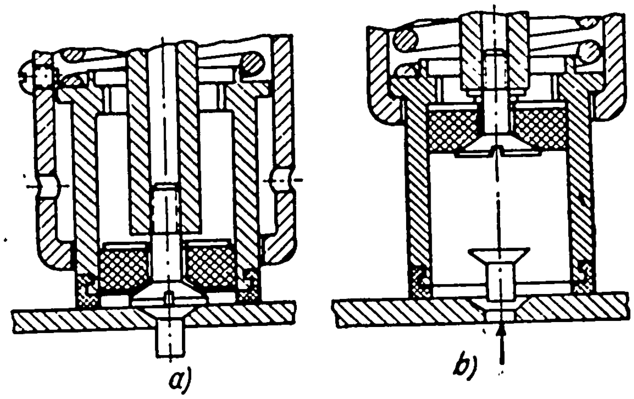

Fig.82 - Vacuum Extractor

a - Vacuum extractor installed on the planking surface, with the movable mechanism in its extreme low position; b - Instant of expulsion of the rivet from the recess

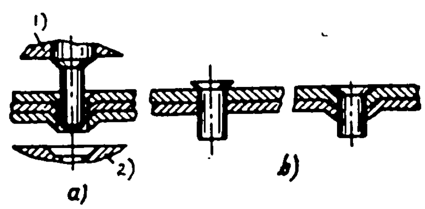

Fig.83 - Methods of Dimpling Recesses

a - Dimpling with a punch and die; b - Dimpling with the rivet head

1) Punch; 2) Die

at the same time, depending on their thickness. Multiple dimpling of recesses in a stack of several parts increases the labor productivity and eliminates the necessity of spending time in making the recesses coincide during assembly of the parts.

Dimpling of recesses in parts made of alloy V95 is done by preheating the area

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in which the recess is made.

Recesses may be dimpled by two methods, namely: 1) with a punch and die; 2) using the rivet head itself (Fig.83). Depending on the method used in dimpling recesses, the tools used can be classified into the following three groups (Fig.84):

1) Devices working on the principle of crimping the holes;

2) Devices working on the principle of drawing dies;

3) Devices working on the principle of crimping the holes and using a chisel blade.

Dimpling the recesses with the above devices is done on presses or with pneumatically operated hammers.

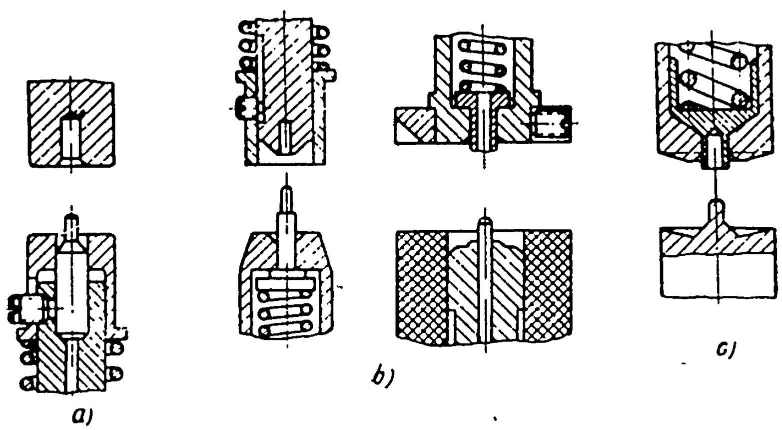

Fig.84 - Types of Tools for Dimpling Recesses

a - Tool working on the principle of crimping the holes; b - Tool working on the principle of drawing dies; c - Tool working on the principle of crimping the holes with use of a chisel blade

Below, the requirements for recesses for flush riveting made on dimpling tools and machines are given:

1) Preservation of the original aerodynamic smoothness of the surface of the parts dimpled;

2) Obtaining precise recesses with an even and smooth transition from the surface of the part worked;

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3) Absence of cracks and torn edges in the dimpled recesses;

4) Feasibility of dimpling recesses in sheets of various thickness, either separately or in a stack of two or three at a time.

When working with the tools of the first group, as shown in Fig.85, the recesses are obtained by radial flexure or bending of the material. The effect of the bending is manifest not only in the area of the recess but also in the adjoining portions

Table 17

Diameter of Drilled Holes for Dimpling Recesses with Tools of the First Group

Diameter of rivets, in mm	2.6	3.0	4	5.0
Diameter of holes drilled before dimpling of recesses, in mm	2.1	2.7	3.6	4.1

of the material, thus producing a cambering of the material.

In this case, during the first stages of dimpling, the sheet is deformed over a

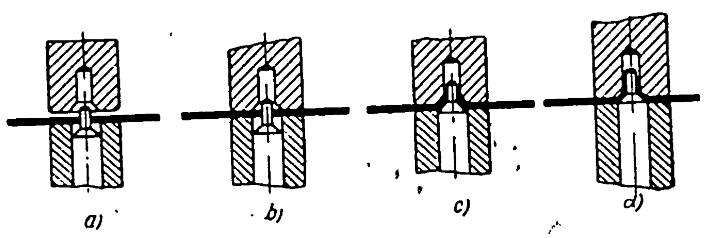

Fig.85 - Schematic Diagram of Procedure in Dimpling Recesses with Tools of the First Group

a - Aligning the part with the pilot stem of the punch; b - Holding the part in place; c - Initial stage of dimpling by crimping the hole; d - Last stage of the dimpling process

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radius larger than the radius of the die. On further application of pressure in dimpling, the radius becomes smaller, and in the last stage it becomes equal to the

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radius of the die. On completion of the dimpling, the radial stresses in the bent area produce considerable elastic deformation of the material in the recess, increasing the angle of the protruding material by 3 to 4° in the area of the recess.

Most of the deformation is on the convex side of the recessed hole, which contributes to the development of radial cracks (Fig.86). The presence of cracks around the hole depends also on the quality of the work. Special attention must be given to the presence of burrs which are the principal cause of development of cracks. For this reason, it is necessary to remove all burrs after drilling. The drilling of the holes must be done from the inside of the part, i.e., from the side on which the protruded portion of the recess will appear. This precaution results in reducing the number of burrs at the outlet point of the drill.

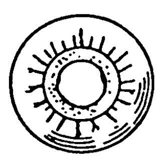

Fig.86 - Cracks on the Convex Side of the Recess

Dimpling of recesses with the described tools is done by pre-drilling the holes to a diameter corresponding to that of the rivets (Table 17).

Work with the tool shown in Fig.85 is done in the following sequence: The tapered pilot stem of the punch is placed into the pre-drilled hole; from the opposite side, the mating die is placed in position (Fig.85a), after

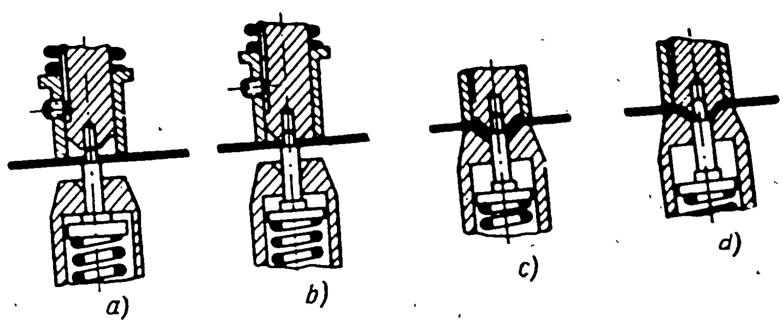

Fig.87 - Schematic of the Procedure Used in Dimpling with Tools of the Second Group

a - Placing the part to be stamped over the pilot stem of the punch; b - STAT al stage of dimpling (pressing the part tightly against the hole); c - Drawing of the material; d - Finishing operation of the process

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which the pneumatic hammer or press is started up. During the first stage of operation, the hammer or the press tool tightly presses on the part being stamped, as shown in Fig.85b, and finally the punch is brought into action and the dimpling of the recess is completed to the required dimensions (see Fig.85c,d).

It is either possible to dimple each part separately or both mating parts together. It is feasible to dimple the stack of mating parts at the same time, but it is not recommended to dimple the parts separately, since this will result in a lower production output and a poorer surface smoothness. In individual dimpling, the parts

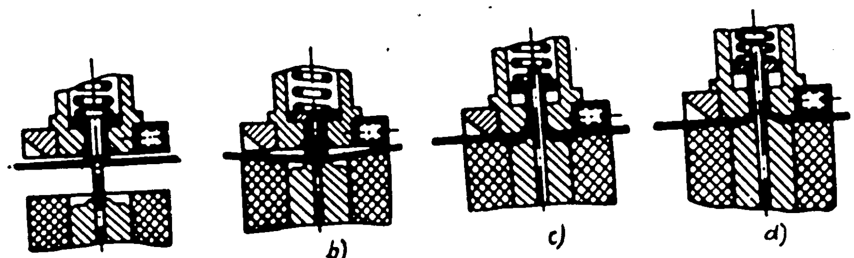

Fig.88 - Schematic Diagram of Dimpling with Tools Provided with Rubber Support Sleeves

a - Placing the part to be dimpled over the pilot stem of the punch; b - Application of pressure around the hole of the material; c - Drawing of the material; d - Finishing stage of the drawing process

are assembled in mating stacks and the holes are drilled to the final dimensions, whereas in simultaneous dimpling the holes are drilled immediately after the dimpling.

Before any work on dimpling is started, the working parts of the punch and dies must be checked for proper function by dimpling sample recesses in some specimens.

The described group of tools for dimpling does not fully meet the quality requirements of recess making and has the following drawbacks:

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1) Buckling of the material after dimpling;

2) Presence of burrs around the holes, resulting in the formation of radial

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cracks after dimpling;

3) Wrong dimensions of the recess, in some cases.

The drawbacks mentioned are partially eliminated when using tools of the sec. group, shown in Fig.87. In this case, radial cracks are eliminated by holding the part tightly in place by the plunger. During the first stage of dimpling, the material is being pressed into the area around the hole, and as the plunger moves further, drawing of the material takes place. Elastic deformation is therefore less than in the case of dimpling with tools of the first group.

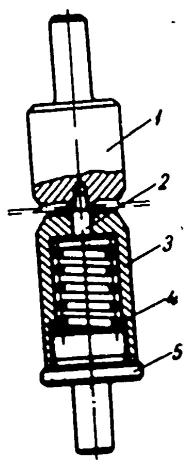

Fig.89 - Tool Set for Dimpling

1 - Punch; 2 - Holding plunger; 3 - Die; 4 - Spring; 5 - Washer with stem

To reduce elastic deformation and buckling of the planking material around the recess, the pressure during the initial stages of dimpling is absorbed by a rubber sleeve or support around the plunger (Fig.88). The tools shown are operated on the same principle as drawing dies.

The third group includes tools working on the principle of crimping the holes by embossing. The tool shown in Fig.89 consists of a punch (1) and die (3), whose hole carries the plunger (2), held in extended position by the spring (4), which rests on the washer (5). The dimensions of the tapered part of the punch correspond to the dimensions of the rivet head. The pilot stem of the plunger is chamfered at an angle of 2° to facilitate the release of the part after the recess is formed. The working surface of the punch in contact with the material is made concave and that of the mating die is made convex for the purpose of avoiding the bulging out of material in the area around the recess. [redacted] of the conical part of the recess of the mating die is the [redacted]nch (1), it is possible to use one set of tools for siSTATn- [redacted] dimpling of recesses in sheets having a thickness from 0.5-1mm.

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The plunger with the pilot stem ensures a tight hold of the material at the edges of the hole, during the entire travel of the plunger. The initial tension of the spring on the plunger may vary from 60 to 80 kg.

As the punch approaches the die (Fig.90), the sheet not only is bent and drawn, but is also upset, being coined under pressure and flowing between the working parts

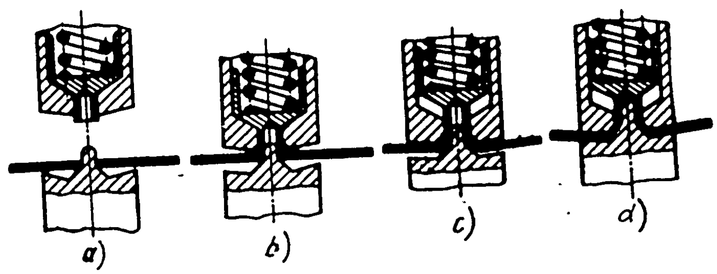

Fig.90 - Schematic Diagram of Procedure in Dimpling With Tools of the Third Group

a - Placement of the workpiece on the pilot stem; b - Beginning of the process - contact of plunger and die with the material; c - Crimping and coining under pressure of the material in the area of the hole; d - Finishing stage of the process - the material is upset in accordance with the contour of die and plunger

of the punch and die. Due to the effect of coining, the resultant recess has a sharp and well-defined transition line to the surface of the sheet.

Table 18

Diameter of Holes in Dimpling With Tools of the Third Group

(See Fig.89)

Diameter of rivet stem, in mm	2.6	3.0	3.5	4.0	5.0
Diameter of holes under the pilot stem of the punch, in mm	2.4	2.7	3.1	3.6	STAT 4.5

The washer (5) with its stem (Fig.89) serves the purpose of adjusting the a-

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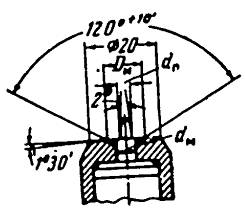
mount of compression on the spring. The degree of spring pressure required depe... on the kind of material worked, its thickness, dimensions, and the type of rivet...

Table 19

Dimensions of the Working Parts of the Dies Used in Tools of the Third Group

(See Fig.89)

Sketch	Diameter of rivets, in mm	Dimensions in mm		
		D_M	d_M	d_p
	2.6	$5.7^{+0.025}$	$3.6^{+0.025}$	$2.4^{+0.02}$
	3.0	$6.5^{+0.030}$	$3.9^{+0.025}$	$2.7^{+0.02}$
	3.5	$7.3^{+0.030}$	$4.4^{+0.025}$	$3.1^{+0.025}$
	4.0	$8.2^{+0.030}$	$5.2^{+0.025}$	$3.6^{+0.025}$
	5.0	$9.9^{+0.030}$	$6.1^{+0.030}$	$4.5^{+0.025}$

used. The correctness of the amount of spring pressure is judged visually from the appearance of the recesses obtained in preliminary tests (Fig.91). The dimpling with the described tools is done on holes which have been pre-drilled, whose diameters must correspond to the diameters of the rivets used (Table 18).

Complete dimensions of the working parts of the tools - punch and die - for dimpling in power presses are given in Tables 19 and 20.

Coining enables satisfactory smoothness of surface, but the sharp line of transition of the surface of the recess to the surface of the planking causes a concentration of stresses, which lowers the strength of the joint as compared with joints made with recesses which have been stamped out with a smooth and even transition line. The force required for stamping recesses in sheets of 0.6 to 0.8 mm in thickness are given in Table 21.

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Dimpling of recesses, utilizing the rivet heads may be done by the following two methods:

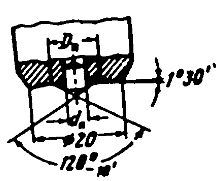
1) Simultaneously with riveting;

2) Separately, i.e., at first the recesses are dimpled with the rivet head; followed by upsetting the rivet with other tools.

When dimpling simultaneously with riveting on power presses, the tool shown in Fig.92 is employed. This tool consists of the set die (1) which has a smooth sur-

Table 20

Dimensions of the Working Parts of Punches Used in Tools of the Third Group (See Fig.89)

Sketch	Diameter of rivets, in mm	Dimensions in mm	
		D_p	d_p
	2.6	$5.7_{-0.025}$	$2.4_{-0.02}$
	3.0	$6.5_{-0.03}$	$2.7_{-0.02}$
	3.5	$7.3_{-0.03}$	$3.1_{-0.025}$
	4.0	$8.2_{-0.03}$	$3.6_{-0.025}$
	5.0	$9.9_{-0.03}$	$4.5_{-0.025}$

face, and the body (4), which accommodates a punch. The buffer sleeve (2) is actuated by the spring (3), and serves for holding the part being dimpled.

The work in using this device is done in the following order: Holes are predrilled in the piece which is then placed in the power press in such a way that the stem of the rivet fits into the hole of the buffer sleeve, with the rivet head against the set die. The press is started up, causing the flat surface of the die to descend and thus stamp out the recess to the shape of the rivet head.

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In dimpling by the second method in power presses, simpler devices, as shown

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in Fig.93, are used. The procedure of work with such tools is carried out in the following sequence: As in the previous case, holes are drilled in the piece to be dimpled, to the diameter of the rivets used, the rivets are inserted, and the piece is placed in the power press in such a manner that the stem of the rivet fits into the removable die which must have a conical hole of the same shape as the inserted rivet head. As the press is started up, the flat surface of the set die descends, thus stamping out the recess. After this, the parts are moved to another power press which is provided with a mechanism for riveting, and the riveting operation is performed on the entire piece worked.

Table 21

Force Required for Dimpling on Power Presses

Diameter of rivets, in mm	Dimpling force, in kg
2.6	1900
3.0	2400
3.5	3000
4.0	3800
5.0	5300

4. Countersinking the Inner Sheet and Dimpling the Outer

By this method (see Fig.65c), the formation of the recesses underneath the heads of flush rivets is carried out on each of the mating parts separately. In the parts of the airframe which are of greater thickness, the recesses are countersunk while in the thinner skin the recesses are dimpled. Since the countersunk recesses are completely filled by the rivet heads as well as by the material of the outer sheet, using the tools of the first group for dimpling (see Fig.85) will cause the recesses to be countersunk deeper than in conventional countersinking, by $0.4\delta_1$, where δ_1 is the thickness of the outer sheet being dimpled.

To obtain greater surface smoothness of the planking at the edges of the countersunk recess, these edges are chamfered to a depth from 0.3 to 0.5 mm. In that case, the dimpled recess in the planking will fill the countersunk recess in the airframe completely. The chamfering is done with a countersinking tool, having a taper angle of 150°.

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When using tools (see Fig.89) for dimpling the planking, the depth of the countersunk recesses in the airframe depends on the type and diameter of the rivets used.

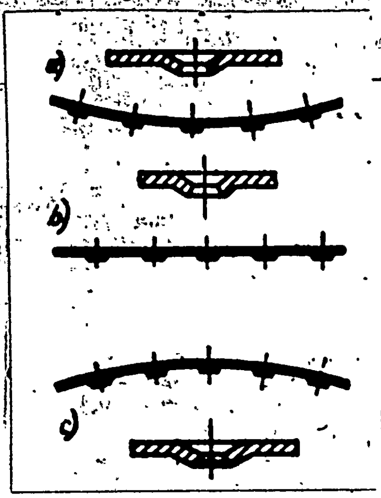

Fig.91 - Determination of Correct Spring Pressure in Tools Used for Dimpling by Visual Inspection of Recesses Made in Test Specimens

a - Insufficient spring pressure; b - Correct spring pressure; c - Excessive spring pressure

The process of dimpling and countersinking recesses and the use of tools and instruments in connection with this operation, does not differ from the process described above.

5. Dimpling in Magnesium Alloy Parts

The magnesium alloys of specification MA-1 and MA-8, used in structures, have only a limited dimensional stability at room temperature because of their thermoplasticity; this makes them unsuitable for dimpling.

Cracks, torn edges, or irregular shapes of the recesses develop if dimpling is done cold in magnesium alloy parts. Such defects weaken the riveted joint and disrupt the surface smoothness. For this reason, magnesium alloy parts are stamped by pre-heating the area of the metal.

The pre-heating of the stressed area can be done by resistance heating or by contact heating.

In resistance heating (Fig.94), an electric current is passed through the stressed area of the sheet from oppositely placed electrodes which function as the source of heat. One electrode is connected to the conical section of the punch and the other to the mating die; when these come together and make contact with the edges of the drilled hole, an electric current of considerable magnitude passes through the resistance offered by the metal. The greatest resistance is in the area

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where the edges of the hole are in contact with the punch, which results in heat this area of the sheet to the highest temperature.

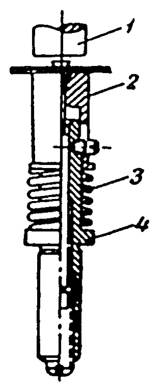

Fig.92 - Device for Dimpling Simultaneously with Riveting in Power Presses
1 - Set die; 2 - Buffer;
3 - Spring; 4 - Body

The temperature to which the dimpling area should be heated depends on the type of material. For dimpling parts of MA-1 alloy a temperature of 325 - 375°C is required, while dimpling of parts of MA-8 alloy (annealed), requires raising the temperature to 300 - 350°C. In dimpling by the electric resistance method of heating, a transformer with a power rating of 10 - 15 kw is required, which permits pre-heating the parts by bringing them to the required temperature within 0.5 - 1 sec.

The process of dimpling by the electric resistance method is carried out in the following sequence:

1. The parts to be dimpled are placed between the punch and the die which are integral with the mechanism of the power press. Then the part is placed on the pilot stem of the punch, through the hole;

2. The part is tightened under pressure between the punch and die and the area of the metal to be deformed is heated;

3. The recess is dimpled;

4. The punch and die are retracted to their original open position.

Then, the recesses are dimpled over the entire part worked.

Pre-heating of the sheet by the contact method (Fig.95) is accomplished by the transfer of heat from a previously heated device. The intensity of the heat transfer from the device to the sheet depends on the temperature differential and on the area of the surfaces in contact, the material of the device, the pressure existing

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between the heated part of the device and the sheet, and on the thickness of [illegible] sheet. The plunger and the die in that case are made with a wider area of [illegible].

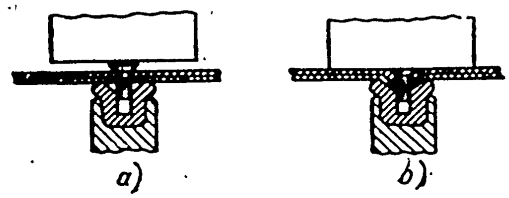

Fig.93 - Dimpling With the Rivet Head

a - Starting position; b - Dimpled recess

When pre-heating by the contact method, the temperature of the punch and the die material must be higher by 20 - 30°C than the temperature of the area if the recess were dimpled by the resistance method. Under these conditions the heating is done within 8 - 15 sec.

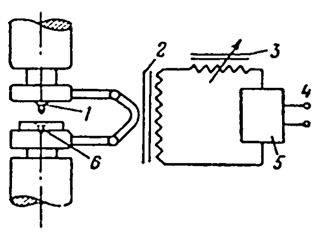

Fig.94 - Schematic Diagram of Heating Parts by the Electric Resistance Method

1 - Punch; 2 - Transformer; 3 - Potentiometer; 4 - Power line; 5 - Switch box; 6 - Die

The process of dimpling when pre-heating by the contact method is carried out in the following sequence:

1) The heating device is brought to the required temperature in special heating equipment;

2) The part to be dimpled is so aligned that the pilot stem of the punch fits into the previously drilled hole;

3) The part is held tight between the punch and die, and the area of deformation of the sheet is thus pre-heated;

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4) The recess is dimpled;

5) The punch and die are retracted to the original position and recesses are then dimpled over the entire piece.

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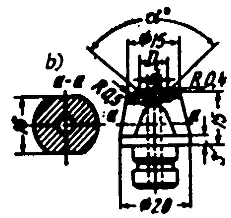
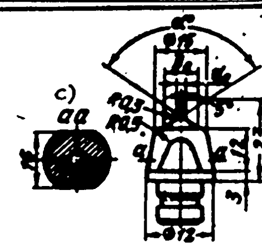
Table 22

Dimensions of the Working Parts of Dies and Punches for Dimpling with Heating by the Resistance Method

a)										
										
d)	e)	f)	g)							
			h)				i)			
			D_1	j)	d_1	k)	D_0	l)	d_0	m)
	3	0,8	6,10		2,5		5,4		2,2	
		1,0	6,25							
		1,2	6,50							
		1,6	6,75							
		2,0	7,05							
		0,8	7,85							
$90°_{-30'}$		1,0	8,0							

a) Sketch; b) Section through a – a; c) Section through a – a; d) Conical angle α ; e) Rivet diameter in mm; f) Thickness of; g) Dimensions in mm; h) Die; i) Punch; j) Tolerance on D_1; k) Tolerance on d_1; l) Tolerance on D_0; m) Tolerance on d_0

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Table 22 (continued)

$120°_{-30'}$	4	1,2	8,20	+0,05	3,5	+0,10	7,2	−0,05	3,1	−0,1
		1,8	8,70							
		2,0	8,85							
	5	1,0	9,80		4,5		9,0		4,1	
		1,2	10,00							
		2,2	10,80							
	3	0,8	6,90		2,5		6,5		2,2	
		1,0	7,05							
		1,2	7,15							
		1,6	7,35							
	4	0,8	8,60		3,5		8,2		3,1	
		1,0	8,75							
		1,2	8,85							
		1,8	9,15							
		2,0	9,25							
	5	1,0	10,45		4,5		9,9		4,1	
		1,8	10,55							
		2,2	11,10							

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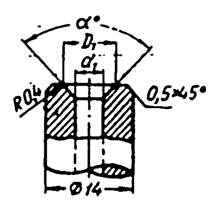
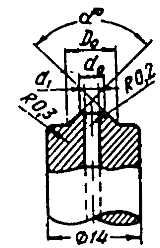
Table 23

Dimensions of the Working Parts of Dies and Punches for Dimpling with Heating by the Contact Method

a)													
			e)										
			f)				g)						
b)	c)	d)	D_1	h)	d_1	i)	D_0	j)	d_0	k)	d_1	i)	$h\approx$
		0,8	6,10										
		1,0	6,30										
	3	1,2	6,45		3,30		5,45		2,65		2,2		1,4
		1,6	6,80										
		2,0	7,10										
		0,8	7,90										
		1,0	8,10										

a) Sketch; b) Conical angle $\alpha°$; c) Rivet diameter in mm; d) Thickness of stamped sheet stack; e) Dimensions in mm; f) Die; g) Punch; h) Tolerance on D_1; i) Tolerance on d_1; j) Tolerance on D_o; k) Tolerance on d_o;

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Table 23 (continued)

90°–30'	4	1,2	8,25	+0,05	4,30	+0,013	7,25	–0,05	3,65	–0,02	3,1	+0,02	1,8
		1,8	8,75										
		2,0	8,90										
	5	1,0	9,90		5,50		9,05		4,65		4,1		2,2
		1,2	10,05										
		2,2	10,85										
	3	0,8	7,00		2,85	+0,010	6,55		2,40		2,2		1,2
		1,0	7,10										
		1,6	7,40										
120°–30'	4	0,8	8,70		3,85	+0,013	8,25		3,40		3,1		1,4
		1,0	8,80										
		1,2	8,90										
		1,8	9,20										
		2,0	9,30										
	5	1,0	10,50		4,95		9,95		4,40		4,1		1,6
		1,2	10,60										
		2,2	11,10										

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The accuracy and cleanliness with which the punch and die are prepared infl..- ences the quality of the dimpled recess to a considerable degree. Tables 22 and give data on the shapes and dimensions of the working parts of the tools used for dimpling of various types and dimensions and by different methods of heating.

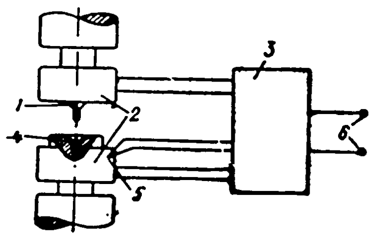

Fig.95 - Schematic Diagram of Pre-heating Parts by the Contact Method

1 - Punch; 2 - Heat transfer devices; 3 - Regulating control box; 4 - Die; 5 - Thermocouple; 6 - Power line

Before any work is started on dimpling of parts, it is necessary to make sure that all equipment is in good working order. This includes all tools, instruments, fixtures, the equipment which serves as a supply of heat to the punch and die, from which the heat is transferred to the material worked, as well as the performance condition of the regulating instruments. The adjusting of the equipment is done by dimpling specimens of the same material and of the same thickness as the part on which the dimpling is to be performed. After checking the accuracy of the test recesses by means of calibrated rivets and making certain that there are no cracks on their surfaces, the dimpling operation can be started.

Dimpling of recesses under the rivet heads by pre-heating, in accordance with the technical procedure outlined above, can be applied to other materials which have a limited ability to withstand changes in shape at normal room temperature.

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CHAPTER VI

TYPES OF RIVETS IN USE AND THEIR MANUFACTURE

1. Types of Rivets

Depending on the degree of ease of access to the place of riveting, various types of rivets are used. For riveting in open places of structures, where it is possible to approach the work from two sides, rivets with solid shanks are used (Fig.96), which represent approximately 97% of the total number of rivets used on

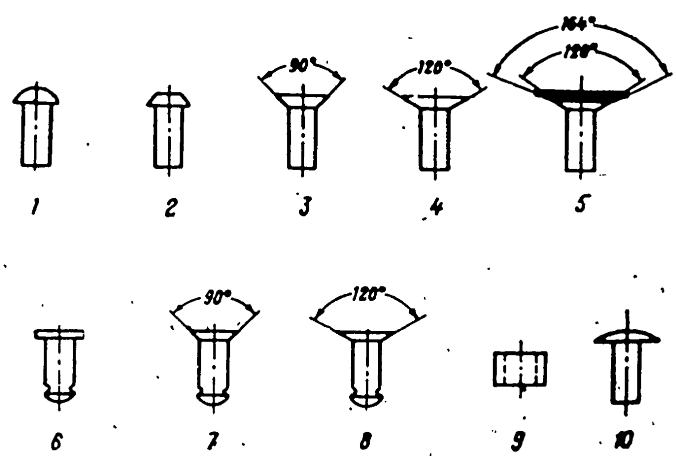

Fig.96 - Types of Rivets with Solid Stems

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1 - Semicircular; 2 - Flat; 3 - Countersunk head or flush, $\alpha = 90°$; 4 - Flush type, $\alpha = 120°$; 5 - Double cone, $\alpha = 120°/164°$; 6 - Flat head with high shearing strength; 7 - Blind rivet; 8 - Flush type, $\alpha = 120°$ with high shearing strength; 9 - Sleeve for rivets with high shearing strength; 10 - Plano-convex type

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conventional structures of light alloys. The rivets shown in Fig.97 are used for riveting in enclosed portions of the structures, i.e., where it is impossible to u[illegible] rivets with solid shanks and where the riveting is done from one side only.

Depending on the fit of rivets in certain structures, rivets with various sha[illegible] of heads are used, known as protruding and as flush types. The protruding type includes rivets with semicircular, plano-convex, and flat heads. Such rivets are used for joining parts of the airframe which are not exposed to the air flow.

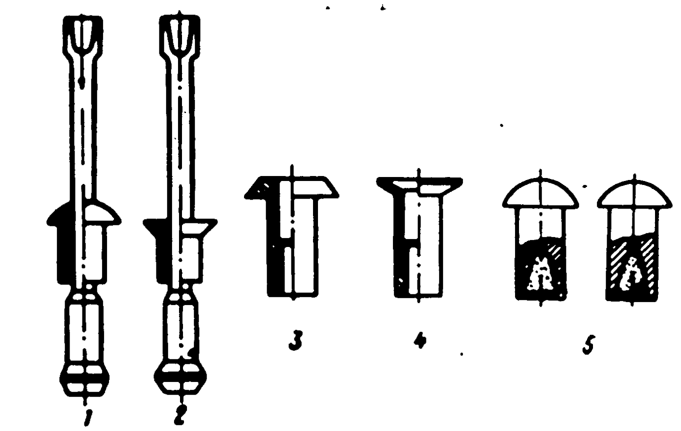

Fig.97 - Rivet Types for Riveting From One Side

1 - Mandrel with hollow round-head rivet; 2 - Mandrel with hollow flush-head rivet; 3 - Tubular rivet with flat head; 4 - Tubular rivet with flush head; 5 - Explosive Rivets

Flush-type rivets are subdivided into rivets with a cone angle of the recessed head of $\alpha = 90^\circ$, rivets with a cone angle of the recessed head of $\alpha = 120^\circ$, and rivets with two cone angles of the head of $\alpha = 120^\circ/164^\circ$.

Flush rivets are used in the following manner:

1) Rivets with heads having a cone angle of $\alpha = 90^\circ$ in countersunk recesses;

2) Rivets with heads having a cone angle of $\alpha = 120^\circ$ in countersunk and dimpled recesses;

3) Rivets with heads having two angles $\alpha = 120^\circ/164^\circ$ only in dimpled recesses.

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Table 24

Standardized Code Designations of Rivets with Shanks

a)	b)									f)
	c)					d)				
	V65	D 18	D 16	AMg5	AMTs	e)	20GA	1X18N9T (E'Yalt)	30XGSA	
g)	2006A50	2008A50	—	2007A50	2009A50	2010A50	2011A50	—	—	2021A50
h)	2024A50	2026A50	—	2025A50	2027A50	2028A50	—	2029A50	—	—
i)	2000A50	2002A50	—	2001A50	2003A50	2004A50	2005A50	—	—	—
j)	2013A50	2015A50	—	2014A50	2016A50	2017A50	2018A50	2019A50	—	—
k)	2020A50	2022A50	—	2021A50	—	2023A50	—	—	—	—
l)	2030A50	—	—	2031A50	—	—	—	—	—	—
m)	—	—	—	—	—	—	—	—	2034A50	—
n)	—	—	—	—	—	—	—	—	2032A50	—
o)	—	—	—	—	—	—	—	—	2033A50	—
p)	—	—	2035A50	—	—	—	—	—	—	—

a) Type of rivet; b) Standard code designations; c) Aluminum alloys; d) Steel; e) 15A and 10 cold-hardened; f) Copper M2; g) Half-round head; h) Plano-convex head; i) Flat head; j) Flush type $\alpha = 90^\circ$; k) Flush type $\alpha = 120^\circ$; l) Double conical head $\alpha = 120^\circ/164^\circ$; m) Flat head with high shear strength; n) Flush type with high shear strength, $\alpha = 90^\circ$; o) Flush type with high shear strength, $\alpha = 120^\circ$; p) Rivet sleeve with high shear strength

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Flush rivets are used principally in riveting the streamlined surfaces of aircraft exposed to the airflow, such as in joining the skin to the fuselage frame.

Roughness of the outer surface of high-speed aircraft increases the drag. For this reason, one of the fundamental conditions determining the quality of the outer surface of the aircraft, is the use of high-precision flush rivets; 65 - 70% of the total number of rivets used in the construction of aircraft is of this type.

The use of flush rivets in conjunction with accurate holes and recesses result in a seam of high-quality workmanship.

Rivets used in the construction of aircraft are standardized. The standards are differentiated by a definite letter and number code, classifying the rivets by the type of heads, kind of material, diameter, and length (Table 24). For example, the designation 2006 A50-4-18 is decoded as follows:

1) The number 2006 signifies a round-head rivet, made from material V65;
2) The letter A signifies its use in aircraft manufacture;
3) The number 50 is the year of issue of the standard (1950 in the given case);
4) The figure 4 refers to the rivet diameter;
5) The figure 18 refers to the rivet length.

2. Materials for Rivets and Their Identification Marks

The material for rivets is wire of aluminum alloys and of various kinds of steel, manufactured in accordance with the technical specifications in Table 25.

The chemical composition and mechanical properties of rivets manufactured from the materials listed, are given in Tables 26 and 27.

Rivets made from V65 and D18 alloys are used in riveting strong joints (such as the skin of the airframe, parts of longerons, ribs, tie components, and major units). Rivets made from these alloys are characterized by the fact that they can be used for riveting right after their aging period, and that throughout their entire storage period no repeated heat treating is required. This property is quite important since

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it results in simplification and in lowering the cost of production.

Rivets of AMts alloy are used principally for riveting welded containers and tanks.

Rivets of AMg5 materials are normally used for joining parts consisting of magnesium alloys.

Rivets made from steel of specification 15, 10 (cold-hardened), 20GA and 1Kh18N9T, which possess high strength, are used in joining steel components and mixed

Table 25

Technical Wire Specifications for Various Kinds of Materials

Material	Identification marks of material	Technical specifications for wire
Aluminum alloys	V65	265 AMTU-49
	D18, AMts, AMg5	349 SMTU
Steel	15A (select) 20GA	ChMTU 100
	10 cold-hardened	ChMTU 285
	30KhGSA	MPTU 2333-49
	1Kh18N9T (EYa1T)	MPTU 2320-49
Copper	M2	GOST 770-41

structures, i.e., structures in which aluminum alloys and steel are used in combination.

Rivets of material 30KhGSA which possess high shear strength are used in structures subjected to high shearing forces, such as in longerons, heavy ribs, etc. Rivets having high shear strength may replace bolts, since they are lighter in weight, simpler to use, and more economical in production work. In applications where the rivet heads are subjected to tension stresses, it is not recommended to use rivets

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Table 26

Chemical Composition and Mechanical Properties of Aluminum Alloy for Rivets

a)	b)									c)		
	Cu	Mg	Mn (d)	Fe (d)	Si (d)	Zn (d)	Fe+Si (d)	e) (d)	Al	f)	g)	h)
D18P	2,2—3,0	0,2—0,5	0,2	0,5	0,5	0,1	—	0,1	i)	30	24	19
AM-5	> 0,2	4,7—5,7	0,2—0,6	0,4	0,4	—	0,6	0,1	•	27	23	16
AMTs	> 0,2	> 0,05	1,0—1,6	0,7	0,6	—	—	0,1	•	—	—	7
V65	—	—	—	—	—	—	—	—	•	40	20	25

a) Type of material; b) Chemical composition of alloy in %; c) Physical properties; d) Not more than; e) Total of other ingredients; f) Ultimate unit stress in tension σ_b, in kg/mm^2; g) Relative elongation in %, δ_{10}; h) Stress in shear τ, in kg/mm^2; i) Remainder

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Table 27

Chemical Composition and Mechanical Properties of Steel for Rivets

a)	b)								d)		
	C	Si	Mn	P	S	Cr	Ni	Ti	e)	f)	g)
				c)							
15A (select)	0,15—0,20	0,17—0,37	0,35—0,65	0,035	0,035	0,20	0,30	—	45—60	3	34
20GA	0,18—0,26	0,17—0,37	1,30—1,60	0,035	0,035	0,020	0,30	—	—	19	47—55
30XGSA	0,27—0,32	0,90—1,20	0,80 - 1,10	0,030	0,030	0,80—1,10	0,40	—	125	10 (l=5d)	72
1X18N9T (Yarit)	> 0,14	> 1,0	> 1,5	0,035	0,03	17—20	8,11	0,8	—	—	> 44

a) Type of material; b) Chemical composition of alloy in %; c) Not more than; d) Physical properties; e) Ulti[illegible]e unit stress in tension σ_b, in kg/mm^2; f) Relative elongation δ in % (l = 100 mm);

g) Stress in shear τ, in kg/mm^2; h) 15A (select)

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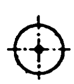
Table 28

Markings of Rivets Manufactured from Various Alloys

a)	b)				d)	c)			n)
	V65	D18P	AMG5	AM1s		20GA		1X18.Г (Yarit)	M2
e)	f)	g) h)	f)	f)		g) h)		f)	f)
i)	j)	 k) l)	 l)	 l)	j)	 k) l)		 m)	j)

a) Material; b) Aluminum alloy; c) Steel; d) 15A and 10 cold-hardened; e) Rivet type; f) For all types; g) Flush type; h) Half-round and flat; i) Marking; j) Not marked; k) Indented point; l) Raised point; m) Raised line; n) Copper.

having a high shear strength.

To facilitate a material identification of the rivets, the rivet heads have definite marks. The marking is done during the heading operation, in the form of a coded design which may be raised or indented dots and rectangles. Table 28 shows the marks specified as standard for rivets.

These identification marks permit selection of the proper type of rivet at any stage of production, beginning with the heading of the rivets, and channeling the rivets to the proper job. Flush-type rivets have marks depressed in the head, since they are used for riveting the fuselage skin for which rigid requirements as to surface smoothness are made. These markings are an aid in the inspection of the rivets during their manufacture as well as of the entire riveted joint.

A distinguishing feature of the most widely used V65 alloys of aluminum and 15A of steel is the absence STAT stamped marks.

All above statements refer to rivets with solid shanks. Rivets intended

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for riveting from one side only and rivets subjected to alternating stresses, as we as other types, will be investigated in detail in the appropriate Sections of this book.

3. Established Rivet Requirements

Rivets must meet the corresponding requirements as set forth by the technical specifications 53ATU-51.

As to exterior appearance, rivets must have a clean and smooth surface, without cracks, scratches, flakes, blisters, beads, and rough surface stains which is an indication of incipient corrosion.

In dimensions and tolerances rivets must meet the requirements corresponding to the riveting job specifications. The shanks of the rivets must be straight or of circular cross section.

Bright spots are allowed on the rivet heads which are due to incomplete contact with the punch head during upsetting, provided they do not affect the minimum dimensions. Slight fins, which are caused in upsetting and are not fully removed in rotary polishing with an abrasive, are tolerated provided they do not affect the dimensions of the rivets within the specified limits. In addition, the following defects are tolerated:

a) Insignificant hollow depressions and traces of marks of the upsetting dies, provided they are within the limit of one half of the allowed variations in the specified dimensions;

b) Deviations from the perpendicular of the face and the seating surface of the head, as well as of the flat end of the shank by 30' with respect to the shank axis;

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c) Out-of-round of the shank, within the limits of permissible deviation of the diameter.

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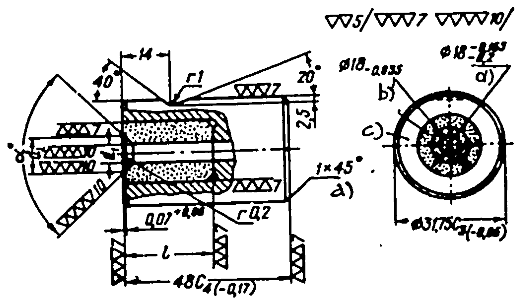
4. Manufacture of Rivets and Their Heat Treatment

Rivets used in the assembly of light alloy sheets are made by the cold upsetting process from wire stock. The diameter of the wire is somewhat smaller than that of

Table 29

Die with Inserts of Hard Alloy for Heading Flush Rivets on Automatic Machine 52VA



a°	e)	f) d₁ g)	f) d₁ h)	f) d₂ g)	f) d₂ h)	l
90°+1°	2,6	2,59	+0,03	4,6	+0,(5	14
	3	2,99		5,2		20
	3,5	3,49		6,1		
	4	3,99		7,0		
	5	4,99	+0,05	8,8		26
	6	5,99		10,5		
120°+1,5°	2,6	2,59	+0,03	5,35	+0,06	14
	3	2,99		6,1		20
	3,5	3,49		6,9		
	4	3,99		7,8		
	5	4,99	+0,05	9,5		26

a) From both sides; b) Insert; c) Body; d) Hole; e) Specified diameter of STAT ts d, in mm; f) Dimensions, in mm; g) Specified; h) Allowed deviation

the fabricated rivet. This is done for the purpose of facilitating the entry of the wire into the openings of the upsetting dies. The surface of the wire must be bright

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and must show no traces of oxidation. The appearance of apparently insignificant longitudinal lines on steel wire and more particularly on chromium-molybdenum wire, is one of the causes of the development of cracks during the further cold-working in the riveting operations.

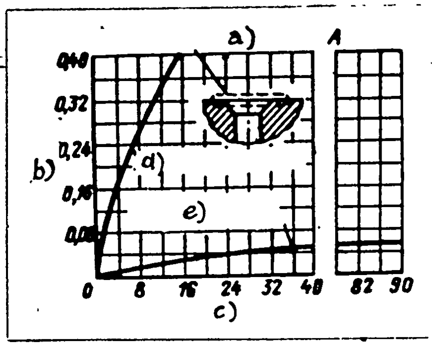

Fig.98 - Wear of Dies of Material Kh12M and in Dies with Hard-Alloy Inserts, as a Function of Working Time

a) Wear area A; b) Amount of wear in the area A, in mm; c) Work time of dies, in hours; d) For die Kh12M; e) For die of hard alloy

Fundamental factors which determine the quality of fabricated rivets are as follows:

1) Quality and size of the wire used in heading the rivets;
2) Quality and accuracy of the work in preparing the heading tools;
3) Accuracy of the automatic heading machine;
4) Technical procedure in the further work on the rivets.

The dies and punches of automatic heading machines are the basic tools which determine the dimensions and configurations of the rivets, so that special emphasis should be placed on their correct production.

Higher stability to resist wear and maintain dimensions of the rivets is attained if the dies are made with inserts of hard-metal alloys. A general view and practical dimensions of a die of this type are given in Table 29.

Tests made on dies fitted with inserts of hard alloys have shown that they have greater durability than dies made of Kh12M steel, (Fig.98). For example, in STAT 12-hour period of work, the amount of wear in the area A of the die was as follows:

For the die fitted with hard-alloy inserts	0.02 mm
For the die made of Kh12M steel	0.34 mm

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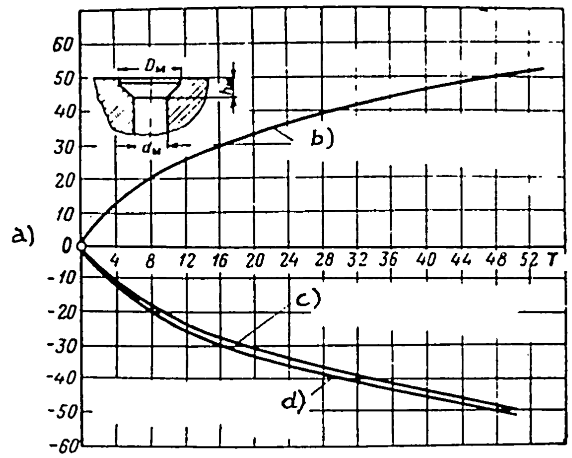

Fig.99 - Wear of Dies with Hard-Alloy Inserts in Heading Rivets

a) Wear in mm; b) Wear on hole diameter d_m; c) Wear on height of recess under rivet head h_m; d) Wear on diameter of recess under rivet head D_m

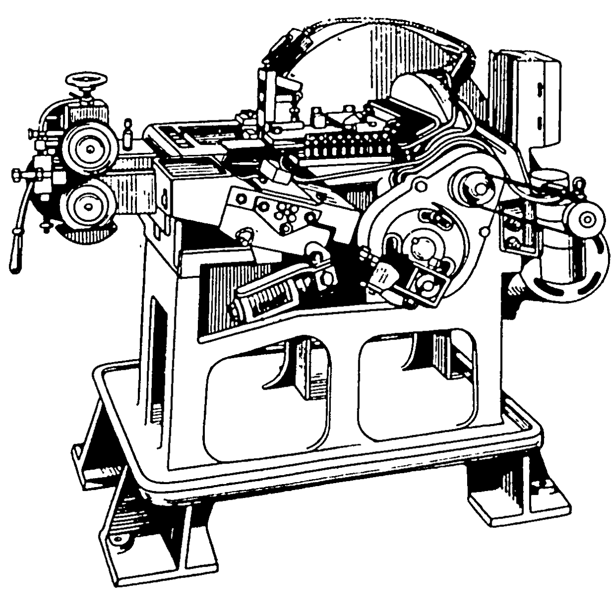

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Fig.100 - Automatic Rivet-Heading Machine

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This shows that dies fitted with hard-metal alloys have almost 17 times as much service life as similar dies made of Kh12M steel.

Figure 99 shows characteristic curves for the wear of dies in heading machines. The curves indicate that during the working time when the dimension d_m increases, the

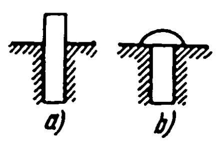

Fig.101 - Formation of the Head of the Rivet on Single-Stroke Automatic Headers

a - Wire stock installed in the die;

b - Upset head

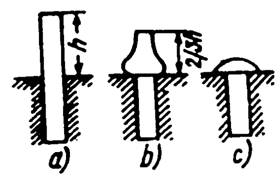

Fig.102 - Formation of the Rivet Head on Two-Stroke Automatic Headers

a - Wire stock installed in the die;

b - One third of the height h upset;

c - Upset head

dimensions D_m and h_m decrease. An analysis of these curves shows that in dies with hard-alloy inserts, their wear has no significant effect on the dimensions of the rivets for all practical purposes, since this wear is only 0.05 mm. Such dies are usually removed from service because of splitting or cracking of the hard-alloy insert. The material used for making the inserts in the dies is the hard alloy VK8 or VK10 of specification GOST 3882-47.

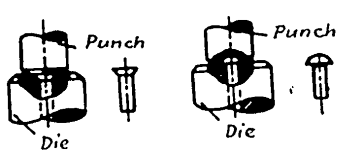

Fig.103 - Position of the Rivets Between the Punch and Die at the Finishing Stage in the Heading Operation

The rivets are manufactured on special automatic heading machines (Fig.100).

Automatic headers are classed according to the number of strokes, as single-stroke and two-stroke machines. The operating principle is the same in single-stroke and in two-stroke machines. The difference consists in that single-stroke

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machines have one punch which heads the rivet in one stroke (Fig.101). Two-stroke machines have two punches, one for the preliminary and the other for the finishing operation. The preliminary punch aligns the stock in the die and at the same time heads the shank by 1/3 of the usual allowance h to form the head; then the finishing punch, by a second stroke, gives the head its proper shape (Fig.102). The rivet heads have a more correct outline when made on the two-stroke automatic headers than on the single-stroke machines.

The position of the rivets between the punch and die at the end of the heading operation, is shown in Fig.103.

The heading operation in both the single- and the two-stroke automatic machines is carried out automatically throughout. The supervising operator is charged only with the initial setting up of the wire in the machine, with checking that the machine is operating correctly, keeping the mechanism lubricated, and changing the punch and die tools as necessary.

Determination of Precision Characteristics of Automatic Heading Machines

The accuracy of the rivets manufactured on automatic headers is checked during

Form 1

Form for Entering the Results of Measurements in Determining the Precision Characteristics of Rivets on Automatic Headers

X_i	m	$X_i m$	$X_i - \bar{X}$	$(X_i - \bar{X})^2$	$(X_i - \bar{X})^2 m$
Total	Σmn	$\Sigma X_i m$			$\Sigma (X_i - X)^2 m$

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their operation by numerous (usually from 150 to 300) measurements with micrometer indicating instruments to determine any deviation from the control caliber. The

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measurements are made on rivets from one coil of wire made on one die. The micrometer is set to the zero point on the first rivet produced, and measurements of subsequent rivets will then indicate the deviation relative to the first rivet. The results of the measurements are entered on Form No.1.

The following symbols are used in Form No.1:

X_i - Deviation in the measurements of the rivet head relative to the calibrated specimen, in mm;

m - Frequency of deviations;

$X = \frac{\sum X_i m}{\sum m}$ - Arithmetic mean for the experimental group, in mm;

$(X_i - X)$ - Deviation from the arithmetic mean.

After entering in the Table the measurements and making the proper calculations, the error is determined by the method of least squares, from the formula

$$\sigma = \sqrt{\frac{\sum (X_i - \bar{X})^2 m}{\sum m}}.$$

The magnitude of 6σ indicates the scattering of the results of the actual measurements.

Investigation* on determining the precision of the automatic header in the manufacture of flush-type rivets (Table 30, Fig.104), show that it is possible to obtain rivets with much closer tolerances (with respect to deviations Δh of the heads of the rivets from the calibrated control) than required by the established standards for rivets.

Inspection of Rivets by the Statistical Method

In view of the fact that a considerable quantity of rivets is used in the production of aircraft, and that the manufacture of rivets proceeds in accordance with a systematic sequence, to definite specifications on a large scale, it is obvious that the adoption of the statistical method of inspection is quite rational. This

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* Investigation made by Engineer Bayemanov

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Table 30

Example of Recording the Precision of Automatic Headers

X_i	m a)	b)	c)	$X_i m$	$X_i - \overline{X}$	$(X_i - \overline{X})^2$	$(X_i - \overline{X})^2 m$
−0,004	////	4	5	−0,0175	−0,0070	0,000049	0,000245
−0,003	/	1					
−0,002	///////	7	11	−0,0165	−0,0050	0,000025	0,000275
−0,001	////	4					
0	//////////////	14	25	0,0375	−0,0030	0,000009	0,000225
+0,001	///////////	11					
+0,002	////////////////////////////	28	40	0,1000	−0,0010	0,000001	0,000040
+0,003	////////////	12					
+0,004	/////////////////////	21	29	0,1300	0,0010	0,000001	0,000029
+0,005	////////	8					
+0,006	/////////////////	17	24	0,1560	0,0030	0,000009	0,000216
+0,007	///////	7					
+0,008	////////	8	11	0,0935	0,0050	0,000025	0,000275
+0,009	///	3					
+0,010	////	4	5	0,0525	0,0070	0,000049	0,000245
+0,011	/	1					
d) Total			Σ 150	Σ = 0,5355			Σ0,00550

$$\overline{X} = \frac{\Sigma X_i m}{\Sigma m} = \frac{0,5355}{150} = 0,0035;$$

$$\sigma = \sqrt{\frac{\Sigma m (X_i - \overline{X})^2}{\Sigma m}} = \sqrt{\frac{0,00155}{150}} = 0,00316;$$

$$6\sigma = 0,019.$$

a) Marks; b) Frequency; c) Total measurements in groups; d) Total

method contributes to the quality of the product, reduces rejects, and result STAT reduction of labor in the inspection of the rivets.

Essentially, the statistical method of inspection of rivets during their process of manufacture consists in rating the rivets on the basis of measurements of their parameters on a selected small number (usually 10 to 15 rivets) from the large

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number of rivets produced during a definite interval of time (usually one hour).

In such cases, the method of statistical analysis is applied to the characteristics of a small number of selected samples, after which a relation is established between the parameters of the small group of rivets and the parameters of the total

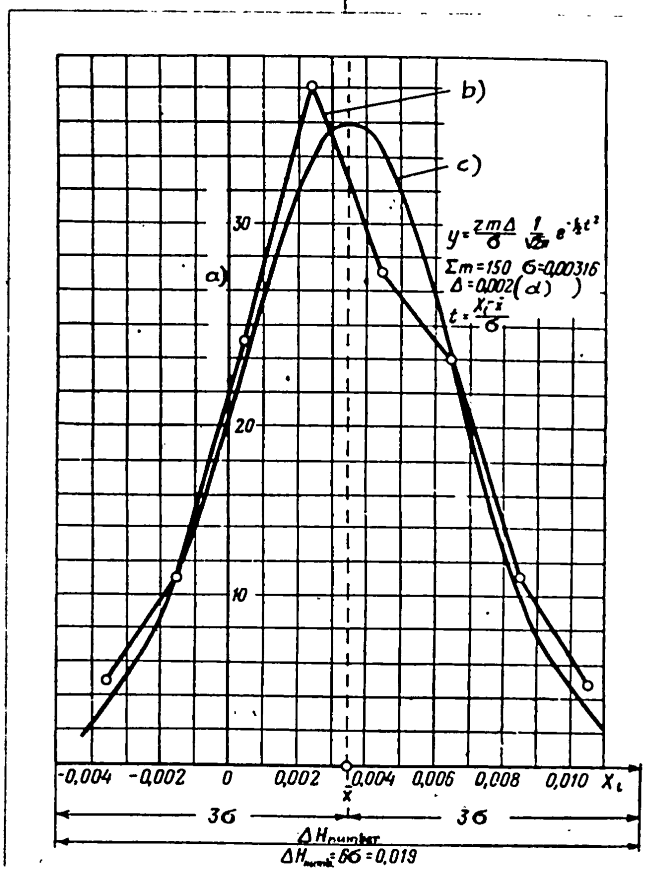

Fig.104 - Practical and Theoretical Dispersion Curves, Characterizing the Quality of an Automatic Rivet Header

a) Number of measurements; b) Practical dispersion curve; c) Theoretical dispersion curve; d) Measurement intervals STAT

output of the machine over the same interval of time, all of which will possess the same characteristics.

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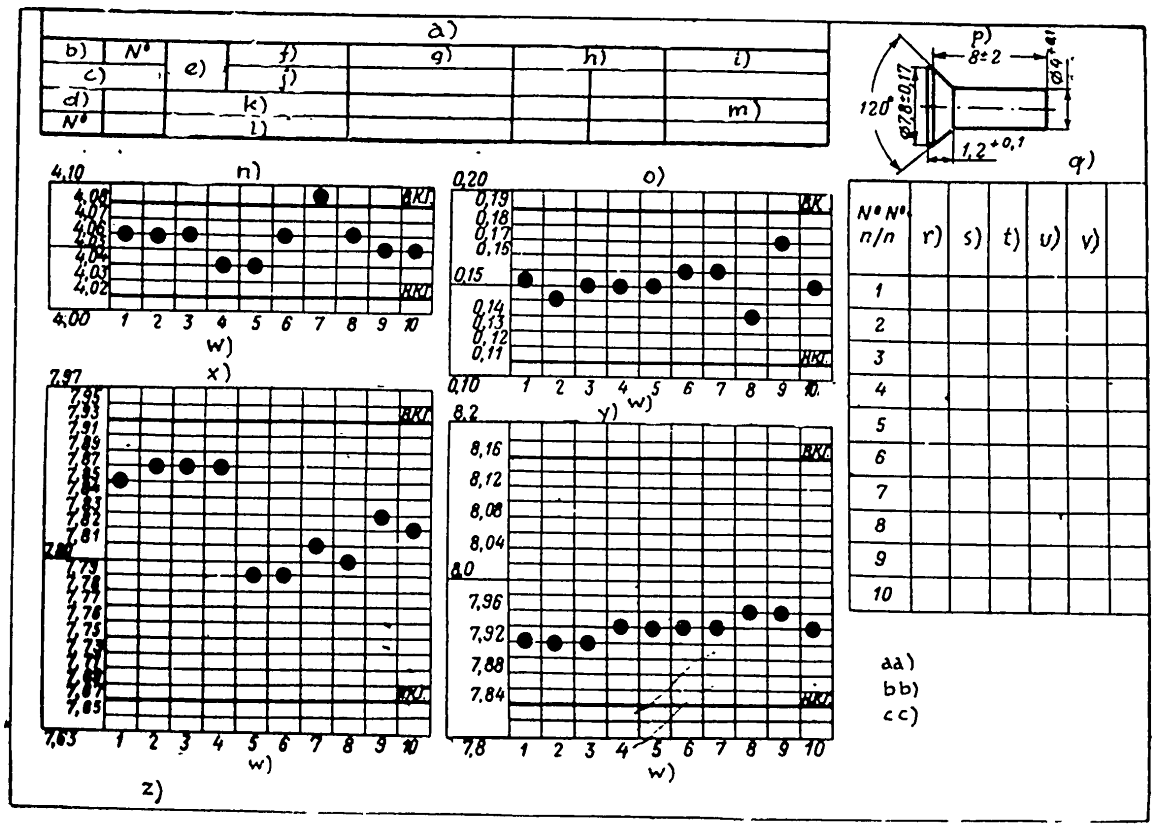
Form 2



a) Statistical inspection chart; b) Section No.; c) Equipment; d) Type No.; e) Part; f) Name; g) Rivet; h) For measurements; i) Technician; j) Code; k) Number of rivets in selected group; l) Working period for selection; m) Adjuster; n) Rivet diameter; o) Height of head; p) Sketch; q) Example; r) Fins; s) Skewing of head; t) Cleanliness; u) Cold-hardening; v) Cross section; w) Time in hours; x) Diameter of head; y) Rivet length; z) Inspection foreman; aa) Inspector; bb) Female assistant; cc) Repair workman

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A record of the correct procedure of rivet manufacture is kept on special statistical records or charts (Form No.2).

The data on these statistical inspection charts are worked out in the technical section of the rivet manufacturing plants, thus maintaining a continuous record on the quality of production. The upper and lower tolerance limits are shown on these charts in heavy lines, and the inspection data are entered between the lines. The decision as to whether or not the rivet output is in accordance with quality specifications is based on the inspections of a few selected rivets on any one run of the machine.

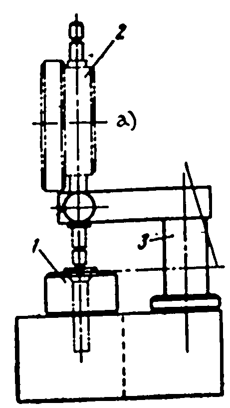

Fig.105 - Measurement of the Deviation of Rivets from specified Size in a Calibrated Gage, Using an Indicator

1 - Master gage; 2 - Indicator dial; 3 - Pedestal support of indicator

a) The dial of the indicating instrument is set at "zero"

The checking of the dimensions of the rivets is done by the inspection department with conventional measuring instruments, such as micrometers for diameters of the shanks and the heads, and slide calipers for measuring the length. A special indicating device is used for determining the height deviation of the rivet head from the specified dimensions (Fig.105). The dimensions of the working parts of the gage used in rivet inspection are given in Table 31.

After all dimensioning of the parameters of the rivets is done, the arithmetic mean of the selected group of rivets is determined by the formula

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$$\bar{x} = \frac{x_1 + x_2 + x_3 + \ldots + x_n}{n},$$

where x_1, x_2, x_3 ..., x_n are the measurements of the rivets in the group; n is the number of rivets in the selected group.

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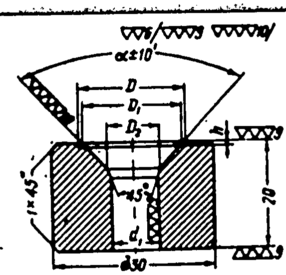
Table 31

Dimensions of the Working Parts of the Gage Used in Inspecting Rivets During Their Manufacture, in mm



α°	90°									120°								
d	d_1		D_1		D_2		D	k		d_1		D_1		D_2		D	k
a)	b)	c)	b)	c)	b)	c)	b)	c)		b)	c)	b)	c)	b)	c)	b)	c)
2,6	2,70	+0,05	4,8	+0,02	2,9	+0,02	8,0	0,35		2,7	+0,05	5,7	+0,02	3,0	+0,02	8,5	+0,3
3	3,10		5,4		3,3		8,5			3,1		6,5		3,4		9,5	
3,5	3,6		6,3		3,8		9,0			3,6		7,3		3,9		10,0	
4	4,10		7,2		4,3		10,0			4,1		8,2		4,4		11,0	
5	5,10		9,0		5,3		12,0			5,1		9,9		5,4		13,0	
6	6,15		10,8		6,4		14,0			6,15		11,9		6,5		15,0	
8	8,15		14,4		8,4		17,5			—		—		—		—	
9,5	9,65		17,1		9,9		20			—		—		—		—	
10	10,15		18,0		10,4		21			—		—		—		—	

Note: 1. Material is steel of designation U12A according to GOST V-1435-42
2. Heat-treatment: quenching and tempering $R_C = 50 - 55$
3. Coating: chromium-plated.

a) Rivet; b) Specification; c) Tolerance

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Table 32

Common Defects During Manufacture of Rivets and Remedies

Type of defect	Cause of defect	Remedy
Flat surface of head skewed with respect to rivet axis	Punch of finish heading installed crooked	Install punch so that the working surface is in contact with the die surface without clearance and properly aligned
Cracks in the rivet head	Wire not sufficiently ductile	Check the chemical composition of the wire and make several mechanical tests
1. Rivet head of elliptical shape 2. Lines on the flat surface of the head	Flat surface of punch has tool marks which interfere with the flow of metal during the heading process	Finish and polish the flat surface of the punch
Rivet shank has longitudinal lines and traces of annular grooves	1. Longitudinal scratches on the wire 2. Traces of tool marks on the inner surface of the bushings 3. Excessive feed-roller pressure on the wire	1. Change the coil of wire 2. Change the bushings 3. Reduce pressure on stock feed rollers
Incomplete rivet head	1. Insufficient movement of the guide block 2. Insufficient outlet of wire for the formation of a full head	1. Increase the stroke of the reciprocating movement of the guide block 2. Increase the length of the wire feed
1. Wire stock does not enter into the die opening 2. Rivet shank is bent	1. Diameter of stock is greater than die hole 2. Diameter of wire is less than die hole	Change to the wire type
Fin on head not removed in drum polishing, although the punch is adjusted correctly	1. The setting of the wire stroke limiter at the intake side of the die not adjusted properly 2. Cutting edges of the knife have become dull	1. Adjust the setting for proper feed of stock 2. Change the cutoff knife STAT
Insufficient length of rivet	Insufficient length of stock fed to machine	Adjust the setting for proper feed of stock

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Type of defect	Cause of defect	Remedy
Uneven length of rivets after upsetting	Slipping of the wire takes place at cutoff point	1. Increase the braking force of the stock-feed mechanism 2. Increase gripping force on wire stock
Rivet head displaced with respect to center line of shank	Improper position of punch in the finish heading stage	Adjust position of punch with respect to center of die
Fin formed on head exceeds allowed size	Surplus of stock for formation of the head	Adjust feed mechanism of wire

The arithmetic mean is entered on the statistical inspection chart. If the mean figure $\bar{x}$ is within the limits of tolerance, the machine output is correct. If the mean figure is outside the upper or lower tolerance inspection limits, (U.T.I.L. or L.T.I.L.), but is within the set allowable upper and lower limits (A.U.L. or A.L.L.), the inspector must give a warning signal to readjust the exit mechanism of the heading machine. In the first and second cases mentioned, the rivets are segregated and are counted as acceptable.

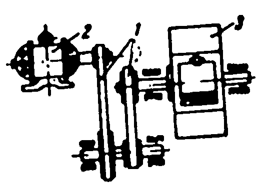

Fig.106 - Schematic Sketch of a Polishing Drum
1 - V - belt; 2 - Electric motor; 3 - Polishing drum

If, however, the average figure is outside the allowable upper or lower tolerance limits, the inspector must immediately order readjustment of the header mechanism. In that case, the rivets produced between the two check periods are segregated from the regular machine output and are set apart for sorting as "suitable" and "scrap".

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In addition to inspecting the rivets by their parameter measurements, a visual inspection of the exterior appearance is also made, and the results observed are entered in the statistical inspection chart (see Form No.2).

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As stated above, as soon as deviations from the standards shown on the statistical inspection chart occur, further work on the heading machines is stopped until the defects are eliminated. In such cases, the maintenance workman must define the reasons for the deviation and determine the remedy. Table 32 lists common defects which arise in the process of rivet heading, together with the remedies. Following the heading operation, the rivets are subjected to drum polishing, to heat treatment, and to anodizing.

Rotary Drum Polishing

Drum polishing and cleaning is one of the important operations, and has a marked influence on the quality of the rivets. In this process, any fins and burrs remaining on the rivets after heading, are removed. The removal of the burrs and fins is effected by rolling the rivets in special drums filled with abrasive particles or sawdust. Figure 106 gives an outline of a mill in which the rivets are polished in rotary drums with wood shavings, using the following process:

The rivets, together with the oak shavings, are charged into the drum. The number of rivets and shavings should not exceed one third of the volume of the drum. By rotating the drum for about 25 to 40 min, the fins and burrs are removed from the rivets. The time required for the polishing operation depends on the size and shape of the rivets, the nature of the adhesions, the rivet material, their contour, shape of the drum in the mill, number of revolutions, condition of the inner surface of the drum, and the species of the wood from which the shavings or sawdust is produced. When a large quantity of rivets has to be polished, the milling installation consists of a number of revolving drums mounted to a common drive shaft.

After the rivets are polished, they are screened, separating them from tSTATw-dust. The rivets are washed in a kerosene bath to remove any adhering dirt and grease and are then immersed in another bath of water, maintained at a temperature of 50 - 60°C. Then, they are dried by centrifuging.

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Heat-Treating

After passing the polishing operation, the rivets are forwarded to the heat-treating department. Quenching and tempering, together with natural aging, represent the final operations in the heat-treating process of duralumin rivets. This increases the physical properties of the rivets to their maximum. The schedule followed in heat-treating the rivets is given in Table 33.

Table 33

Heat-Treating Schedule for Rivets of Aluminum Alloys

	a)	b)		
		D 18	V65	
c)	e)	l)		
	f)	495—503° C	515—520° C	
	g)	∅ 2—5 mm—20 min. ∅ 6—10 mm—30 min.	∅ 2—5 mm—30 min. ∅ 6—10 mm—40 min.	
	h)	n)		
	i)	20 - 30° C		
d)	j)	o)	50° C	o)
	k)	4 weeks	3 weeks	10 weeks
	q)	r)	s)	

a) Heat-treating schedule; b) Type of rivet material; c) Quenching; d) Aging; STAT
e) Fluid; f) Heating temperature; g) Soaking time; h) Cooling fluid; i) Cooling temperature; j) Temperature; k) Holding time; l) Potassium nitrate; m) Min; n) Circulating water; o) Room; p) Weeks; q) Conditions and time limit for use of rivets in structures; r) When quenched and aged, without time limit, but not earlier than four weeks after quenching; s) When quenched and aged, without time limit, but not earlier than three weeks by artificial aging or 10 weeks by natural aging

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Rivets made from alloy of AMg5 and AMts brands are used in the tempered condition. The tempering is done from a temperature of 350 to 400°C, maintained for

Table 34

Schedule for Heat-Treating of Steel Rivets

Type of rivet material	Quenching medium	Heating temperature, °C	Drawing temperature, °C
15A	–	–	650
20GA	Oil	880	650-680

60 min and followed by cooling in water or air.

The heat treatment of steel rivets is done in accordance with the specifications for steel rivets 56ATU-48, as per schedule shown in Table 34.

Table 35

Protective Coatings for Rivets of Various Type of Material

Designation of rivet material	Condition of rivets before coating	Protective coatings
V65	Quenched and naturally aged at elevated temperature	Anodizing
D18	Quenched and naturally aged	Anodizing
AMts	Not heat-treated	Without coating
AMg5	Annealed	Anodizing
Steel 10 Steel 15A	After annealing	Galvanizing and passivating
20GA; 30KhMA; 30KhGSA	After quenching and annealing	Galvanizing and passivating
1Kh18N9T (E'YalT) M2	Annealed	Without coating

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For steel rivets made from 15A material, normalizing or quenching and annealing can be substituted for the procedure given in Table 34.

Rivets of YalT material are used in the annealed or tempered state. Previously heat-treated rivets possess higher strength and greater ductility, which facilitates the riveting operation in structures.

Protective Coatings

After the rivets are heat-treated, they are given a protective coating. The type of coating depends on the material of the rivets, in accordance with the schematic given in Table 35.

Physical Tests on Rivets

After heat-treating and depositing a protective coating on them, the rivets are subjected to physical tests on shear and on riveting. Rivets made from any material are subjected to tests on resistance to shear, with the exception of rivets from AMts and M2 materials. Rivets with high shear strength, made from material 30KhGSA which are heat-treated, are tested for hardness.

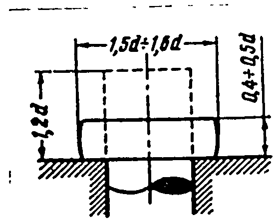

Fig.107 - Dimensional Tolerance and Dimensions of the Clinched Head, in Testing for Riveting Properties

The results of the tests must meet the standard specifications given in Tables 26 and 27. For shear tests it is customary to pick 10 rivets from each batch (weight of batch, 10 kg) and if unsatisfactory results are obtained on more than two rivets out of ten, then a further test is made on 20 rivets picked out of the batch. If the results of the repeated test are unsatisfactory on more than two rivets, the batch is scrapped.

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Tests on the riveting properties are made on rivets of all types of material,

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with the exception of those possessing high shear strength. The testing of riveting properties is done on power presses in plates of material 30KhGSA, in which the holes must be of such a diameter that the rivets will fit snugly. The allowed mater-

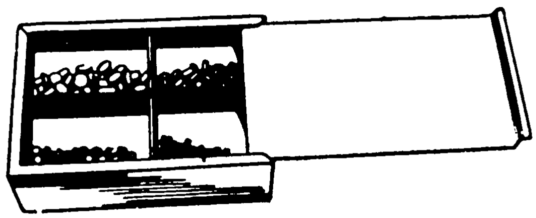

Fig.108 - Drawer for Rivets

ial in the length of the rivet shank, 1.2 d, must be used up only for the formation of the clinching head of the rivet (Fig.107).

After the riveting, the clinching head must be free of cracks and chips, and in planview the shape of the head must be round. When defects in the clinched head occur in as little as one rivet out of 20 inspected rivets, the batch is rejected and scrapped.

The finished rivets are forwarded to the warehouse section of the plant, together with inspection rating charts for each batch of rivets.

5. Working Arrangement for Riveting

In the departments where assembly work is done by riveting, the rivets are stored in special racks. Each rack is equipped with a number of drawers, all of which must be of the same size and somewhat larger in number than there are riveting places in a particular section of the plant. Each drawer should have a number, which refers to a particular riveting place. The drawer (Fig.108) has four compartments, to have a maximum number of rivets of various sizes for particular applications handy; but, as a rule, these should not exceed four.

The supply of rivets in the drawers is carried out in the following sequence:

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After checking on the requirements of each riveting place as to type, material, sizes, and number of rivets needed, the stockroom manager sorts the rivets in the drawers. He then distributes the filled drawers to the riveting places, making sure that there will be enough rivets for one full shift. With this system, interruption of work due to lack of rivets is eliminated.

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PART III

METHODS OF RIVETING, EQUIPMENT AND TOOLS USED

CHAPTER VII

CLASSIFICATION OF METHODS AND PROCEDURES IN RIVETING

1. Riveting Process

Depending on the method used for dimpling, the procedures followed in riveting practice may be grouped as A, B, C, and D processes.

Riveting by the A process is characterized by the fact that the recesses in the materials to be joined are made by dimpling with a punch and die, so that the rivet

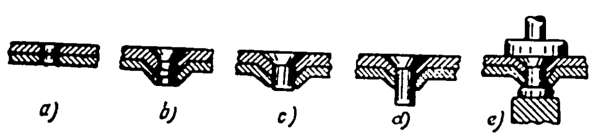

Fig.109 - Schematic of the Riveting Procedure by Process A

a - Preliminary drilling of holes; b - Dimpling of recesses; c - Drilling of holes to final dimensions; d - Fitting of rivets; e - Heading

head fits into the recess and is flush with the surface of the parts. The technical procedure of riveting by the A process (Fig.109) consists of the following steps:

1. The planking is placed on the airframe, holes are drilled for holding t STAT assembly in position, and the holding devices are installed at 150 to 300 mm spacing. The tools used in these operations are drill presses or hand drills, clamping devices, and wrenches for tightening the clamps.

2. Holes are drilled to preliminary size in the mating parts, using templates

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or guide holes, either in a drill press or with hand drills.

3. The recesses are dimpled either separately in each part or simultaneously on both mating parts by means of a punch and die, using a power press or a pneumatic hammer.

4. The holes are again drilled to final dimensions, corresponding to the size of rivets used.

5. Rivets are inserted in the dimpled recesses.

6. The riveting is performed by fitting the smooth surface of the punch and die into a pneumatic hammer or into a suitable power press.

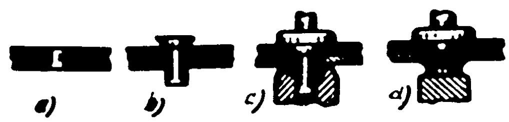

Fig.110 - Schematic of the Riveting Procedure by Process B

a - Drilling of holes; b - Insertion of rivets; c - Dimpling of recesses; d - Heading

Riveting by the B process is done by using the rivet head for dimpling the recess under the rivet head for flush riveting. The technical procedure of the B process (Fig.110) consists of the following steps:

1. As in the A process, the skin is placed on the airframe, holes are drilled for the clamping devices, and the holders are fixed in place.

2. Holes are drilled in the mating parts to a size corresponding to the diameter of the rivet, using templates, drill jigs, or the guide holes previously drilled in one of the parts.

3. The rivets are inserted in the holes.

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4. The recess is dimpled in the skin and airframe, using the rivet head itself; in this operation the proper die and the smooth end of the punch are used, mounted to the power press or pneumatic hammer.

5. The riveting is done in a power press or with a pneumatic hammer.

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Riveting by the C process is done by forming the recess for the flush rivet head by a combination of two operations: dimpling of the recesses in the skin and countersinking of the recesses in the airframe. The technical procedure of riveting by

Fig.111 - Schematic of the Riveting Procedure by Process C

a - Drilling the hole and countersinking the recess in the airframe; b - Placing the skin on the airframe and drilling the holes in the skin; c - Inserting the rivet in the hole; d - Dimpling the recess; e - Heading

the C process (Fig.111) consists of the following steps:

1. Holes are first drilled in the airframe and are then countersunk. In some cases, the drilling and the countersinking is done at the same time.

2. The skin is placed on the airframe, holes are drilled for the holding devices, and these are fixed in place.

3. Holes are drilled in the planking through the holes in the airframe.

4. The recesses in the skin are either dimpled by using the rivet head itself or with the aid of a punch and die.

5. The rivets are inserted into the holes.

6. The riveting operation is performed.

Riveting by the D process is done by countersinking the recess for flush riveting in the planking. The technical procedure of riveting by the D process (Fig.112) consists of the following steps:

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1. The planking is placed on the airframe, holes are drilled for the holding devices, and these are fixed in place.

2. Holes are drilled in the skin, following the guide holes in the airframe.

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3. The recesses for the rivet heads are countersunk in the planking.

4. The rivets are inserted.

5. The riveting operation is performed.

Flush riveting by the A, B, C, and D processes can be done in power presses or with pneumatic hammers, using special jigs, tools, instruments, and equipment as described below.

The data on establishing tolerance limits for riveting with the A, B, C, and D processes are given in Chapter V on "Methods of Forming Recesses".

Comparison of Characteristics of Riveting Processes

The basic characteristics determining the quality of work and the rate of production by a given process are governed by the following factors:

a) Smoothness of surface of flush-riveted seam;

b) Strength of the joint;

c) Volume of work output.

Surface smoothness of riveted seams is characterized by the degree to which the flush rivet heads protrude above the surface of the parts (planking).

To obtain the required degree of smoothness in flush-riveted seams when riveted by any process, the geometry of the recess must be correlated to the geometry of the

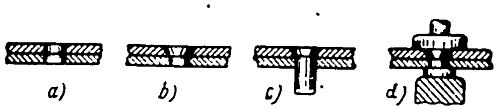

Fig.112 - Schematic of the Riveting Procedure by Process D

a - Drilling the holes; b - Countersinking the recesses; c - Insertion of rivet; STAT

d - Heading

flush-type rivets. This requirement can be met by using countersinking tools which are so adjusted that the depth of the recess is correct, that carefully machined

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punches and dies are used for dimpling, that highly mechanized drilling and power press equipment is available, and that the rivets are accurate.

Other conditions being equal, riveting by the D process gives better surface smoothness than other methods. For this reason, in the production of structures with relatively thick planking, this process is chiefly used in connection with flush riveting. When using the A, B, or C process in which the recesses are formed by dimpling, better results are obtained if the dimpling is done on power presses rather than with pneumatic hammers. This is explained by the fact that, in the dimpling, the hammer and the prop may be unsteady and subject to change of relative position, causing indentation marks on the skin surface and incorrect shape of the recess.

The strength of the joint is affected to a considerable degree by the riveting process used.

Tests with static loads on joints have shown (Table 36) that specimens with countersunk recesses, and riveted by the D process have a strength lower by 20% than similar joints with dimpled recesses (A process), regardless of the combination of different materials in the seam.

The results of vibration tests [with n ≈ 2000 cycles per minute, with the specimens pre-stressed so that $\sigma_{mean} = 0.33\,\sigma_{fail}$ (Fig.113), the basis of the tests being equivalent to 10^7 cycles], have shown that joints made with countersunk recesses (riveted by the D process) have a lower fatigue strength under all load conditions than similar joints riveted by the A process. The decrease in strength in the fatigue limit is 23%. For example, the yield point for joints made with dimpled recesses was $\sigma_{\omega d} = 6.2$ kg/mm^2, and for joints with countersunk recesses the yield point was $\sigma_{\omega d} = 4.8$ kg/mm^2.

In testing joints under repeated static loads, the number of load cycles re- STAT sulting in failure of the joint by rupture, was taken as the reference point.

The ultimate load for the joint is

$$\sigma_{max} = K \cdot \sigma_{fail.}\ Kg/mm^2,$$

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where K is the load coefficient;

σ_{fail} is the ultimate stress in kg/mm^2 at which the joint fails.

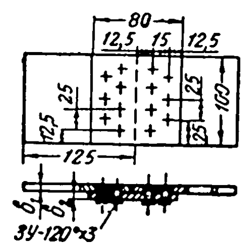
The lower limit load represents 0.1 of the upper limit load, i.e.,

$$\sigma_{min} = 0{,}1\ \sigma_{max}.$$

In the procedure of the above tests, the load coefficient was taken as 0.5. The

Table 36

Significance of Tensile Strength σ in kg/mm^2 of Joints in Relation to the Riveting Process Used



Characteristic of the sheet stack	Riveting process: D — Manner of forming recesses: Countersinking	Riveting process: A — Manner of forming recesses: Dimpling with punch and die
δ_1 = 0.8 mm of MA8 δ_2 = 1.0 mm of MA8 Rivet type ZU − 120° × 3 of AMg5	11.25	13.35
δ_1 = 0.8 mm of MA8 δ_2 = 1.0 mm of D16T Rivet type ZU − 120° × 3 of AMg5	11.40	13.45

($\sigma = \frac{P}{F}$; where F is the cross-sectional area of the sheet over its width, in mm^2)

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load cycle fluctuated within 8 - 16 cycles per minute.

The test results on joints, under repeated loading, (Table 37) indicate that the strength of the joints, when riveted by the A process, is higher than in similar

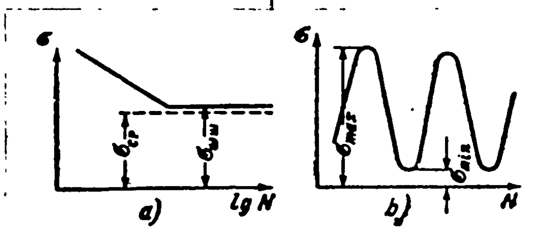

Fig.113 - Manner of Stressing in Tests with, (a) Vibration and (b) with Repeated Static Loading

joints riveted by the D process. A particularly noticeable difference is observed in joints consisting of a combination of sheets of MA8 and D16AT materials. Here the reduction in the joints riveted by the D process amounts to 35%.

For evaluating the strength of joints riveted by the C process, a comparison was made with similar joints riveted by the D process, and with joints in which the rivets had protruding heads.

As indicated in Table 38, joints riveted by the C process have a greater strength in shear under static loads. In the C process, the recesses in the mating parts are made by countersinking and by dimpling.

It is of interest that seams riveted by the C process are more rugged and deform less when stressed by static loads (Fig.114). For example, at a stress in the seam of $\sigma = 10$ kg/mm^2, the slip in seams riveted by various processes is as follows:

a) 0.8% of the rivet diameter in seams riveted by the C process;

b) 4.3% of the rivet diameter in seams riveted by the D process;

c) 1.5% of the rivet diameter in seams with protruding rivet head. STAT

In this manner, the slip in joints riveted by the D process is 4 - 6 times greater than in similar joints riveted by the C process.

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Tests with vibrational loads (at $\sigma_{shear} = 0.33\ \sigma_{fail}$) show that the strength is greater in joints riveted by the C process, in which the recesses are dimpled and

Table 37

Number of Repeated Loadings in Rupture Tests of Joints Riveted by the A and D Processes

Characteristics of the sheet stack	Riveting method: D	Riveting method: A
	Load coefficient $K = \frac{\sigma_{max}}{\sigma_{fail}} = 0.5$	
	$\sigma_{max} = 5.6$ kg/mm^2; $\sigma_{min} = 0.6$ kg/mm^2	$\sigma_{max} = 6.6$ kg/mm^2; $\sigma_{min} = 0.6$ kg/mm^2
$\delta_1 = 0.8$ mm of MA8	5167	7828
$\delta_2 = 1.0$ mm of MA8	6825	6800
Rivets type ZU - 120° × 3 of AMg5	6818	6525
Average value	6270	7050
$\delta_1 = 0.8$ mm of MA8	6738	10951
$\delta_2 = 1.0$ mm of D16AT	8624	10774
Rivets type ZU - 120° × 3 of AMg5	6552	11115
Average value	7300	10950

countersunk, than in joints riveted by the D process, in which the recesses are countersunk only (Fig.115). The reduction in strength in joints with countersunk recesses is 30% and in joints with protruding rivet heads, 20%.

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Thus, the strength of joints made by various riveting processes can be summarized as follows:

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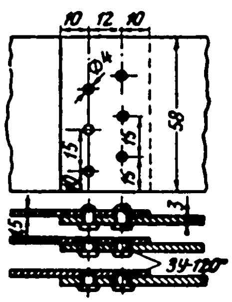
1) The application of the riveting process C results in the greatest strength when testing the joints by all described tests. 2) Next in order are joints riveted

Table 38

Strength of Riveted Joints as Related to the Riveting Process



Flush-Riveting Process		D Countersinking	C Countersinking and dimpling	Joints with protruding rivet heads
Strength	P in kg	1540	2260	1850
	in kg/mm^2	17.7	26.0	21.3
	%	100	146.7	120
Coefficient of strength of the seam	$\varphi = \frac{P}{P_l}$	0.4	0.6	0.45

Note: 1. Sheets are of D16AT material; rivets of D18 material. 2. P is the load in kg at which the sheet ruptures over its entire width.

by the A process with protruding rivet heads, resulting in almost the same strength of joint. 3) Finally, joints riveted by the D process, in which the recesses are countersunk, have the least strength.

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The output rate with these riveting processes depends not only on the particular process used but also on the degree of mechanization available, such as equipment, tools, instruments, and fixtures used for drilling, countersinking, dimpling,

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as well as riveting proper. For example, other conditions being equal, greater production may be obtained by the riveting process A and by using power presses for

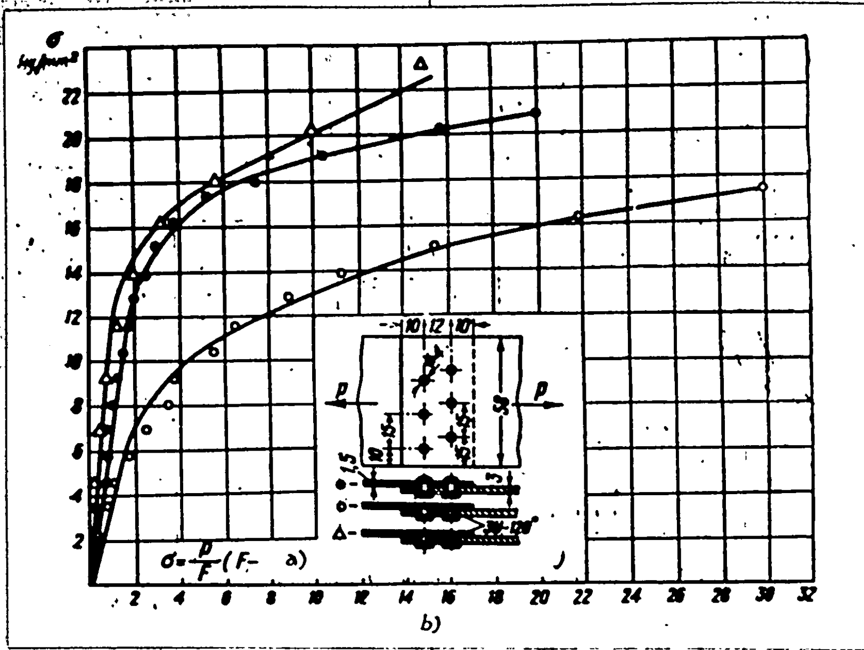

Fig.114 - Effect of Riveting Process on the Slip in Joints

(Plates of D16AT; Rivets of D18)

a) F - Cross-sectional area of the sheet; b) Slip of the sheet Δ in % of the rivet diameter

dimpling, stationary drill presses for drilling and countersinking the recesses, and power presses for group riveting. Then follows riveting by the D process; finally, the most laborious is the C process since it requires two operations: countersinking and dimpling.

2. Methods of Forming the Clinched Rivet Heads

Regardless of what particular method is used in flush-riveting operations, the heading at the tail end of the rivet shank is done with power presses or pneumatic hammers.

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When riveting with pneumatic hammers, depending from which side the hammer is applied relative to the head of the rivet that fits into the recess, the operation is known either as direct or as reverse.

In the direct method, the blows of the hammer are directed on the shank end of

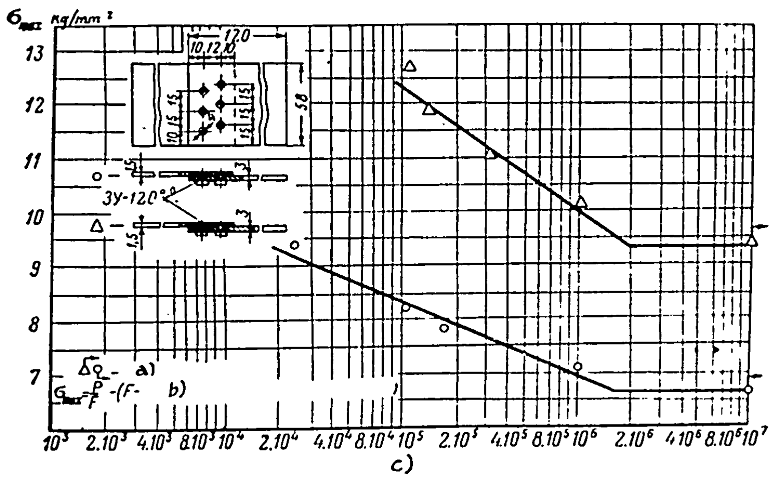

Fig.115 - Effect of Process Used in Forming Recesses on the Fatigue Strength of Joints (Sheets of D16AT, Rivets of D18; Tests Were Carried Out at $\sigma_{shear} = 0.33\ \sigma_{fail}$)

a) Without rupture; b) (F - is the cross-sectional area of the sheet); c) Number of cycles to failure

the rivet, while a heavy prop is pressed against the flush rivet head (Fig.116). Riveting by this method with flush-type rivets is carried out in the following sequence (Fig.117).

1. The rivet is fitted into the drilled hole and the countersunk recess.

2. A heavy prop support is placed against the flush rivet head.

3. A tightening device is installed on the side of the rivet shank, thus squeezing the parts to be joined.

4. The capping tool which fits into the pneumatic hammer is placed in contact

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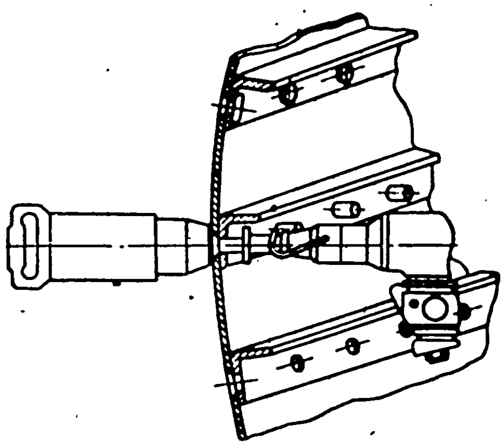

Fig.116 - Riveting by the Direct Method

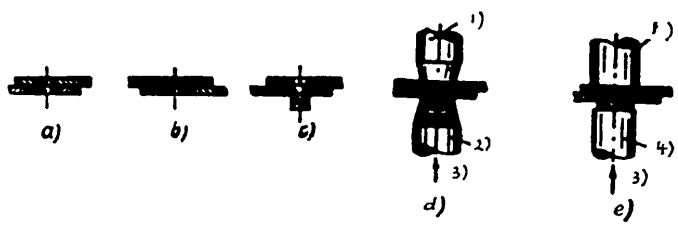

Fig.117 - Outline of Riveting Flush-Type Rivets by the Direct Method

a - Drilling holes; b - Countersinking recesses; c - Inserting rivets;

d - Squeezing sheets together; e - Riveting

1) Prop; 2) Squeezing; 3) Blows; 4) Riveting punch

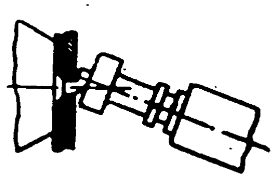

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Fig.118 - Bending of Rivet Shank

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with the protruding shank and the heading is done by pressing the lever which turns on the compressed air that operates the hammer.

A characteristic disadvantage of this method of riveting is the tendency to bend the end of the rivet (Fig.118), which occurs if the hammer is not lined up co-

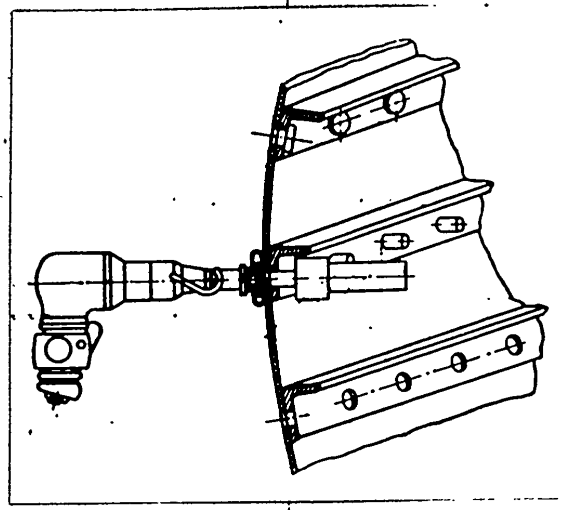

Fig.119 - Riveting by the Reverse Method

axially with the rivet shank. However, this defect is observed only during the first few days while the riveters are broken in, and usually disappears after they have become accustomed to the requirements of the job.

The reverse method of riveting consists in directing the hammer blows on the head of the flush-type rivet, so that heading is produced by the transmitted blows of the shank against the prop (Fig.119).

The riveting of protruding heads is carried out by this method as follows:

1. The rivets are inserted in the drilled holes.

2. The punch end of the pneumatic hammer is placed in contact with the rivet head, while a prop is placed against the outlet end of the shank at the opposite side.

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3. As pressure is applied on the starting lever, the hammer blows fall on the

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rivet head, with the result that the end of the shank becomes upset as it impinges against the prop.

When rivets with flush-type heads are riveted by the reverse method, recesses are formed under the rivet heads (see Fig.112).

Characteristic disadvantages of riveting flush-type rivets by this method are as follows:

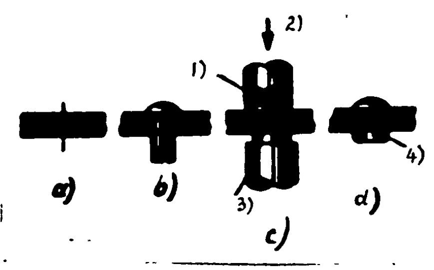

Fig.120 - Riveting Rivets with Protruding Heads by the Reverse Method
a - Drilling holes; b - Inserting rivets; c - Riveting; d - Riveted joint
1) Squeezing; 2) Blows; 3) Prop; 4) Clinched head

1. Occurrence of cavities in the planking around some rivets: These cavities cause buckling of the surface of the planking (Fig.121a).

2. Depressions over the surface of the entire riveted seam (Fig.121b), which is observed more generally on multiple row seams with a short distance between the rows and between the rivets in the row, as for example, along the rids, where butt joints of the skin may occur, etc.

This is explained by the fact that any blows directed on the rivet head are transmitted to the outer surface of the planking, resulting in depressions. Such depressions are often observed in structures in which the airframe is not sufficiently rigid.

When riveting is done on power presses, the concept of "direct" and "reverse" riveting methods does not exist, since then the number of operations and the quality of work no longer depends on the relative position of the working parts of the tools with respect to the original and the clinched heads of the rivets.

An evaluation of the quality of joints, produced by various riveting methods, was made by subjecting them to static, vibrational, and repeated static loads. The results of the tests on joints with static loads showed that there is some tendency

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toward an increase in strength (by 2 to 3%) when the riveting is done in power presses. Tests on similar joints with vibrational (Fig.122) and with repeated static

Fig.121 - Characteristic Defects in Riveting Flush-Type Rivets by the Reverse Method

a - Cavities in the area of the rivet heads; b - Depressions in the surface of the skin along the riveted seam

loads (Table 39), showed that the method used in riveting has no influence on the strength of the joints when tested under such loading conditions. However, for

Table 39

Load Cycles to Failure in Tests on Joints Produced with Various Riveting Methods

(see Fig.122)

Riveting method	Load coefficient $K = \frac{\sigma_{max}}{\sigma_{fail}}$	
	0.7	0.5
	$\sigma_{max} = 8.9$ kg/mm^2 $\sigma_{min} = 0.89$ kg/mm^2	$\sigma_{max} = 6.4$ kg/mm^2 $\sigma_{max} = 0.64$ kg/mm^2
Power press	7700	29,700
Direct blow	7890	26,380
Reverse blow	7780	30,910

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Note: 1. Sheets of V95AT; rivets of V65 material. 2. The load cycles shown in the Table, are the average of three tests

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smoothness of the outer surface and production output, preference should be given to power-press riveting. The application of the direct riveting method can be considered rational only when there is no possibility of using power-press riveting. The

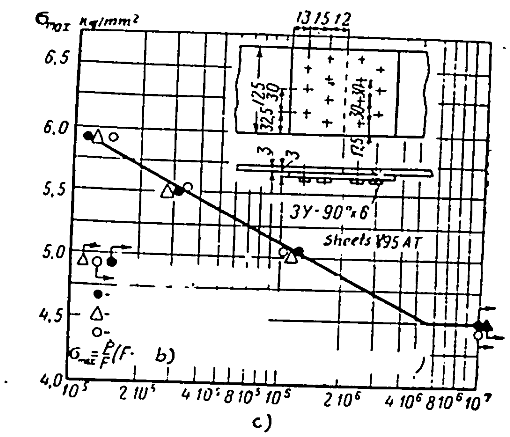

Fig.122 - Effect of Riveting Method on the Fatigue Strength of Joints (Sheets of V95AT, Rivets of V65; Test Carried Out at $\sigma_{shear} = 0.33\ \sigma_{fail}$)

Without rupture

● - Press riveting

Δ - Direct blows

o - Reverse blows

a) Sheets V95AT; b) (F is the cross-sectional area over the entire sheet);

c) Number of cycles to rupture

application of the reverse method of riveting is permissible only where power-press riveting or hammer riveting by the direct method is impossible.

3. Dimension of Clinched Rivet Heads

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In ordinary riveting (with protruding rivet heads) as well as in flush riveting (rivet heads flush with the surface), in the majority of cases the rivets are headed to a flat shape, the dimensions of which are shown in Table 40.

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The lower limit for the diameter of the clinching head is set to preserve a certain strength of the joint; the upper limit is set to minimize deformation of the

Table 40

Dimensions of Clinching Rivet Head, in mm

a)	b)	2,6	3	3,5	4	5	6	8	9,5	10
c)		3,9	4,5	5,25	6	7,5	8,7	11,6	13,8	14,5
d)		±0,25	±0,3		±0,4	±0,5		±0,8	±1	
e)		1,1	1,2	1,4	1,6	2	2,4	3,2	3,8	4

a) Specified rivet diameter d; b) Sketch; c) Diameter of clinching head D; d) Tolerance in D; e) Lowest tolerance of height h

joined parts in riveting.

At the established correlations of the rivet diameter, drill diameter, and length of shank allowed for heading of the rivet, the outside diameter of the clinched rivet head D will be equal to 1.5 ± 0.1 of the diameter of the rivet shank, i.e.,

$$D=(1,5\pm0,1)d.$$

The above correlation applies to rivets with a diameter of 5 mm. For diameters larger than 5 mm, the head is determined by the relation

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$$D=(1,45\pm0,1)d.$$

The height of the head is set by the lower limit, which assures equal shear strength of the head and bearing strength of the shank. Regardless of the rivet diameter, the height of the head will be h = 0.4 d.

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The dimensions of the head are greatly influenced by the overall length of the rivet, which depends on the grip of the parts being riveted and on the diameter of the drilled hole, corresponding to the diameter of the rivet.

In forming the rivet shank by upsetting, part of the material is intended for filling the clearance between the surface of the shank and the walls of the hole, and another part for the heading.

The volume of the rivet shank required for filling the annular space between the walls of the hole and the shank is determined by the relation

$$V = \frac{\pi (d_0 - d)^2}{4} S,$$

where d is the specified diameter of the rivet;

d_0 the greatest allowable diameter of the hole;

S is the thickness of the stack being riveted.

The volume of the rivet shank necessary for heading is determined by the relation

$$V = \frac{\pi D^2}{4} h,$$

where D is the greatest allowable diameter of the clinching head of the rivet;

h is the smallest allowable height of the clinching head of the rivet.

Aside from the above relations, other factors must be considered in calculating the length of rivets.

Table 41 contains data on the selection of rivets of lengths correspondi STAT the grip of riveted parts and also to the diameter of the rivets. The lengths shown in this Table will give clinching heads of dimensions corresponding to those in Table 40.

To determine the rivet length from Table 41, matching the corresponding grip of the parts, a straightedge is placed on the divisions of the scale of the nomogram which indicates the grip; the figures in the columns at right angles which intersect

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the straightedge line then will give the length of the rivet for the corresponding rivet diameter.

For example, for riveting a stack of sheets of a thickness of S = 8 mm, the lengths of the rivets should be as follows:

For d = 2.6 mm	L = 12 mm
For d = 3.0 mm	L = 13 mm
For d = 4.0 mm	L = 14 mm
For d = 8.0 mm	L = 17 mm

The tolerance for the rivet length depends on their length (from ± 0.2 to ± 0.4 mm). A deviation of ± 0.2 applies to rivets whose length does not exceed 10 mm; a tolerance of ± 0.4 mm applies to rivets whose length does not exceed 30 mm.

If the length of the rivets is properly selected for any particular grip, the holes will be properly filled, the head will be of the correct form, and the required strength of the joint will be met.

The riveting of stacks of great thickness with rivets of large diameter presents considerable difficulties. For the heading, relatively great forces are needed, requiring special powerful equipment. Furthermore, during the process of riveting with large-diameter rivets, the stack of sheets is subject to considerable deformation, distorting the original shape of the parts.

Rivets of a special type with centrally located holes in the shank end are used for certain riveting operations, with the purpose of reducing the work. Data on the design and dimensions of such rivets, together with the special tools requi STAT are given in Tables 42 and 43.

The force required for heading such rivets is considerably less than the force required for heading ordinary rivets with solid shanks. The strength of such rivet seams, based on static shear and tension tests, compares well with the strength of joints made with ordinary rivets having solid shanks.

A distinctive feature of this riveting process lies in the fact that, after the

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Table 41

Data for Selecting Proper Rivet Length for Various Diameters, Depending on the Thickness of the Stack Being Riveted

d	2	2,6	3	3,5	4	5	6	8	9,5	10
S	Length of Rivets L									
	4	4	5	6	6	8	10	14	18	18
	5	5	6	7	7	9	11	15	19	19
	6	6	7	8	8	10	12	16	20	20
	7	7	8	9	9	11	13	17	22	22
	8	8	9	10	10	12	14	18	24	24
	9	9	10	11	11	13	15	19	26	26
	10	10	11	12	12	14	16	20	28	28
	11	11	12	13	13	15	17	22	30	30
	12	12	13	14	14	16	18	24	32	32
	13	13	14	15	15	17	19	26	34	34
	14	14	15	16	16	18	20	28	36	36
	15	15	16	17	17	19	22	30	38	38
	16	16	17	18	18	20	24	32	40	40
		17	18	19	19	22	26	34	42	42
		18	19	20	20	24	28	36	44	44
		19	20	22	22	26	30	38	46	46
		20	22	24	24	28	32	40	48	48
			24	26	26	30	34	42	50	50
				28	28	32	36	44	52	52
					30	34	38	46	54	54
					32	36	40	48	56	56
						38		50	58	58
						40				60

S: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48

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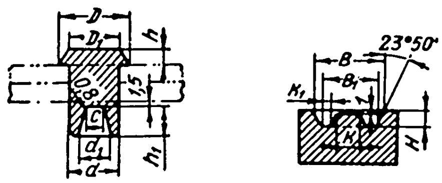
holes are drilled in the sheet stack, the edges of the hole are chamfered at the spots where the rivet shank is headed (Fig.123). This prevents cracks and reduces

Table 42

Dimensions of Rivets and Dies for Heading, with Depressed Head



a)	b)	c) d) 16	20	22	24
D	1,4	22,5	28	31	33,5
h	0,32	5	6,5	7	7,5
c	0,4	6,5	8	9	9,5
d_1	0,6	9,5	12	13	14,5
h_1	0,6	9,5	12	13	14,5
B	1,4	22,5	28	31	33,5
K	0,35	5,5	7	7,5	8,5
H	0,32	5	6,5	7	7,5
B_1	1,16	18,5	23	25,5	29
K_1	0,18	3	3,5	4	4,5

a) Symbol; b) Dimension in terms of rivet diameter d; c) Dimension of rivet and die; d) Rivet diameter d, in mm

the force required for riveting. STAT

When the riveting is done properly, the rivets will fit snugly fit into the holes in the sheet stack, while the dimensions of the heads becomes as follows:

a) For a head with a depression in the center (see Fig.123a);

$$D = 1.40\ d$$

$$h = 0.35\ d$$

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b) For an annular head (see Fig.123b),

$$D = 1.51\ d$$

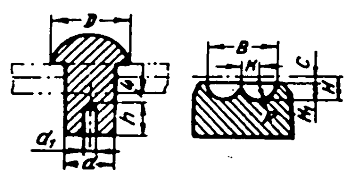
$$h = 0.37\ d$$

4. Filling of Holes with the Rivet Shank

The riveted joints in light-alloy structures are subject to high static and considerable alternating stresses which may lead to premature loosening of their

Table 43

Dimensions of Rivets and Dies for the Formation of Annular Heads



a)	b)				
	c)	d)			
		16	20	22	24
D	1,6	25,5	32	35	38,5
d_1	—	4,5	4,5	5	5,5
h	—	9	12,5	14	15
B	1,51	24	30	33	36
H	0,37	6	7,5	8	9
H_1	0,31	5	6	7	7,5
R	0,37	6	7,5	8	9
c	—	1	1,5	1	1,5
K	0,31	5	6	7	7,5

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a) Symbol; b) Dimension of rivet and die, in mm; c) Dimension in terms of rivet diameter; d) Rivet diameter d, in mm

joints and their destruction. For this reason, the extent to which the holes are filled with the rivet shank in joints of light alloys is one of the fundamental con-

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ditions determining their strength. This basic requirement is met by the proper relation of dimensions of the rivets and the corresponding holes, together with the

Fig.123 - Filling the Hole with the Rivet Shank

a - Head with a central depression; b - Annular head

application of the proper method of cold-riveting.

A comparison of cold-riveting of light metals with hot-riveting of sheet iron shows that the holes are filled better in the first case. Figure 124 gives compara-

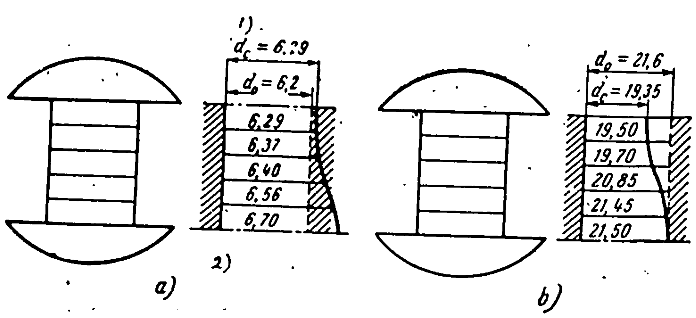

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Fig.124 - Filling of the Hole with the Rivet Shank

a - Cold-riveting of light alloys; b) Hot-riveting of sheet iron

1) Original rivet head; 2) Driven head

tive data for illustrating the extent to which the holes are filled in cold and in hot riveting practice.

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In cold-riveting it is observed that not only is the hole completely filled, there is some increase in the diameter of the hole; i.e.,

$$d_c = (1,02-1,08)\,d_o,$$

where d_c is the diameter of the rivet after riveting.

d_o is the diameter of the hole under the rivet.

In hot-riveting, the rivet shank does not completely fill the hole, i.e., a clearance exists between the rivet shank and the walls of the hole; in that case,

$$d_c = (0,9-0,98)\,d_o.$$

The peculiarities noted are explained by the manner in which the rivet shank is deformed. In cold-riveting, the hole starts first being filled because of the increase in the shank diameter followed by the heading.

In riveting light alloys, the increase in the rivet-shank diameter is not uniform over the thickness of the stack. The shank acquires a conical shape of 2 - 5% taper, with the apex of the cone in the direction of the original rivet head.

The increase in the shank diameter during riveting is accompanied by deformation and toughening of the sheet material, which is sufficiently significant to increase the hardness.

Figure 125 gives a space diagram representing the hardness at different points of the joint. This diagram shows that the increase in hardness of the shank material amounts to 3 - 5%, while the hardness of the material in the upset head reaches STAT 35% over the original. The hardness increases evenly from one area to the next, without skips, and without stress-concentration peaks which would cause premature failure of the joint under load.

The nature of the distribution of hardness and of toughness remains alike, regardless of the particular riveting method (whether by power press or hammering) or of the type of rivets used (Fig.126). In the sheet area in contact with the rivet

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shank, a certain cold-hardening exists, which is evidence that the rivet is under some tension. For this reason, when riveting parts of different materials or of the same material but different thicknesses, the driven head should, if possible, be on

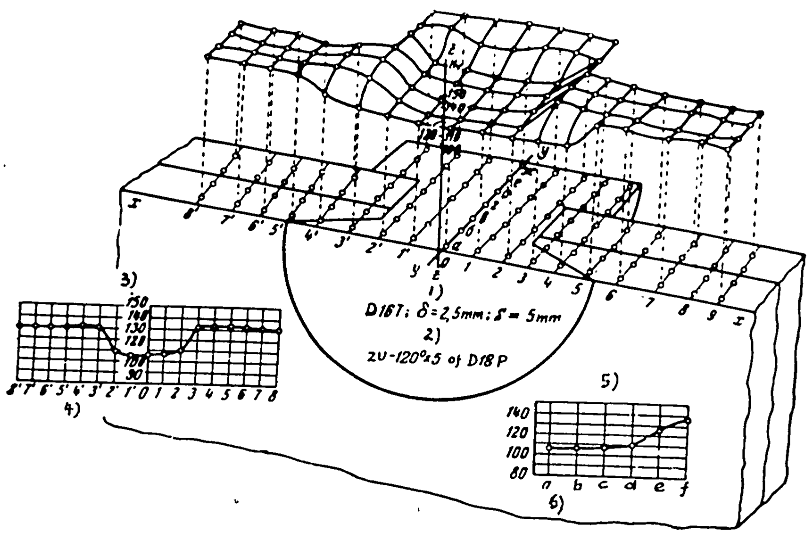

Fig.125 - Hardness of the Rivet and Sheet Material at Various Points of the Joint (Press Riveting)

1) Sheets of D16T; δ = 2.5 mm; S = 5 mm; 2) Rivet type ZU-120° × 5 of D18P; 3) Cross section through B; 4) Points of hardness measured along the axis x-x; 5) Cross section through 1; 6) Points of hardness measured along the axis y-y

the side of the harder material; if the hardness is the same in the riveted parts, then it should be on the side of the thicker sheet. STAT

It has been established that the dispersion of hardness in rivets when the riveting is done in power presses is less than when done by hammering. Hammer riveting does not ensure that the holes are completely filled throughout the thickness of the stack. It is especially difficult to obtain uniform filling of the holes with hammer riveting of stacks having a thickness of S = (2.5 to 3)d, or more. In

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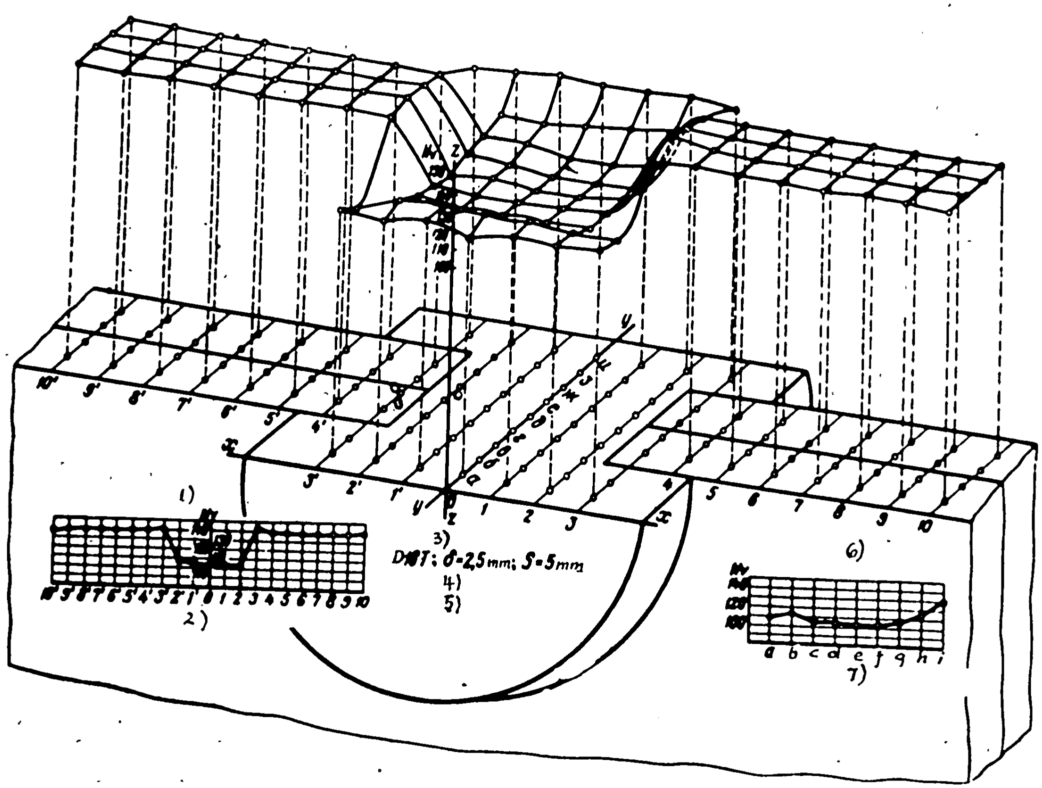

Fig.126 - Hardness of the Rivet and the Sheet Material at Various Points of the Joint (Hammer Riveting)

1) Cross section through e; 2) Points of hardness measured along the axis x-x; 3) Sheets of D16T; δ = 2.5 mm; S = 5 mm; 4) Rivets of type 855A5; 5) Hammer riveting; 6) Cross section through O; 7) Points of hardness measured along the axis y-y

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cases where power press riveting is not possible, this often requires the use of bolts or of rivets having a high shear strength.

The degree to which filling of the hole affects the strength of structural elements is illustrated diagramatically in Fig.127. The diagram shows that the strength of the strip in which the holes are filled is 4 - 8% higher than the strength of similar strips in which the holes have no rivets. This may be explained as follows:

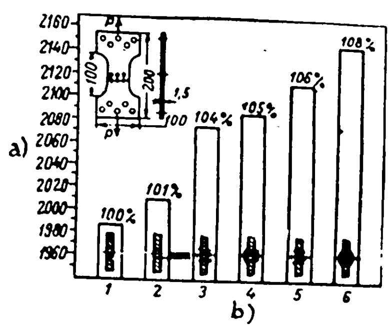

Fig.127 - Strength of Specimen Strips as Related to the Degree to Which the Holes Are Filled

1 - Strip with drilled holes;
2 - Strip with drilled holes exposed to view; 3 - Strip with clenched rivets (flat head) with filed-off heads;
4 - Strip with clenched rivets;
5 - Strip with clenched rivets (half-round heads) with filed-off heads;
6 - Strip with clenched rivets
a) Load at rupture in kg; b) Factors under investigation

During the riveting the rivet shank increases in diameter, exerting a pressure on the walls of the hole, deforming the sheet first within the elastic limit and then plastically beyond. Thus the rivet shank in the hole is under stress whose magnitude changes in proportion to the elongation of the strips. For example, the strength of a strip whose holes are completely filled with rivets having half-round heads, is higher in comparison with a similar strip in which the holes are also filled but with rivets having a flat head. The increase in strength of the strip where the holes are filled with rivets having half-round heads is due to the greater tightness (wedging against the walls of the hole) than that which is present with flat heads.

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The explanation given is confirmed by the results obtained on tests with vibrational loads. The graphs in Fig.128 indicate that the strength of the strip in which

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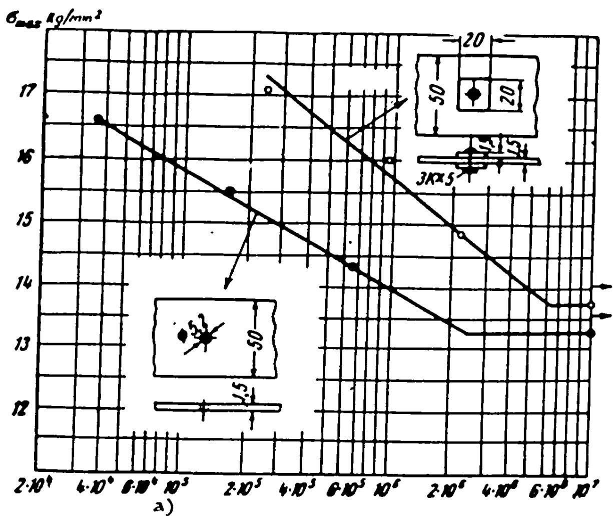

Fig.128 - Fatigue Strength of Strips with Riveted and with Open Holes

(Sheets of D16T; Rivets of D18 Material)

a) Number of cycles to failure

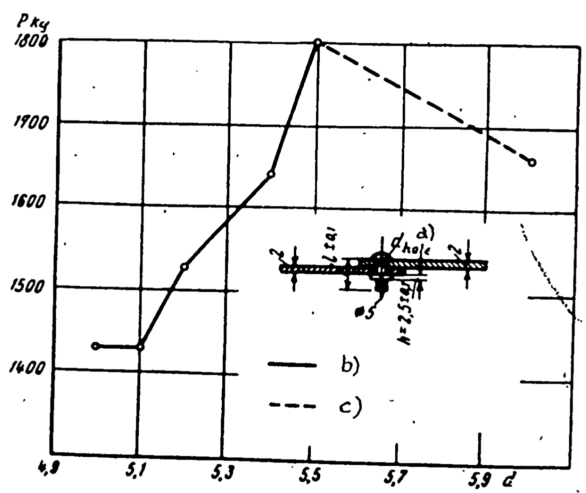

Fig.129 - Strength of Joints in Shear Tests as a Function of the Hole Diameter

a) Hole diameter d; b) Rivets in shear; c) Rupture of sheets

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the hole is filled, is higher under all types of loading than in a similar strip in which the holes are open.

All above statements indicate that, in order to obtain a high quality of workmanship in riveted joints, the holes must be well filled by the rivet shank, which is attained by the following practice:

1) Use of press riveting and hammer riveting by the direct method;

2) Selection of correct rivet length, corresponding to the thickness of the stack being riveted;

3) Adherence to correct technical riveting procedure (drilling, countersinking and riveting proper).

It should be noted that in drilling the holes for rivets, the diameter of the holes is in some cases too large, which may be due to improper grinding of the drill

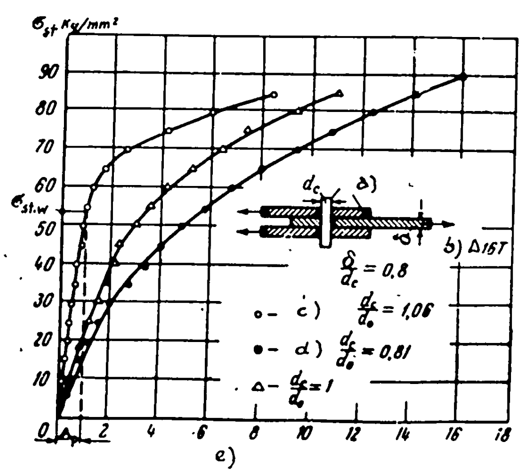

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Fig.130 - Diagram of "Stress Warping - Slip" as a Function of Fit

a) Dowel pin and fixture of steel; b) Sheet D16T; c) Tightness $d_c/d_o = 1.06$; d) Clearance $d_c/d_o = 0.81$; e) Slip Δl in % of diameter of dowel pin (d_c)

and to wobble of the chuck. The hole diameter in such cases is larger than the allowed tolerances. It was proved by experimental investigations that the static

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strength of joints in shear increases to a certain amount as the diameter of the hole is increased, and then drops abruptly (Fig.129). The filling of enlarged holes is done at the expense of the material allowed in the shank for the formation of the clenched head. As a result, the heading is not completed, which leads to premature rupture of the joint when the rivets are subjected to tension.

The degree to which the holes are filled has a considerable effect on the stress in shear, which increases as the hole becomes more tightly filled (Fig.130).

A tightly filled hole increases the ultimate point of elastic deformation in shear σ_{shear}; thus, the elastic deformation causing slip in the joint is lowered under static loads.

As seen from Fig.130, in cases where d_c/d_o = 1.06, which may take place in riveted joints, the ultimate stress σ_{shear} has a higher value, in which case the elastic deformation is at a minimum value.

The last conditions further confirm the necessity of carrying out the technical process of riveting in such a manner that the holes in the stack of sheets are tightly filled with the shank of the rivet.

5. Flush Riveting from Two Sides

In certain structures, surface smoothness on both sides of the seam is required i.e., from the side of the rivet and from the side of the clenched head. In such cases, the rivet heads are made flush on both sides.

Depending on the construction of the assembled units, two-sided flush rivSTAT is done as follows:

1) By countersinking recesses in the skin, under the rivet and under the clenched head (Fig.131a)

2) Countersinking recesses in the airframe (in the thickest portion) and dimpling recesses in the skin for the rivet-clenched heads (Fig.131b)

3) Countersinking in the outer skin under the rivet and in the airframe under

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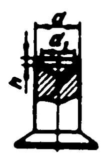
the clenched head, and dimpling recesses under the clenched head in the planking while riveting (Fig.131c).

Regardless of the method used in making the rivets flush on both sides, drilling of the rivet holes in the planking is done, in the case of the end stringer (air-frame), through the guide holes perpendicularly along its chord.

The countersinking of recesses under the rivets and clenched heads is done per-

Table 44

Dimensions of Holes in Rivet Shanks for Two-Sided Flush Riveting, in mm



Rivet diameter d	2.6	3.0	3.5	4.0
Hole diameter d_1	2.3	2.7	3.2	3.7
Depth of hole h	0.7		1.0	

pendicularly to the surface of the skin at each point (Fig.132). The pilot stem of the countersinking tool for this purpose is made short, with a spherical end.

Table 45

Allowance for Heading

Diameter of rivet, in mm	2.6	3.0	3.5	4.0 STAT
Allowance for the clenched head, in mm	1.3	1.5	1.75	2.0

The countersink is made with a cutting tip whose shape depends on the thickness of the sheet being countersunk and the type of rivets used, being as follows:

1) For countersinking recesses under the rivet, the angle of the cutting point

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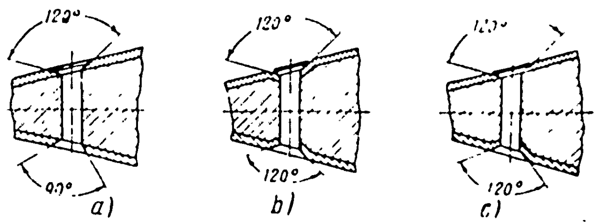

Fig.131 - Methods of Performing Two-Sided Flush Riveting

a - Countersinking recesses in the skin; b - Countersinking recesses in the airframe and dimpling recesses in the skin for the rivet and the clenched heads; c - Countersinking of the outer skin for the rivet and of the airframe for the clenched heads

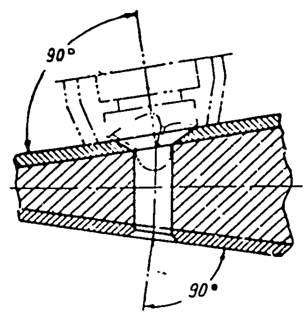

Fig.132 - Aligning of the Countersink for Two-Sided Flush Riveting

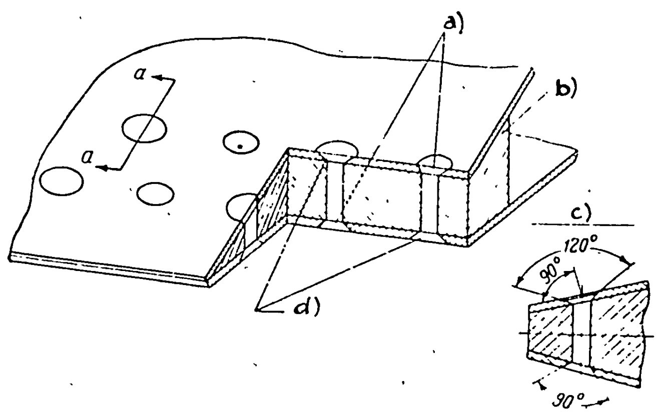

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Fig.133 - Riveting of Skin Over the End Stringer with Alternate Position of the Original and the Clenched Heads in the Countersunk Recesses of the Skin

a) Clenched head; b) End stringer; c) Section through a - a; d) Original head

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is made equal to the angle of the rivet head;

2) For clenched heads in the case of thick plankings the cutting point of the countersink is made to an angle of $\alpha = 90°$;

3) For clenched heads in the case of thin plankings the cutting point of the countersink is made to an angle of $\alpha = 120°$.

The rivets to be used may be of a type corresponding to specification 2022A50, with the shanks finished in accordance with Table 44.

The allowance for the heading is assumed as equal to 0.8 of the rivet diameter; in case rivets of the type listed in Table 44 are used, the allowance for the heading is taken as outlined in Table 45.

The upper and lower plankings are joined along the stringer with one or two rows of rivets in flush riveting. For this reason, the original and the clenched rivet heads must be arranged along the lower and upper skin in a definite sequence, as shown in Fig.133.

The riveting is performed by pneumatic hammers for the direct method, and the reverse method is used in exceptional cases.

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CHAPTER VIII

PRESS RIVETING, AUXILIARY TOOLS AND EQUIPMENT

1. General Considerations

Depending on their operating characteristics, tools used for riveting can be subdivided into two classes; namely, hammer and press types.

The most widely used tools based on hammer action are hand-operated pneumatic hammers. Their advantage consists in that they possess a wide range of application under most situations, particularly when the riveting is done in assembly fixtures. Their disadvantage is that it is difficult to obtain a high degree of surface smoothness, that their operation is noisy, and that the rate of productive output is comparatively low. A more precise method of riveting is to employ power-press equipment, by means of which most of present-day riveting of light-alloy structures is done.

In this country, a great deal of work on press riveting and on the development of technical processes of assembly by riveting was accomplished by the Engineers V.G.Gorokhov, M.M.Belikov, K.P.Kolobayev, L.I.Rokhlin, M.I.Slesarev, V.V.Bakulin, and others.

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A desirable characteristic of press riveting is that the formation of the clenched rivet head is done by uniform pressure on the rivet shank. The basic advantage of press riveting over hammer riveting are as follows:

1) Facilitating the work of riveters due to reduction in noise.

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2) Increase in production output, attained by full utilization of the power of the equipment, the adoption of group riveting procedure, and the elimination of helpers.

3) Improvement in the quality of surface smoothness of the riveted parts.

4) Higher strength of the riveted joints, obtained by tighter and more uniform filling of the holes by the rivet shank.

5) Greater uniformity in the quality of the riveted joints, since individual peculiarities of the workmen are absent.

The advantages of press riveting, whether done singly or by the group method,

Table 46

Economic Aspects of Riveting with Pneumatic Hammers and of Single and Group Riveting on Presses

Economic factors	Type of equipment		
	Press group riveting	Single press riveting	Pneumatic hammer
Average output in a shift per unit of equipment in number of rivets	16,000	4000	3200
Approximate cost to rivet 1000 rivets, including power, labor cost and amortization of equipment, (in rubles)	4	12	13

Note: Computations are based on rivets of 4 mm diameter and a press with a power of 25 tons.

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over hammer riveting, as far as the economic technical aspects are concerned, are illustrated in Table 46.

It is seen from the Table that, in single riveting, the production costs and the output are approximately alike for hammer and for press riveting. Group rivet-

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ing on presses is considerable more economical.

The practical experience of leading plants into which press riveting was introduced confirm its great effectiveness. For example, with a press of 70 tons there was a saving of 61 man-hours on one job of group riveting (planking of a wing) as compared with hammer riveting. In another plant, as a result of changing over to press riveting of 140 assembly units, the amount of labor involved was reduced to one half.

The increase in the volume of work output with press riveting is connected with the necessity of separating major units into their constituent components, such as minor units and panels, and the installation of more highly mechanized equipment, tools, and instruments. If a methodical procedure in the handling of panels in structures is developed, it is possible to bring up the percentage of press riveting to 70 - 80%.

The advantages of press riveting show particularly in structures where, in addition to the requirements of higher strength of the riveted seams, greater surface smoothness of the riveted joints is required. It has been established by investigations that press riveting, either single or group, contributes to the improvement in surface smoothness, as compared with hammer riveting. It is to be noted, however, that the quality of flush-riveted joints depends not only on the tools and equipment used in riveting, but also on how well the geometry of the recesses agrees with that of the rivets, on the quality of work in drilling and countersinking, and on the qualifications of the workers. All of these factors have to be taken into consideration.

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As compared with hammer riveting, press riveting results in considerably less drawing of the material, and for this reason there is less distortion in the shape of the joints which is the cause of cavities, swelling, indentations, and other defects associated with hammer riveting.

When riveting with pneumatic hammers, the sheets are first squeezed together

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before the riveting operation; due to the springiness of the material there may be voids between the parts so that the frictional contact between the sheets is not perfectly uniform, which may cause distortion in the shape of the riveted parts.

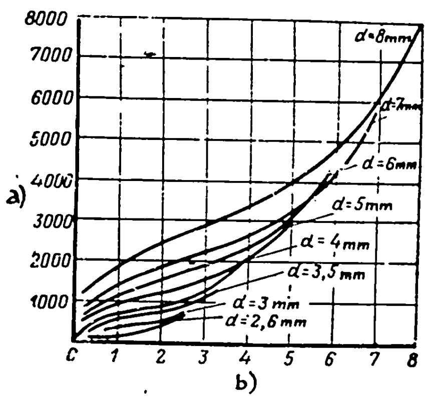

Fig.134 - Curves Showing the Relation Between the Applied Force and the Diameter of Duralumin Rivets with Flat Clenched Heads

a) Force in kg; b) Upset rivet portion in mm

In press riveting, the heading is effected while the stack of sheets is squeezed together firmly, with the adjoining parts in close contact and held by greater frictional forces than in the case of hammer riveting.

While the work in press riveting is facilitated by the methodical handling of the constituent parts of major assembly units, there are also other requirements the compliance with which may result in the use of group press riveting on a wider scale. Among these basic requirements are the following:

1) The panels should preferably have similar curvatures and as far as possible have only longitudinal elements of rigidity that permit free access to the place of riveting.

2) It is desirable that the riveted seams are made in accordance with staSTAT-ized practice throughout and that the number of different types and sizes of rivets is held down to a minimum.

3) Rivets with flat heads in place of rivets with half-round heads should be used for inside component members of the airframe.

4) Components with concealed riveted joints should be limited in number as far

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as possible.

Compliance with these requirements will enable to change over almost entirely from hammer to press riveting of major and minor assembly units.

2. Classification of Riveting Presses

According to the manner of their utilization, riveting presses may be classed as follows:

1) Stationary type for group riveting;

2) Stationary type for single riveting;

3) Portable type for single riveting.

The range of application of one type or another is determined by the volume of riveting work, the dimensions of the assembled units, ease of access to the place of riveting done, and by other structural and technical characteristics of the parts being riveted.

Riveting presses may be classed according to the power requirement and the method of utilization as follows:

1) Lever-type pneumatic;

2) Direct pneumatic;

3) Hydraulic;

4) Pneumatic-hydraulic.

The operating principle of pneumatic lever-type presses consists in transmitting the air pressure exerted on a piston head to the die through a system of levers, with the result that a comparatively low force on the piston head is converted into a larger force acting on the die.

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On a majority of presses of this type, the increase in the force acting on the die corresponds to the inherent requirements of the riveting work, the force being greater when the heading is more pronounced, as indicated by the curves in Fig.134. This also increases the efficiency of the press. Such presses are built with a

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quick return motion, which contributes to a greater work output by reducing the machine operation time.

In terms of kinematics, the action of the most widely used lever-type pneumatic presses is based on the principles A, B, or C.

<u>Presses Operating According to Principle A</u> (Fig.135) are simple in design. The mechanism of such presses consists of a system of levers of the 1st or the 2nd order. The following relations apply to presses of this type:

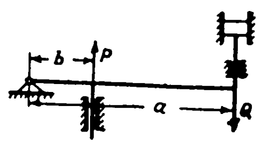

Fig.135 - Kinematic Diagram of the Lever-Type Pneumatic Press, Operating on the Principle A

1. At a constant force Q, exerted on the piston head, the force P exerted on the die is directly proportional to the arms a and b. Usually such presses are built to fixed dimensions of the arms, so that there is a direct relation between the stress P and the force Q, i.e.,

$$P = Q\frac{a}{b}\eta_M;$$

$$Q = \frac{\pi D_p^2 p}{4},$$

where p is the pressure of the available compressed air (5 kg/cm^2);

η_M is the mechanical efficiency, equal to 0.9 - 0.95;

D_p is the diameter of the pneumatic cylinder, in cm.

2. The motion of the die under the stress P and of the piston under the force Q is inversely proportional to the arms a and b, whence the distance traveled by the die is

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$$y = x\frac{b}{a},$$

where x is the travel of the piston in cm.

Figure 136 gives a curve for the relation between the force acting on the die and its travel. The travel is indicated by the straight line DC, while the work

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performed by the die in one cycle of operation is indicated by the shape of the ABCD. The curve AC represents the actual force required to upset the flat head in duralumin rivets (see Fig.134). The cross-hatched triangle ABC is the part of useful work utilized in upsetting the head, while the area of the triangle ADC represents the lost work.

The ratio of useful work performed to the total work done by the press is de-

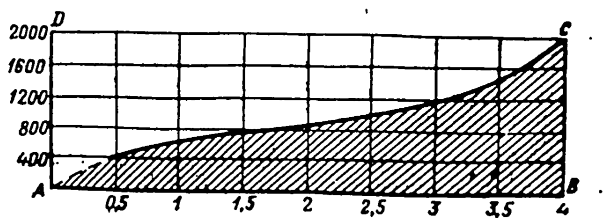

Fig.136 - Diagram of the Pressing Process on the Principle A

a) Stress P, in kg; b) Travel of set die, in mm

fined as the coefficient of efficiency η_k of the riveting process.

Usually presses operating on this principle have a comparatively low efficiency, $\eta_k = 0.4 - 0.5$. This is due to the fact that the force P acting on the set die, which is equivalent to the force required for upsetting the rivet, acts during the entire travel, while actually this force is needed only at the end of the stroke.

<u>Presses Operated According to Principle B</u> (Fig.137) have a more complicated system of levers. The relationship between the force P on the die and the force Q on the piston, in presses operated according to principle B, is expressed mathematically by the formula

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$$P = \left[Q \frac{1 + \operatorname{tg} \alpha \operatorname{tg} \gamma}{\operatorname{tg} \beta - \operatorname{tg} \alpha} \right] \eta_{м}.$$

The travel of the die is determined by

$$y = a \cos \alpha - b \cos \beta.$$

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The force P on the die and its travel may be represented graphically by the shape of curve (1) in Fig.138. The work performed by the press during the working stroke is represented by the hatched area. The actual work needed for the rivet

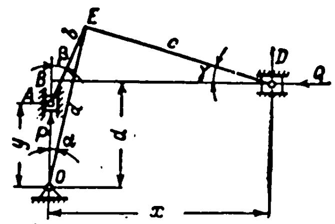

Fig.137 - Kinematic Diagram of Lever-Type Pneumatic Presses Operating on Principle B

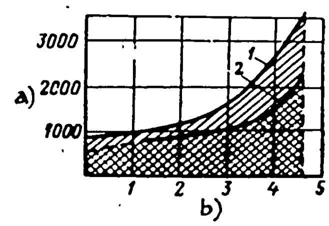

Fig.138 - Diagram of the Stroke in Press Riveting, According to Principle B
a) Force P in kg; b) Travel of die in mm

heading is represented by the cross-hatched area under the curve (2).

The coefficient of efficiency of the riveting process when presses of this type are used, is η_k = 0.5 - 0.6. In cases where such presses are utilized in riveting

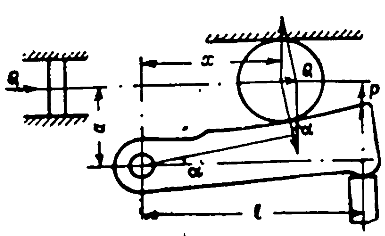

Fig.139 - Kinematic Diagram of Lever-Type Pneumatic Presses, Operating on Principle C

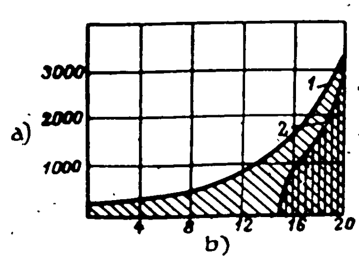

Fig.140 - Diagram of Press Riveting According to Principle C
a) Force P in kg; b) Travel of set die, in mm

work, using rivets of a smaller diameter than that for which the press is intended,

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will be still less, since the area under the curve (2) is correspondingly reduced.

Presses Operated According to Principle C (Fig.139) are in much wider use. The relation between the force P and the force Q in presses operated in accordance with principle C is expressed mathematically by the formula

$$P=\left[\frac{Q}{b}\left(a+\frac{x}{\operatorname{tg}\alpha}\right)\right]\eta_{м}.$$

For practical calculations, the travel of the die can be determined from the change in the angle of the lever by the formula

$$y=l\operatorname{tg}(\alpha_{initial}-\alpha_{end}),$$

where $\alpha_{initial}$ is the angle of the lever at the beginning of the stroke;

α_{end} is angle of the lever at the end of the stroke.

The work diagram of press riveting according to the principle C is represented in Fig.140, where curve (1) shows the force P on the die as a function of its travel, and curve (2) represents the force necessary for upsetting duralumin rivets.

The coefficient of efficiency in riveting with presses of group C is sufficiently high, with η_k = 0.7 - 0.8.

The basic operating principle of pneumatic presses consists in utilizing directly the energy of compressed air, whose pressure is transmitted throug STAT series of pistons onto a plunger that holds the die (Fig.141).

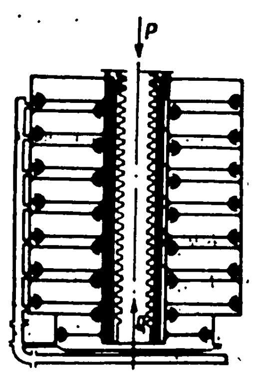

Fig.141 - Simplified Power Diagram for Pneumatic Press

In presses of this type

$$P=Q\eta_{м}=\left[\frac{\pi D_{F}^{2}}{4}pn\right]\eta_{м},$$

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where D_p is the diameter of the piston inside the cylinder, in cm;

p is the pressure of the compressed air in the system, in kg/cm^2;

n is the number of pistons in the cylinder.

The force acting on the set die is constant, and is independent of its travel.

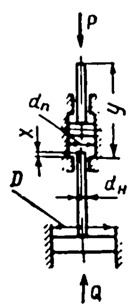

Fig.142 - Simplified Kinematic Diagram of the Hydraulic Press

The diagram of the process of press riveting is the same as for presses operating according to principle A (see Fig.136).

The operating principle of hydraulic presses consists in the conversion of comparatively low oil pressure into high hydraulic pressure by passing it from the main oil line through an intensifier, the pressure being transmitted through a cylinder in the press to the set die. Figure 142 shows a simplified diagram of the principle on which such presses operate. In the utilization of presses in this group the relation between the forces P and Q is expressed mathematically by the formula

$$P = Q\frac{d_p^2}{d_n^2}\eta_м.$$

In the diagram shown for the press, d_p and d_n have constant values, and consequently the force P is constant throughout the working stroke and is directly related to the pressure of the oil which goes from the main oil system into the booster.

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The same diagram applies also to presses which combine pneumatic and hydraulic operation, having in the same unit pneumatic and hydraulic cylinders. A combination of this sort makes it possible to convert low compressed-air pressure into high pressure in the hydraulic cylinder, which is transmitted through a mechanical system to the set die of the press.

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Pneumatic, hydraulic, and pneumatic-hydraulic presses may be used for riveting stacks of variable gage without re-adjustment for the thickness of the stack, for the reason that such presses possess the characteristic that the force is the same, re-

Table 47

Force in kg, Required for the Formation of Flat Clenched Rivet Heads

Rivet material	Diameter of rivet, in mm								
	2.6	3	3.5	4	5	6	8	9	10
Aluminum alloys D18, D16, and V65	700	950	1500	2000	3000	5000	8000	10000	12500
Steel 15A	1000	1300	2200	2500	5000	6000	10000	13000	16000

Note: 1. The forces indicated are in round figures.

2. For the formation of half-round clenched rivet heads, the riveting forces are 2.2 times greater than those given in this Table.

gardless of the position of the actuating power piston in the cylinder.

A very important condition that determines the suitability of a press for a variety of riveting work, is its maneuverability, which is determined by the size and weight of the press.

Figure 143 shows comparative sizes of power cylinders used in pneumatic, hydraulic, and pneumatic-hydraulic presses, which develop a force on the die necessary for riveting duralumin rivets of 6 mm in diameter. The diagram indicates that hydraulic presses are of smaller size as well as of lesser weight. This fact should be given particular consideration in connection with any project involving portable presses.

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Presses of the required capacity are selected on the basis of the force needed for formation of the clenched rivet head (Table 47).

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The design of riveting presses must fully meet the following basic requirements:

1) Provide a high rate of production by increasing the number of working strokes per unit time;

2) Permit operation of the press without re-adjustment whenever the thickness of the stack or of the diameter of the rivet is changed;

3) Permit smooth travel of the plunger;

4) Ensure unhampered movement of the parts being riveted in the working area of the press;

5) Permit operation of automatic straightening and relocation of panels and assembly units of large size in group steps, (when using automatic straightening and supporting devices);

6) Permit automatic riveting operation and servicing of the press by one workman.

The domestic industry is manufacturing a series of riveting presses of original

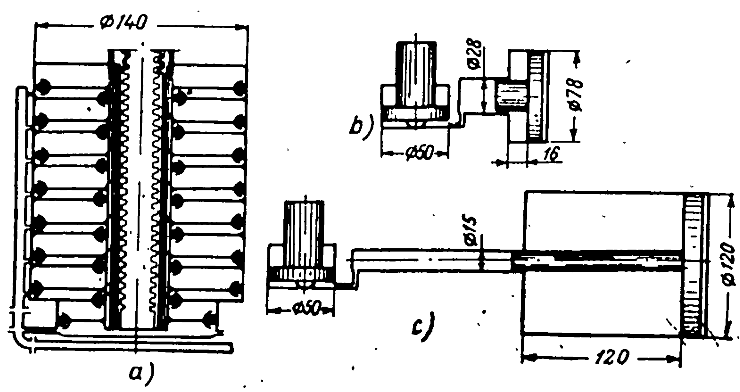

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Fig.143 - Comparative Sizes of Power Cylinder Units Developing Pressures up to 6000 kg

a - Power unit of pneumatic presses; b - Power unit of hydraulic presses; c - Power unit of pneumatic-hydraulic presses

design, which, because of their high productivity and simplicity of maintenance, are

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used successfully for riveting of light alloy structures.

3. Presses for Group Riveting

A feature of presses for group riveting is that they have solid housings, which permits the application of high pressure by the plunger on the supporting prop

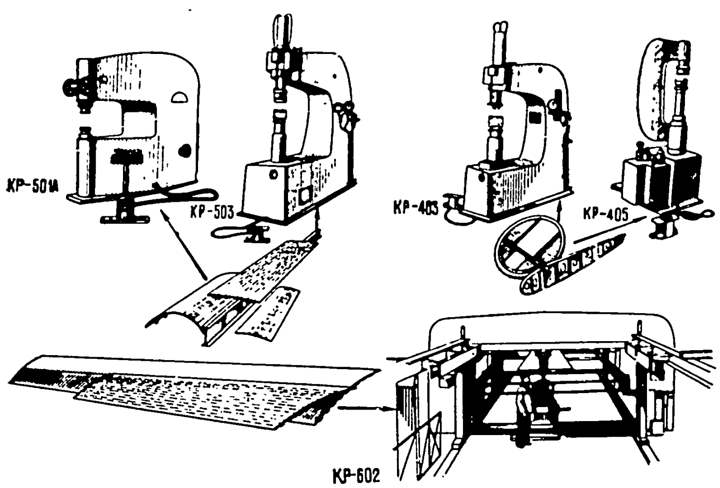

Fig.144 - Press Equipment for Group Riveting of Various Assembly Units and Panels

through a group of rivets. According to their capacity they are subdivided into the following types (Fig.144):

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1. Presses of type KP-602, for riveting panels of large size with a large spread of the riveted seams;

2. Presses of type KP-501 and KP-503, for riveting components such as girders, panels of intermediate size, and other assemblies;

3. Presses of types KP-403 and KP-405, for riveting comparatively small assembly units such as ribs, frames, small girders, etc.

Technical characteristics of these presses are given in Table 48.

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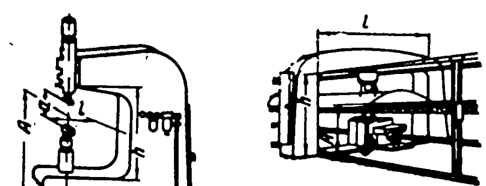
Table 18

Technical Characteristics of Presses for Group Riveting

a)	b) Ø3 mm	b) Ø4 mm	b) Ø5 mm	b) Ø6 mm	b) Ø8 mm	c)	d)	e)	f)	g)	h)	i)	j) l)	j) m)	k) n)	k) o)	k) p)	q)
KP-602	—	36	22	16	8	70000	3—4	200	450	1700	150	300	4600	2300	28000	6700	3250	—
KP-510	32	24	14	10	6	48000	10	100	—	—	—	—	1200	500	2260	2670	690	—
KP-501A	28	15	10	7	4	30000	12—20	35	430	1400	115	70	1050	600	2500	2360	930	0,13
KP-503	25	12	8	—	3	25000	5—14	16	500	1400	175	125	1200	1000	2700	2450	700	0,22
KP-403	12	6	4	3	1	12000	12—24	16	490	1300	175	125	750	1000	1800	2400	500	0,13
KP-405	12	6	4	3	1	12000	15—30	16	216	1350	200	—	300	690	2700	2450	700	0,05



a) Type of press; b) Number of duralumin rivets being riveted in one stroke of the press; c) Force on plunger, in kg; d) Number of working strokes per minute; e) Working travel of the lower plunger, in mm; f) Greatest distance between the contact surfaces of the dies, in mm; g) Greatest distance from floor to the center line of riveting; h) Auxiliary travel of the lower die to the center line of riveting, in mm; i) Travel of upper die to center line of riveting, in mm; j) Opening of press, in mm; k) Overall dimensions, in mm; l) Overhang, l; m) Jaw opening, h; n) Length; o) Height; p) Width; q) Consumption of air during one working cycle, in m^3

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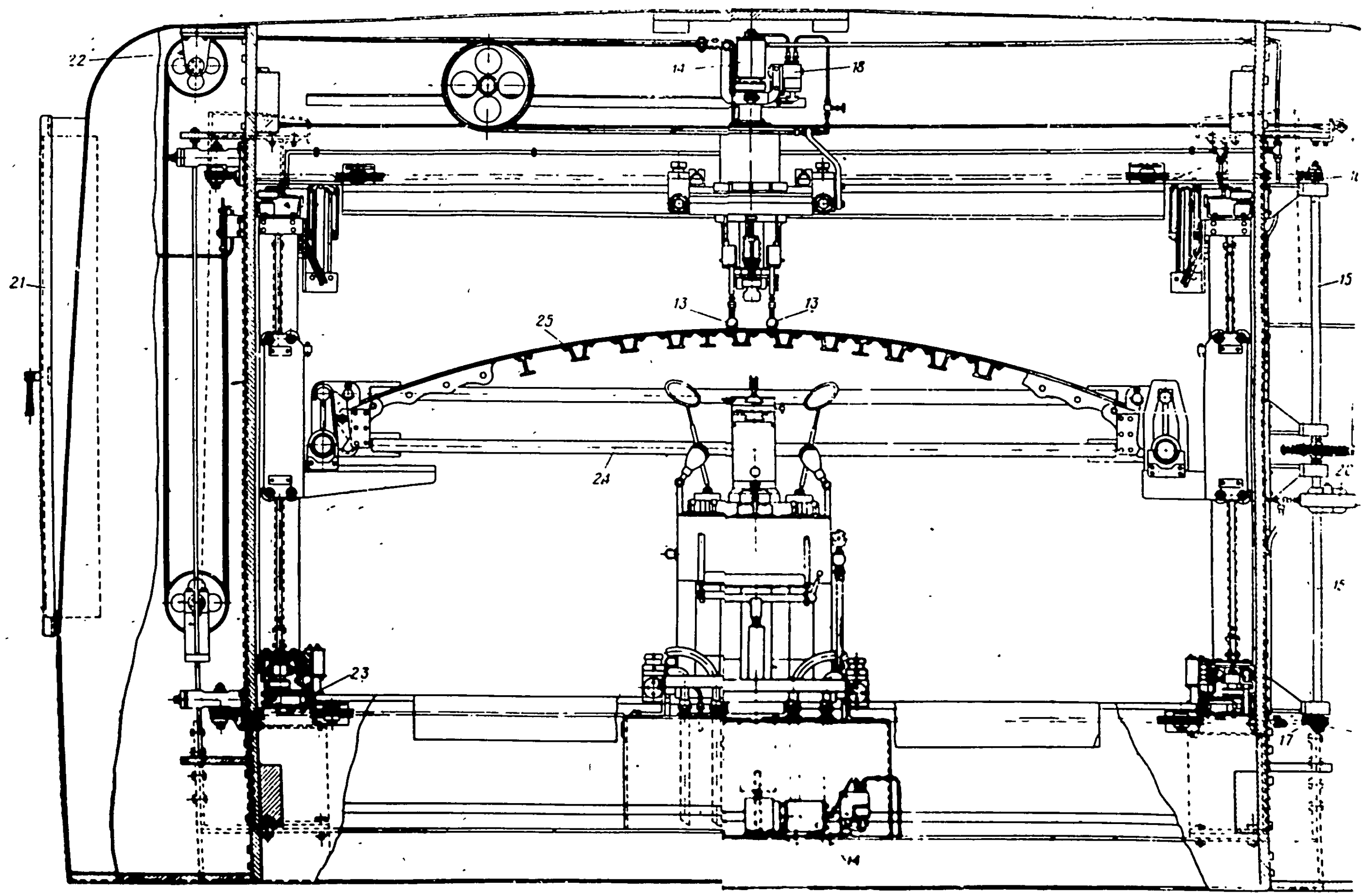

Fig.145 - Construction of Press KP-602 for Group Riveting

(For continuation and captions see page 185)

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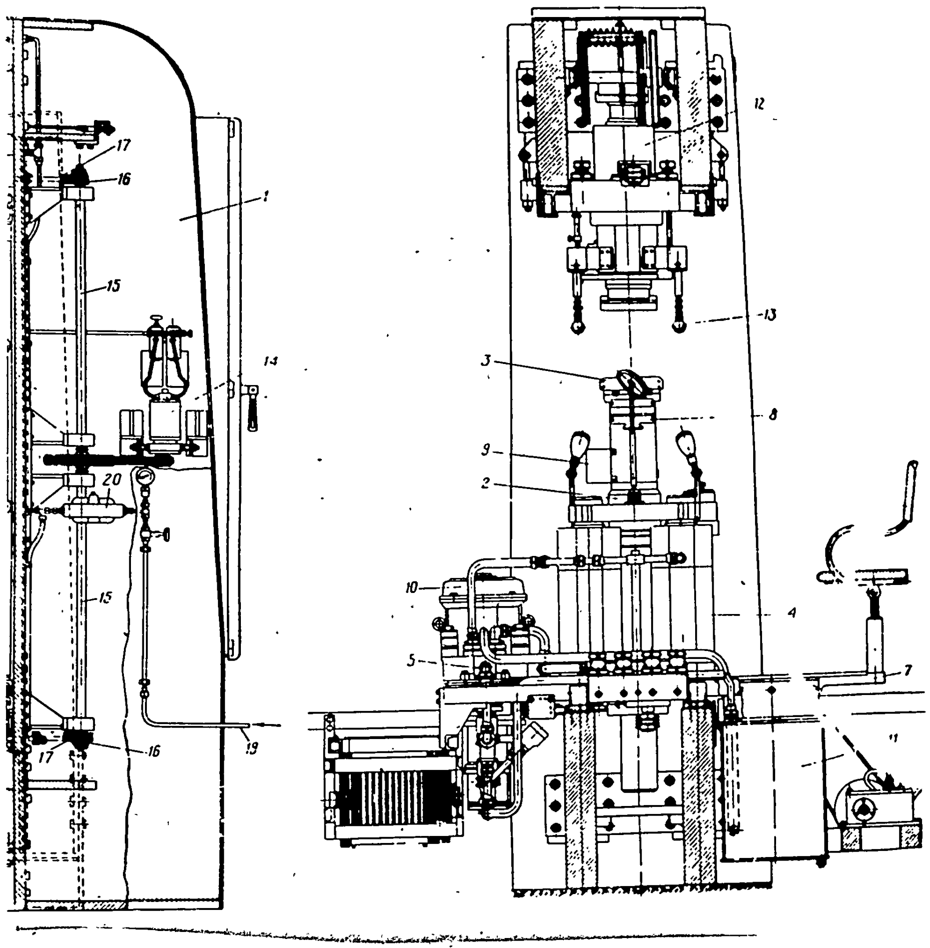

1 - Housing;
2 - Lower plunger;
3 - Riveting tool;
4 - Hydraulic cylinders;
5 - Hydraulic drive;
6 - Riveter seat;
7 - Carriage;
8 - Detecting mechanism;
9 - Automatic mechanism for the formation of the clenched rivet heads;
10 - Electric motor;
11 - Oil reservoir;
12 - Upper plunger;
13 - Feeler gage;
14 - Pneumatic motor;
15 - Vertical rolls;
16 - Control wheel;
17 - Roller chains;
18 - Electro-pneumatic starting device;
19 - Compressed air line;
20 - Automatic lubricator;
21 - Electric appliances;
22 - Tension device for the electrical wiring of the upper head;
23 - Control for the trolleys;
24 - Frame for bracing the part being riveted;
25 - Part being riveted (a panel)

(Fig.145 - continued)

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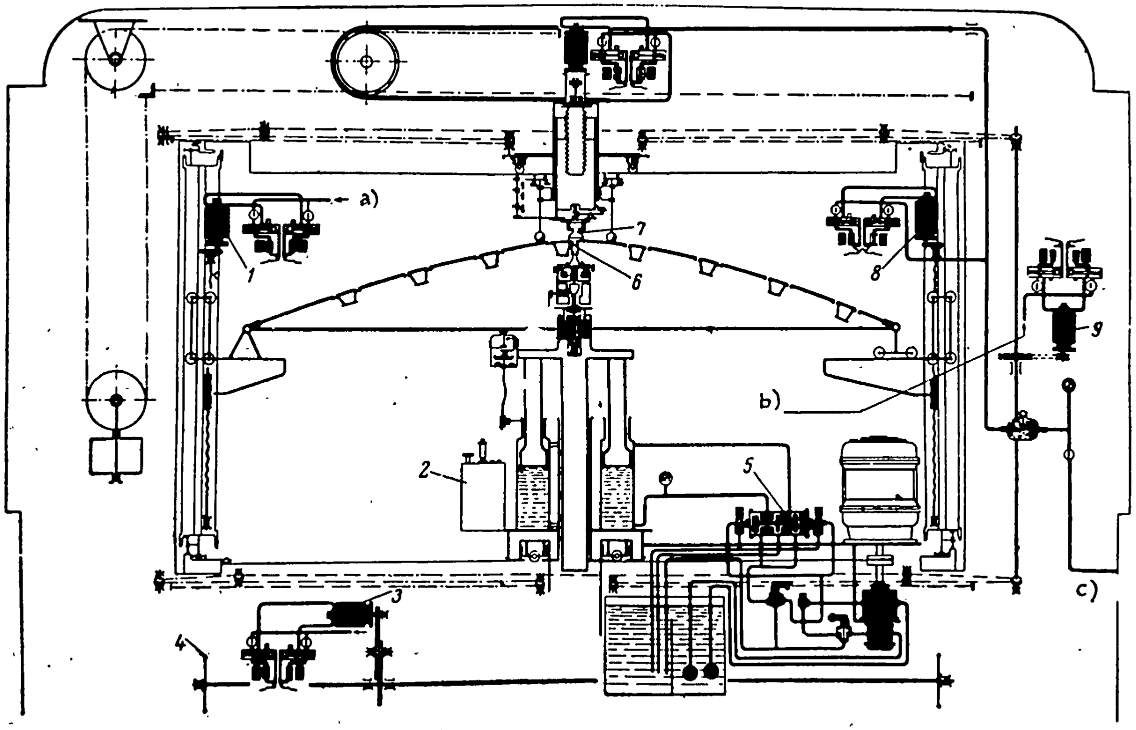

Fig.146 - Kinematic Diagram of Press KP-602

1 - Drive for hoisting mechanisms; 2 - Control panel; 3 - Carriage drive; 4 - Cable for carriage; 5 - Hydraulic system; 6 - Lower die; 7 - Upper die; 8 - Drive for hoisting mechanism; 9 - Drive for horizontal change of position of the heads

a) From the main line; b) From the valve of main manual control; c) From the main line

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Press KP-602

The parts to be riveted are delivered to the press with the rivets installed, and the following operations are performed on the press automatically:

1) The surface of the workpiece is aligned perpendicularly to the axis of the rivet heads;

2) In successive steps, the upper and lower die blocks for group riveting approach the workpiece, the stack is squeezed together, the clenched rivet heads are formed, and the die blocks are returned to the original position;

3) The workpiece is conveyed for other group operations.

The operation of the KP-602 press is controlled by electric microswitches and relays. The riveting of stacks of varying thickness, with rivets of different diameter, is performed without additional adjustment of the press.

The press (Figs.145 and 146) consists of the following components: the housing, lower and upper riveting heads, mechanism for horizontal shifting of the rivet heads, compressed air system, detecting mechanism, mechanism for the formation of the clenched rivet heads, mechanism for automatic withdrawal of the plungers in the lower head, a tightening device, riveting tools and the supporting mechanism.

The housing (1) (see Fig.145) is the basic element of the press, on which are mounted all the principal components and which serves at the same time as a support for the carriage on which the parts to be riveted are laid out and positioned properly for riveting. The housing consists of a steel frame made of two vertical cast steel columns united at the top and bottom by two girders. Each girder serves as a support and guide for the riveting heads.

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There are openings in the sides of the columns for providing access to the mechanisms and apparatus located inside the housing. The top of the housing is provided with a removable cover. The foundation of the housing is below the floor level.

The Lower Riveting Head functions as the power unit for the formation of the

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clenched rivet heads. The riveting head consists of the plunger (2), carrying the riveting die block (3), four hydraulic cylinders (4), the hydraulic line (5) and a control panel with a seat (6) for the operator. The entire mechanism of the lower riveting head is mounted on the carriage (7), which shifts it along guide rails in the opening in the press from one column to another.

The plunger carries the detector mechanism (8) in guide grooves of rectangular cross section for the riveting tool, the automatic mechanism (9) for heading the rivets to the correct height, and an automatic mechanism for withdrawal of the plunger from the workpiece.

The working and the return stroke of the plunger is effected by oil pressure from two pumps operated by an electric motor (10). The oil reservoir (11) of the hydraulic system has a capacity of 340 liters. All elements of the hydraulic system are mounted on the carriage of the lower riveting head and are moved along with it.

The control panel is located in front of the riveter. The upper part of the panel carries the operating controls of the press, such as pushbuttons for starting, manual controls, and signal light.

<u>The Upper Riveting Head</u> with the upper riveting dies takes up the force exerted by the lower riveting head. The plunger (12) of the upper head is lowered and raised by means of a reversible pneumatic motor with the aid of a lead screw which transmits the motion to the nut on the plunger. The pneumatic motor is operated by two valves, providing rotation of the shaft of the motor to the right and to the left.

Four feelers (13) are fixed on the upper head, which serve to start up the mechanism that levels the surfaces of the parts being riveted before the rivetinSTAT eration. A mechanism is located on the upper head for automatic stopping of the travel of the plunger. As the riveting tools come into contact with the surface of the work being riveted and with the supporting props, the corresponding microswitches are actuated. One microswitch stops the plunger in its extreme upper position, while another limits the withdrawal of the plunger during the interval when the work is

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being lined up for another series of group riveting. The upper riveting die fits into a groove in the plunger. The upper head is mounted on a trolley which moves along the upper guide rails of the housing.

The Horizontal Alignment Mechanism for the rivet heads consists in the synchronous alignment of the upper and lower riveting heads along the opening of the press. This mechanism consists of a reversible pneumatic motor (14) installed on a bracket on the right half of the press and the vertical shafts (15) with two sprockets (16), which transmit the motion through a system of intermediate sprockets and roller chains (17), and bring the upper and lower carriages of the riveting heads into alignment.

The Pneumatic System of the Press provides raising and lowering of the upper riveting head, drives the horizontal alignment mechanism for the rivet heads, and operates the carriages and the four hoists for the automatic setting up and alignment of parts to be riveted. The pneumatic system consists of seven reversible pneumatic motors of the same type, electric and pneumatic starting controls (18), air supply lines, and devices for operation and servicing of the pneumatic system. The pneumatic system is supplied with compressed air at a pressure of 5 atm from the main line. The air is supplied to the components of the horizontal alignment mechanism for the rivet heads and to the carriages through pipes, and to the upper head and the hoists through flexible rubber hose.

The most important components of the pneumatic system are the drive of the upper head and the horizontal alignment mechanisms of the carriages. The piping system includes an inlet valve, gage, settling tank, and an automatic lubricator. STAT

The special reversible pneumatic motor shown in Fig.147 is of the piston type and of flange construction. It consists of a revolving cylinder block (1) and a stationary distribution valve (2). The reciprocating motion of the pistons is transformed into rotary motion of the main shaft (3) by means of the rocking disk (4). The planetary gear reducer (6) reduces the number of revolutions of the power take-

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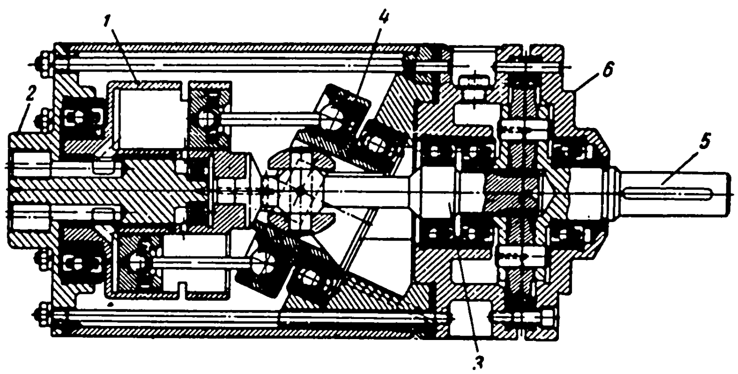

Fig.147 - Reversible Pneumatic Motor

1 - Block with cylinders; 2 - Distributing valve; 3 - Main shaft;

4 - Rocking disk; 5 - Driven shaft; 6 - Planetary reducer

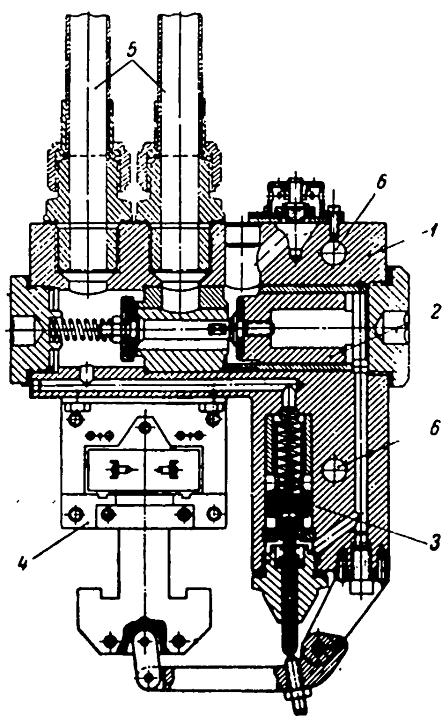

Fig.148 - Electro-Pneumatic Starting Device

1 - Body; 2,3 - Valves; 4 - Electromagnet; 5 - Connecting fittings; 6 - Holes for fastening the electro-pneumatic device

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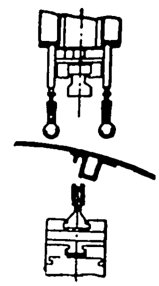
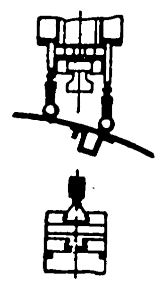
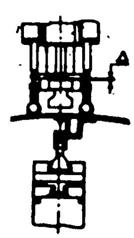
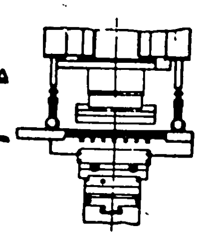
Table 49

Outline of the Technical Process of Riveting on the Press KP-602 in the Automatic Cycle

No. of operation	Type of operation	Sketch
1	Initial position of the workpiece The frame with the workpiece is fastened on the hoist; feelers of the press do not come in contact with the work	
2	Alignment of the workpiece a) Workpiece brought to the feelers; automatic alignment is begun	
	b) The workpiece is aligned Impulse is given for lowering the upper die block	 

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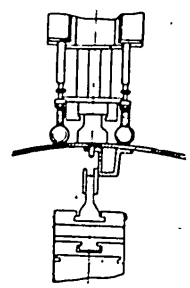
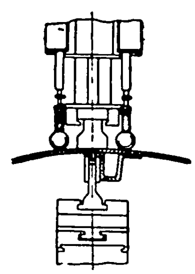
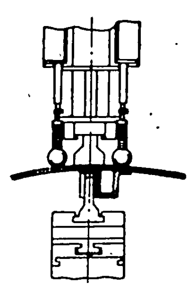
No. of operation	Type of operation	Sketch
3	Lowering the upper die block Travel of the upper die block ceases as it comes in contact with the workpiece; An impulse is given for raising the lower die block	
4	Raising the lower die block a) Contact of the workpiece with the web of the die block, starting up the automatic heading mechanism b) Contact of the rivet with the surface of the die block, stopping movement of the microswitch c) Finish of the press operation, impulse given for withdrawal of the die blocks to the position set during the adjustment	
5	Withdrawal of the die blocks from the workpiece Raising the upper and lowering the lower die blocks, with an impulse given at the end of the travel for shifting the workpiece	

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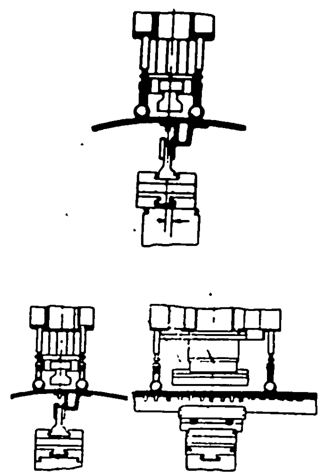
No. of operation	Type of operation	Sketch
6	Shifting of the workpiece in group riveting a) Sliding the die block over the profile of the workpiece produces a displacement of the die block with respect to the plunger, which actuates a mechanism to bring laterally in riveting position another series of rivets b) As the shifting of the workpiece stops on the supporting props in group riveting, no more rivets are presented for riveting; the center lines of the die and plunger meet; an impulse is given for alignment of the workpiece and for lowering of the upper die	

off shaft. The reversal of rotation of the pneumatic motor is done by means of two sets of electric-pneumatic starting devices.

The electromagnetic starting device (Fig.148) consists of the body (1), with a horizontally operated valve (2) and a vertically operated valve (3). The electromagnet (4) is attached to the body, and when the current is on, the valve (3) is lifted. The connection fittings (5) are screwed into the body and serve for tightening the tube conduits. The electro-pneumatic starting device is attached to the body of the press through the holes (6).

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The press has an automatic mechanism for heading the rivets to the required height, regardless what the diameter of the rivet shank may be. This mechanism is located in the upper part of the plunger of the lower riveting head. A description of the construction and operation of this mechanism is carried out in the specifications for the power riveting unit KSA-403.

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The press operates according to the following three cycles:

1. The Automatic Cycle provides full automatic riveting of one seam, regardless of its location on the workpiece. The riveting, the alignment of the work for group riveting, and also the straightening of the parts is done automatically by pressing a button on the central control panel. The job of the operator in this case is to oversee the operation of the press and the quality of the riveting work.

An outline of the technical process of riveting on the press KP-602 with the automatic cycle is given in Table 49.

2. The Semiautomatic Cycle is employed for riveting parts that do not have extensive seams and also in cases where the shape and the size of the piece does not permit automatic alignment for group riveting. The riveting heads are brought into proper position and withdrawn from it automatically in the semiautomatic cycle, but the alignment of the work for group riveting is done by the operator by manipulating the main manual control of the press.

3. The Manual Cycle is an auxiliary aid, and is usually resorted to in adjusting and checking the operation of the various mechanisms of the press while it is being set up and tested. In that case, the riveting heads are brought into proper position and withdrawn from it separately by pressing the proper button on the control panel. The manual control is used for checking the mechanism which feeds and withdraws the parts to be riveted at the feelers of the press, to check the correctness of the stroke of the upper and lower riveting tools, and other operations.

Riveting itself is not permitted during the manual cycle, since the workpiece may be damaged for the reason that, in the manual cycle, the alignment of the press is not tied in with the riveting heads.

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The use of KP-602 presses in combination with equipment for group drilling of holes and countersinking recesses under the rivet heads reduces the labor considerably, results in a better quality of riveting work, improves working conditions, and leads to building up a high concept of organization in connection with assembly

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work by the riveting method.

Lever-Type Press KP-501A

The press KP-501A (see Fig.144) operates on the principle B, and has a characteristic curve of operation similar to that shown in Fig.138. This press has an automatic mechanism for withdrawal of the plunger by 70 mm, which permits to do riveting work on components with protruding elements on their surface. The construction of the parts to which the riveting tools are attached is such that changing and tightening of the upper and lower riveting die blocks can be done quickly, and they may also be turned in a horizontal plane through 360° and set in position with a graduated dial as a guide to an accuracy of 1°. This permits to do riveting work to join parts in a lengthwise as well as in a lateral direction. A kinematic diagram of the operation of this press is shown in Fig.149.

The press consists of the following basic components: housing, lower plunger, group of pistons, upper plunger, pneumatic system, lubricating systems, mechanisms for the control of operation, and riveting tools.

The Housing is a rigid casting holding all mechanical parts of the press which are accessible through door openings. The lower plunger performs the riveting operation, and its up-and-down motion is effected by the action of a group of pistons, a pneumatic system, and a system of levers.

The Piston Group consists of two pistons inside cylinders which operate alternately on the same connecting rod. The large piston is connected to the rod by means of a spherical joint coupling and is actuated by air, supplied at the concave part of the coupling. The maximum stroke of the lower plunger, equal to 35 mm, STAT regulated by the change in the stroke of the large cylinder, using a worm gear pair.

The Upper Plunger functions as supporting prop in riveting. Its up-and-down stroke within the limits of 95 mm is effected by means of a nut which can be moved by hand, using a hand wheel or operated by the pneumatic drive. The operation by

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hand is used in setting up of the upper tools for a particular thickness of the stack. Regulation is effected by means of a dial with a graduated scale. Automatic shifting of the upper plunger comprises an overall distance of 70 mm, while in the case of manual adjustment for thickness of the stack, the distance is within the limits of 25 mm.

The drive for the upper plunger consists of a pneumatic cylinder block with three pistons. One of the pistons carries a rack coupled with a gear whose purpose is to shift the upper plunger by means of a chain and sprocket drive.

The Pneumatic System of the press consists of a mechanism for distribution of the compressed air, and is composed of six valves for the air cylinders and a starting valve, an air intake for stabilizing the air pressure distributed to the working parts and acting as an oil separator, as well as an automatic lubricator for injecting atomized oil into the air lines, to ensure proper operation of pneumatically operated machinery.

The Oil System consists of a pneumatic pump which sucks oil from the oil reservoir through a filter located within it, and supplies oil under pressure to the oil pipe system.

The Operating Controls of the press are mounted on a separate portable panel. The control panel contains, in suitable position, manual controls, starting and stopping switches, and a pressure gage. The lower part of the column, which holds the panel, carries a foot pedal in a conveniently located place for foot operation of the press. Flexible hoses connected with the manometers and valves, deliver compressed air to the press mechanism.

The operation of the press is indicated in the kinematic diagram (see FigSTAT.

Before the parts to be riveted are placed in the press for group riveting between the dies, the upper and lower plungers must be retracted to their extreme upper and lower positions. Valves (1) and (2) located on the control panel and shown in the diagram, are used for this purpose.

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Compressed air from the main line goes into the oil separator and from there through the receiver and the automatic oiler, over the piping (3) and the valve (1), via the valves (4) and (5) and the piping (6) into the chamber of the cylinder of the control device. This causes the piston to which a rack is attached to move to the extreme right position, with the motion transmitted by a chain drive, turning a nut which shifts the position of the upper plunger upward.

At the same time air is supplied through the piping (7), (8), and (9) into the chamber in which the rod is connected to the working piston, with the result that the sleeve with the spring is moved to the right, thus releasing the balls. The rod moves to the right and carries the lower plunger to its extreme low position. While in this position, the parts to be riveted are inserted in the opening of the press, and by means of valve (1) the closing in of the plungers takes place i.e., the upper plunger is lowered and the lower plunger raised (in this case, the valve (1) is in the "forward" position).

The air from the uncoupling chamber of the rod and from the exhaust chamber operating the withdrawal of the tool is exhausted to the atmosphere through the valve (1). At the same time, air from the pipe (3) through the valve (1) and the pipes (10) and (11) enters the chamber which regulates the preliminary position of the tool and shifts the piston with the rack to the left, thus causing the upper plunger to move downward. Simultaneously, through the piping (10), the upper outlet of the valve (12), and the piping (13), air enters the chamber for shifting the tool forward, with the result that the rod is shifted toward the left, permitting entry of the ball into its groove.

The air from the chamber, shifting the tool forward, enters the valve (12) through the piping (14), causing a downward displacement of the valve; this connects the inlet chamber, which shifts the tool of the lower cylinder forward, with the atmosphere; a connection is also made between the compressed-air piping (10) and the starting valve (15).

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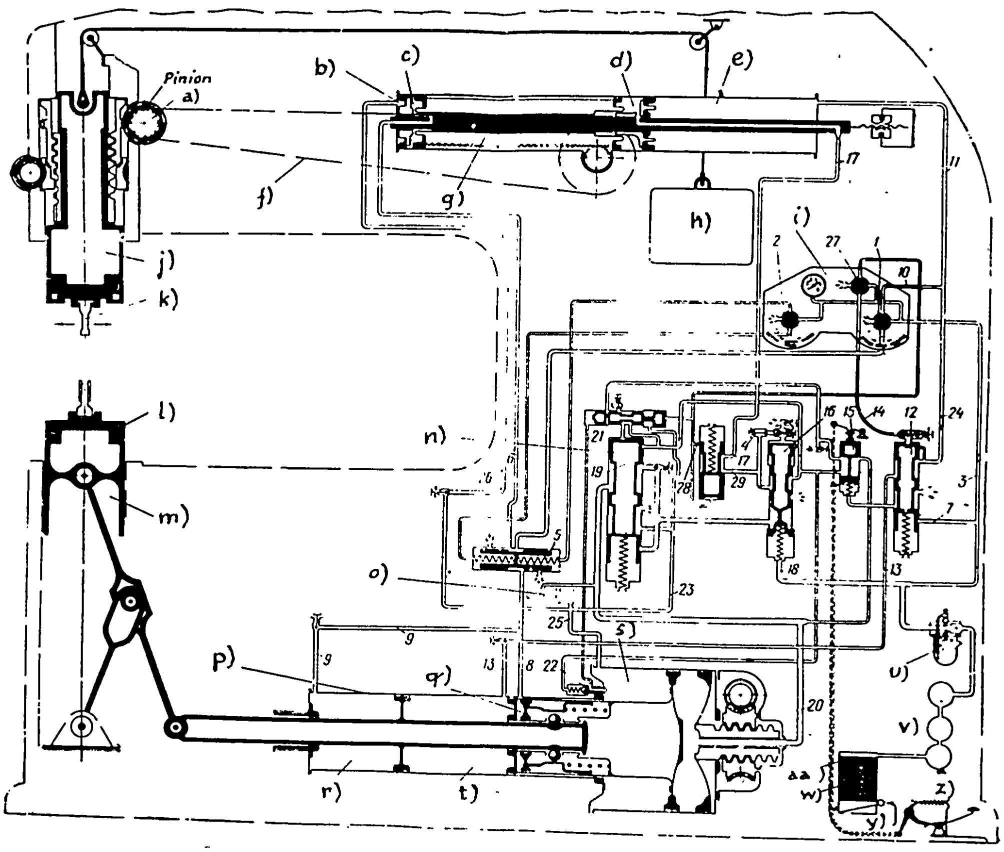

Fig.149 - Kinematic Diagram of Press KP-501A for Group Riveting

1, 2, 27 - Valves; 3, 6 - 11, 13, 14, 17, 18, 20, 21, 23 - 26, 28, 29 - Pipelines; 4, 5, 12, 16, 19, 22 - Valves; 15 - Starting valve

a) Sprocket gear; b) Exhaust chamber for retraction of tool at each working stroke; c) Exhaust chamber for complete retraction of tool; d) Inlet chamber for shifting tool forward at each working stroke; e) Chamber for shifting tool to a preliminary position; f) Motorcycle chain; g) Drive for upper plunger; h) Counterweight; i) Control panel; j) Upper plunger; k) Riveting tool; l) Tool holder; m) Lower plunger; n) Pneumatic system; o) Lubricating system; p) Piston group; q) Uncoupling chamber; r) Reverse stroke chamber; s) Chamber for tool retraction; t) Chamber for shifting tool forward; u) Automatic oiler; v) Receiver; w) Coke; x) Chamber for working stroke; y) From the main line; z) Control; aa) Felt STAT

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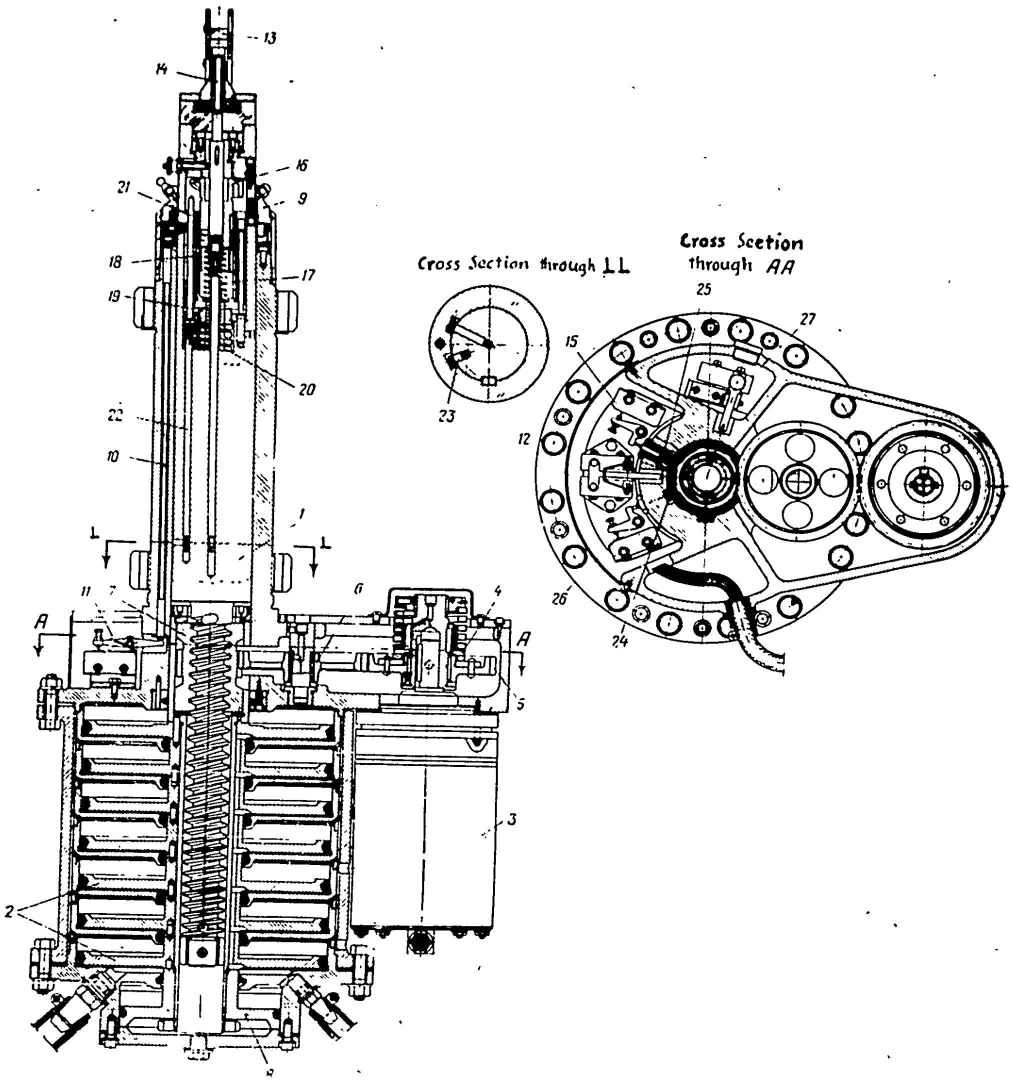

Fig.150 - Power Riveting Unit KSA-403

1 - Plunger; 2 - Piston block; 3 - Reversible pneumatic motor; 4 - Clutch; STAT
5,6 - Gear wheels; 7 - Threaded nut; 8 - Piston; 9 - Dial; 10,21 - Coupling rods; 11,24 - Levers; 12,15,26,27 - Microswitches; 13 - Punch; 14 - Pickup; 16,18,19 - Bushings; 17,20 - Springs; 22,25 - Push rods; 23 - Stud

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In this position, the press is ready for regular riveting.

To carry out group riveting, pressure is applied to the pedal, thus opening the valve (15) and permitting air to flow through the outlet opening in valve (16) into the piping (17) and thence, through the channels in the rod of the upper cylinder, into the chamber which controls the forward travel of the tool.

The piston with the rack is shifted to the left, and the upper cylinder is lowered by 7 mm by means of chain and nut. As sufficient air pressure is built up in the piping (17) for forcing out the check ball in the slide valve (16), the latter is shifted downward. The compressed air in the piping (18) enters the upper opening of the valve (19), goes through the piping (20) and then into the chamber controlling the working stroke, thereby shifting the working piston to the extreme left position and at the same time shifting the lower plunger upward.

When sufficient air pressure, with reference to the line pressure, is built up in the chamber of the working stroke, the air goes through the piping (21) into the valve (22), shifting it to the right; this provides a supply of compressed air to the upper valve surface, shifting the latter downward, with the result that the chamber of the working stroke becomes open to the atmosphere. Compressed air through the piping (23), (24) and (25) enters into the reverse stroke chamber, returning the working piston to its original position. At the same time, through the piping (26) air enters into the chamber controlling retraction of the tool, at the same time moving the piston with the rack to the right and shifting the upper plunger upward by 7 mm.

If it becomes necessary to hold the lower plunger in its extreme upper position, (as in setting up the press), the cock (27) must be set into the position STAT "setting up". In that case, depressing the pedal of the press connected with the piping (28), opposes the shifting of valve (22) to the right for the duration of the automatic cycle.

When retraction of both plungers is not required, as in the case of riveting

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panels with small and tough protruding elements), it is possible to retract either the upper or the lower plunger only. For this, the cock (2) is placed in the position "upper" or the position "lower". This causes the valve (5) to shift to the extreme left (closing the pipeline (7) and permitting only the upper plunger to operate) or to the extreme right position (closing the pipeline (29) and permitting only the lower plunger to operate).

The compressed air is supplied to the operating mechanism in a definite sequence over butterfly valves.

The press is started for operation in the following manner: The main valve is opened for admission of compressed air to the control elements. When the pressure gage on the control panel indicates an air pressure not lower than 4 atm the handle of the cock (1) is turned to the position "supply". In that position, the upper plunger descends and the lower plunger rises. To avoid a deviation of the lower plunger from its extreme upper position on application of pressure to the pedal, the cock (27) must be turned to "setting up".

Next, the press is adjusted for the thickness of the stack being riveted and to the height of the clenched heads, by means of the hand-wheel which controls the raising or lowering of the upper plunger. The distance to which the plunger is raised or lowered is determined by the indications on a dial with 0.2 mm divisions. One full-scale deflection of the pointer over the dial represent 12 mm.

Presses KP-503, KP-403 and KP-405

These pneumatic presses (see Fig.144) represent a particular group of semiautomatic presses for group riveting of components of the type of girders, medium-size panels, etc. In design, these presses consist essentially of a combination of separate self-contained assembled units; namely, a power riveting unit, a support unit, automatic control elements, and other components. The use of such self-contained units permits the erection of special-purpose presses in an economical manner.

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Power Riveting Unit KSA-403

This unit (Fig.150) develops a force required for the working stroke in riveting. The working stroke of the plunger (1) is produced from the piston block (2), while the auxiliary stroke is effected by the reversible pneumatic motor (3) through the clutch (4), the gears (5) and (6) and the threaded nut (7), which transmits the motion to the plunger. The travel of the plunger is 16 mm. The return of the piston block (2) is effected by means of the piston (8).

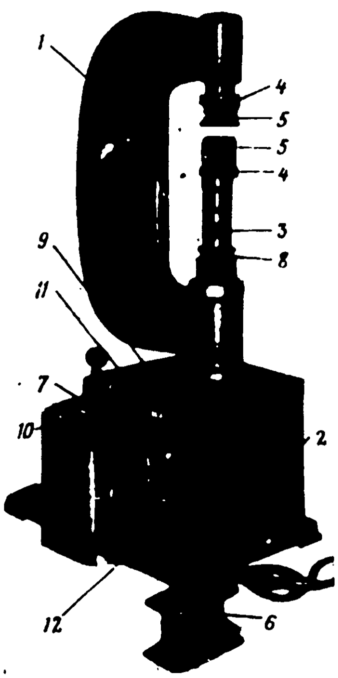

Fig.151 - Press KP-405 for Group Riveting

1 - C-frame; 2 - Pedestal; 3 - Plunger; 4 - Tool holders; 5 - Dies; 6 - Operating pedal; 7 - Electric device with pneumatic motor; 8 - Mechanism for setting the retraction distance of plunger; 9 - Cock for air inlet; 10 - Air cleaner; 11 - Automatic oiler; 12 - Piping for supply of air from the compressed-air system

The distance of retraction of the lower die block from the part being riveted is regulated by means of the dial (9). On turning the dial, the cam at its lower part acts on the lever (11) through the ball and rod (10), which in turn transmits an impulse to the microswitch (12). The microswitch actuates the electro-pneumatic starting device, which controls the motion of the pneumatic motor of the power unit.

The operation of the mechanism for rivet heading to the specified height proceeds as follows: As the plunger is raised upward, the pressure platen of the punch (13) act through the pickup device (14) on the microswitch (15) located on the body of the power unit. The microswitch controls the stopping of the pneumatic motor and turns on the power during the work-

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ing stroke of the plunger from the piston block. As the plunger is in motion, the bushing (16) makes up to three revolutions before the die comes in contact with the shank of the rivet. On further movement of the plunger, the clearance is better defined, with the result that the spring (17) becomes compressed. The bushing (18) is locked under the action of the bushing (19) and the spring (20), and heading of the rivets is done as the plunger moves farther.

The deformation of the rivet shank continues until the time when rod (21),entrained by the plunger, no longer is in contact with the beveled face of the bushing (16). This causes the rod (21) to stop and hold down the push rod (22), which has a drilled recess into which the stud (23) is fitted. On further upward movement of the plunger, the stud (23) is forced out by the bevel edge on the push rod (22) and thus actuates the lever (24). The lever, over the push rod (25), trips the microswitch (26) which prevents further raising of the plunger and starts the rapid withdrawal of the plunger from the workpiece. At the same time, under the action of the piston (8) which controls the reverse stroke, the piston block is returned to its original position, and all the operating chambers in the block are opened for exhaust to the atmosphere.

The press KP-405 (Fig.151) incorporates the basic operating principles of the described power unit KSA-403. In the design of this press, provision was made for changing the C-shaped frame from one size of opening to another, to comply with the riveting specifications for parts which require a large overhang of the frame.

Presses of the type KP-403 and KP-503 utilize the power units KSA-403 and KSA-503, which do not much differ in design; in addition they comprise the supporting units KPA-403 and KPA-503. These supporting units (KPA) absorb the riveting forces and make it possible to shift the upper die blocks vertically within the limits of the available space to the workpiece, thus facilitating the adjustment of the upper parts of the press.

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The presses KP-403 and KP-503 operate on the automatic cycle, which consists in

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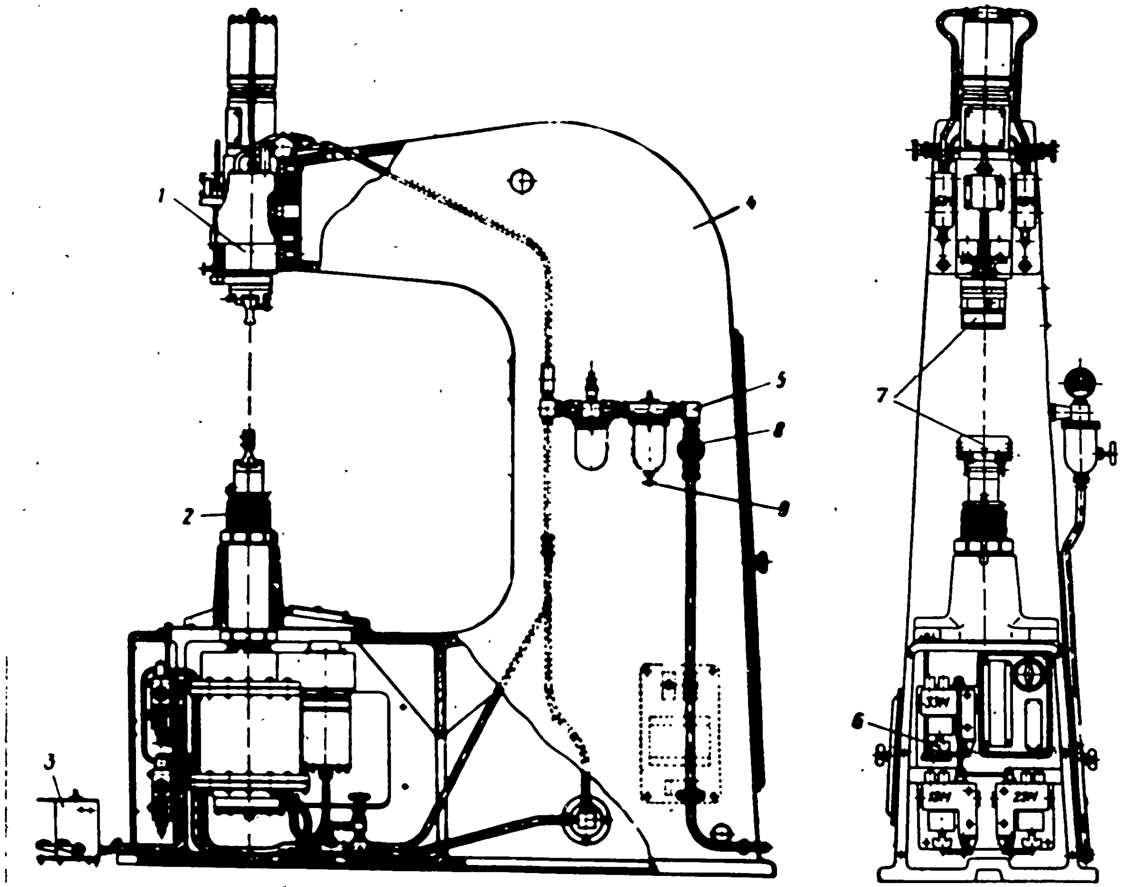

Fig.152 - Arrangement of the Mechanisms of the Press KP-403

1 - Riveting support unit KPA-403; 2 - Riveting power unit KSA-403; 3 - Pedal controlling the press operation; 4 - Housing; 5 - Pneumatic system of the press; 6 - Electro-pneumatic starting devices; 7 - Riveting tools; 8 - Inlet valve; 9 - Drain cock

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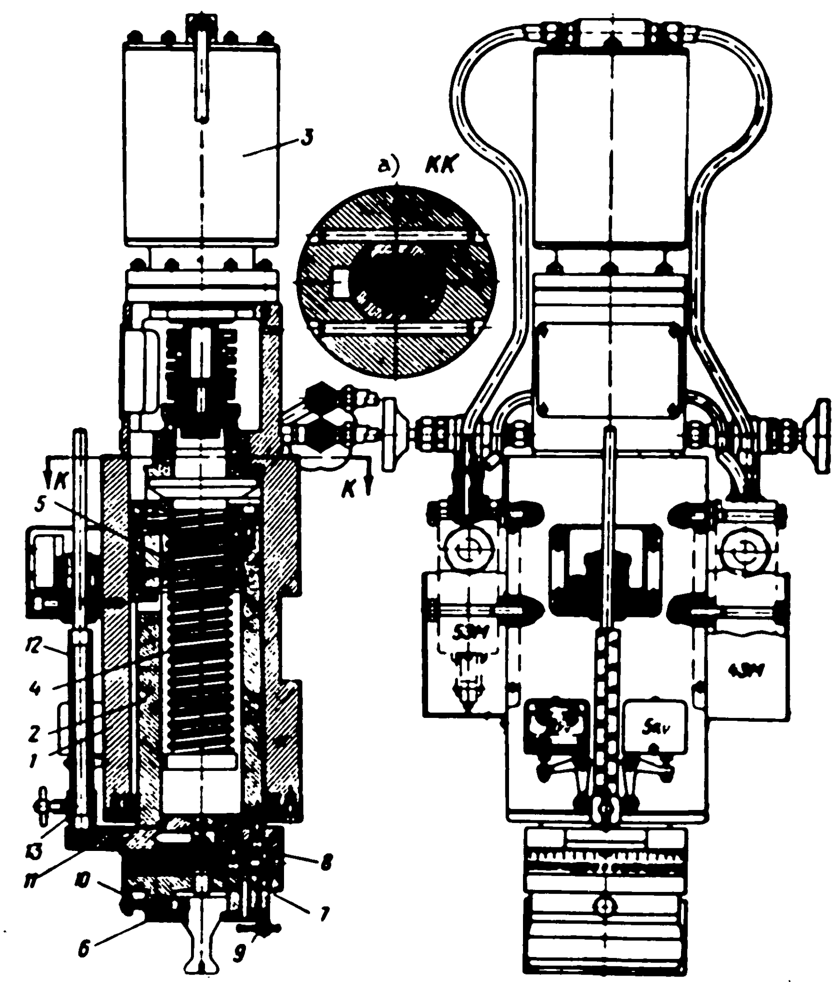

Fig.153 - Riveting Support Unit KPA-403

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1 - Body; 2 - Plunger; 3 - Reversing pneumatic motor; 4,9 - Screws; 5 - Nut; 6,7 - Guides; 8 - Ring; 10 - Handle; 11 - Plate; 12 - Measuring rod; 13 - Thrust support

a) Section through K-K

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the simultaneous travel of the upper and lower plungers. This cycle includes lowering of the upper plunger, together with the upper die block, until it comes in contact with the surface of the workpiece; raising of the lower plunger, together with the lower die block until the rivet is headed; and withdrawal of both tools to the initial position.

These presses are characterized by their large dimensions and by the magnitude of the riveting force. The maximum force developed by the press KP-503 is approximately twice as great as that of the press KP-403.

To clarify the operation of these presses we will analyze the design and schematic of the press KP-403, as a representative type.

Press KP-403

A general view of the press is shown in Fig.144, while the arrangement of the operating mechanism is given in Fig.152. The press consists of a cast housing whose lower pedestal carries the power unit KSA-403. The upper bracket of the frame part holds the support unit KPA-403. The electro-pneumatic devices, together with the electric wiring system, is arranged on the side of the housing in front of the power unit. The control pedal of the press extends outward. The upper and lower brackets of the housing has places for attaching the support and the power units.

We will analyze in detail the design and operation of the separate mechanisms of the press, excluding the power riveting unit KSA-403 which was described above.

The Riveting Support Unit KPA-403 (Fig.153) consists of the body (1) in which the plunger (2) moves; the travel of the plunger by 150 mm is effected by the reversible pneumatic motor (3) through the screw (4) and the nut (5).

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On the lower end of the plunger is mounted a tool holder, consisting of the guides (6) and (7), connected with the rotary ring (8). The setting of the tool holder in the required riveting position is done by means of the screw (9), while the fastening of the tool in the tool holder is done by the handle (10) with a

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The Pneumatic System (Fig.154) of the press KP-403 supplies compressed air to spring. The strut (12) is mounted on the plate (11) and has a graduated scale, over which the support (13) is moved, thus regulating the withdrawal distance of the tool from the workpiece.

On the outer walls of the housing are installed the electro-pneumatic starting

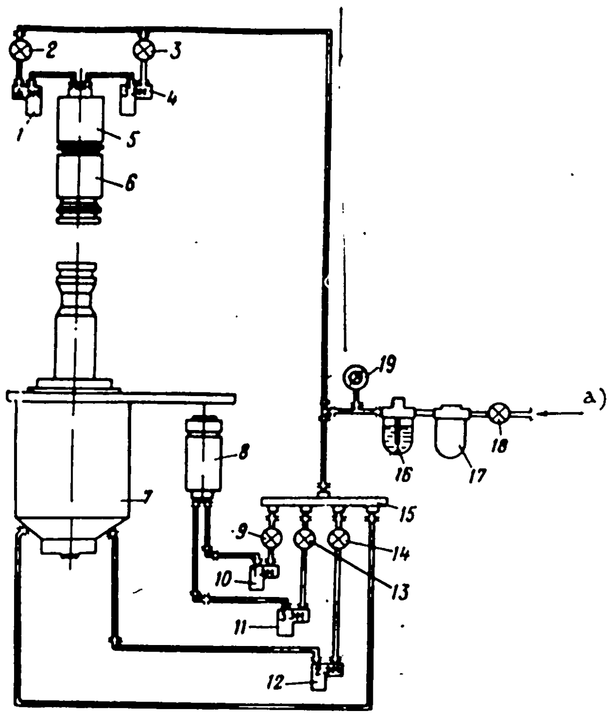

Fig.154 - Diagram for the Pneumatic System of the Press KP-403

1 - Pneumatic device for bringing the upper plunger to the workpiece being riveted; 2 - Valve for regulating the air inlet to the upper plunger drive; 3 - Valve for regulating the air exhaust on withdrawal of upper plunger; 4 - Pneumatic device for withdrawal of the upper plunger from the workpiece; 5,8 - Reversing pneumatic motors; 6 - Riveting support unit; 7 - Riveting power unit; 9 - Valve for regulating the air inlet on raising the lower plunger; 10 - Pneumatic device for withdrawal of the lower plunger; 11 - Pneumatic device for raising the lower plunger; 12 - Pneumatic device for the power stroke of the lower plunger; 13 - Valve for regulatiSTAT the air inlet on raising the lower plunger; 14 - Valve for regulating the air inflow into the hydraulic jack; 15 - Collector; 16 - Automatic lubricator; 17 - Filter; 18 - Valve for admitting air from the main compressed air system; 19 - Pressure gage

devices and microswitches 7KV, 8KV, and 5KV, which control the operations of the mechanisms during the automatic cycle.

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<u>The Pneumatic System</u> (Fig.154) of the press KP-403 supplies compressed air to the support and the power units from the main line at a pressure of 5 atm. Air from the main line is admitted into the intake pipe through a cut-off valve, air filter, and automatic lubricator, and is supplied to the electro-pneumatic starting devices of the upper support unit and below to a collector. From the collector the air goes

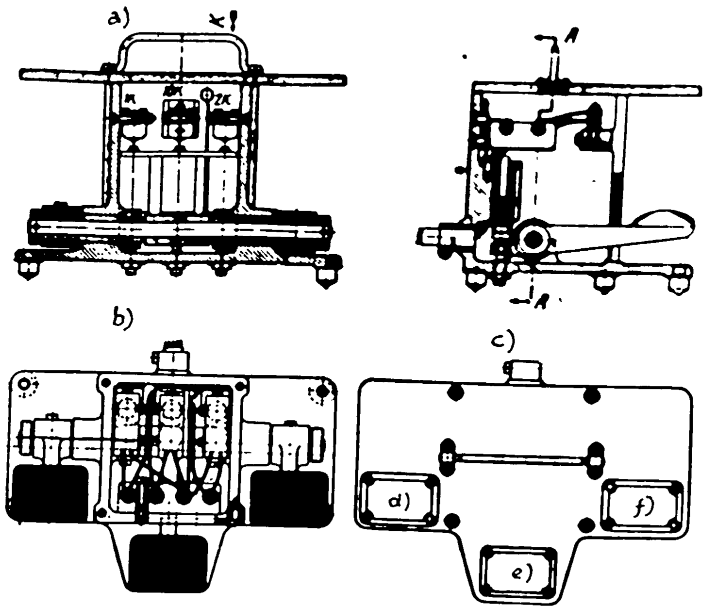

Fig.155 - Pedal for Operating the Press KP-403

a) Cross section through AA; b) View in direction of the arrow K, with cover removed; c) View in direction of the arrow K; d) Retraction of the plungers, e) Raising the lower plunger; f) Work cycle

through a hose to the electro-pneumatic starting devices of the lower power riveting unit and to the cylinder controlling the reverse travel of the cylinder block. STAT

<u>The Control Foot Pedals</u> (Fig.155) for the press KP-403 are mounted as an ordinary casting of box shape. Connection with the electro-pneumatic system of the press is by means of flexible cables. This permits installation of the pedals in the

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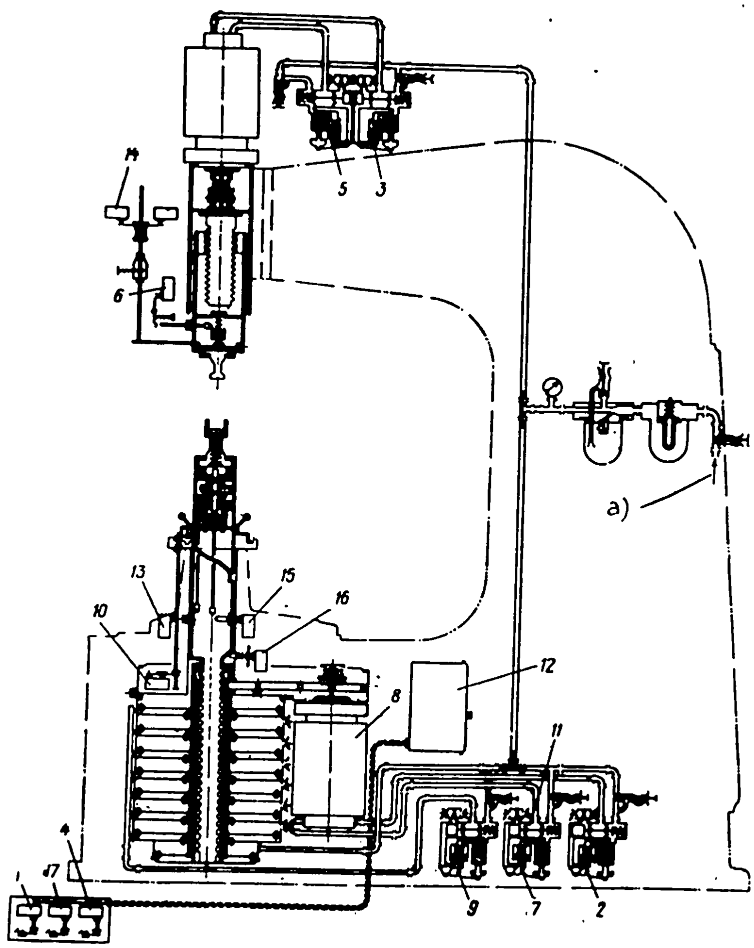

Fig.156 - Kinematic Diagram of the Press KP-403

1 - Microswitch of left pedal (withdrawal of plungers to initial position); 2,3, 5,7 - Electromagnets; 4 - Microswitch of right pedal (starting the press on the power stroke); 6 - Microswitch (disconnects the upper plunger as it approaches the workpiece; 8 - Reversing pneumatic motor; 9 - Electromagnet; 10 - Microswitch (stops the movement of the lower plunger and closes the switch for raising the upper plunger); 11 - Electro-pneumatic starting device; 12 - Fuse box; 13 - Microswitch for making connection with the pneumatic cylinders in the power block; 14 - Microswitch to stop raising of the upper plunger; 15 - Microswitch for making connection with the pneumatic cylinders in the power block; 16 - Microswitch for stopping the lower cylinder in its extreme low position; 17 - Microswitch of center pedal (raising the lower cylinder to the workpiece)

a) From the compressed-air system

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press, in the most convenient location for riveting.

Operation of the press is accomplished by three pedals: The right pedal controls the work cycle of the press; the left pedal operates the retraction of the upper and lower plungers to their initial position; the center pedal is for raising the lower plunger during the setting up of the workpiece in the necessary position with respect to the lower tool. To prevent accidental starting of the press, which may occur if the pedals are depressed accidentally by the workman or if the press is struck by some dropped object, the pedals are installed within the body of the box under its top cover.

Fig.157 - Lever-Type Pneumatic Press KP-204 for Single Riveting

The construction of the reversible pneumatic motors and the electro-pneumatic motors of the starting devices does not differ from the design of the same devices that are used with the press KP-602.

Before the press KP-403 is started for operation it is necessary to make sure that the automatic lubricator is filled with oil. Then the inlet valve (8) (Fig.152) is opened and the air pressure in the compressed-air system is checked by the manometer, which must not be less than 4 atm. Then the riveting tools will be installed in the places provided for them in the tool holders of the upper and lower riveting units.

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It is necessary to withdraw the plungers to their extreme initial positions whenever the workpiece is installed on the movable equipment, for positioning it properly on the support unit. For this purpose, pressure is applied to the left pedal which closes the microswitch (1) (Fig.156), with the result that the electro-

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magnets (2) and (3) are actuated and the two plungers are retracted to their initial position.

After the plungers are parted, the workpiece is installed on the support unit and the seam to be riveted is adjusted to the correct position with respect to the die blocks. On application of pressure to the right pedal, the microswitch (4) is closed and the magnet (5) is actuated, supplying current to the starting devices of the support unit, with the result that the plunger (together with the riveting tool) is lowered until it comes in contact with the workpiece. When the upper tool touches the workpiece, an adjustment of the clearance between the bearing surface of the tool and the corresponding bearing surface of the tool holder takes place. This trips the microswitch (6), with the result that electromagnet (5) is switched off while the electromagnet (7) is actuated and closes the electric circuit of the starting device of the lower riveting unit, and the lower plunger with the die block is shifted upward under the action of the pneumatic motor (8).

At the instant of raising the lower plunger, the lowering of the upper plunger ceases. When the pressure plates of the riveting tool touch the workpiece and settle by 4 mm, the compressed air is automatically cut off at the pneumatic motor and is supplied to the cylinder block, from which the cumulative force of the piston assembly is transmitted to the rivet shank, with the result that the clenched head is formed. During that time, the electromagnets (7), (9) and (5) are disconnected, while the electromagnet (2) is actuated, with the result that, under the action of the pneumatic motor (8), the lower plunger is shifted downward. This continues until the microswitch (10) is tripped and energizes the electromagnet (3) and until, under the action of the starting device (11) and the pneumatic motor, the plunger of the support units is shifted upward. The next step is to shift the workpiece for riveting another series of rivets by the group method, and the operation of the press is repeated.

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In some cases during the operating cycle of the press, it may become necessary

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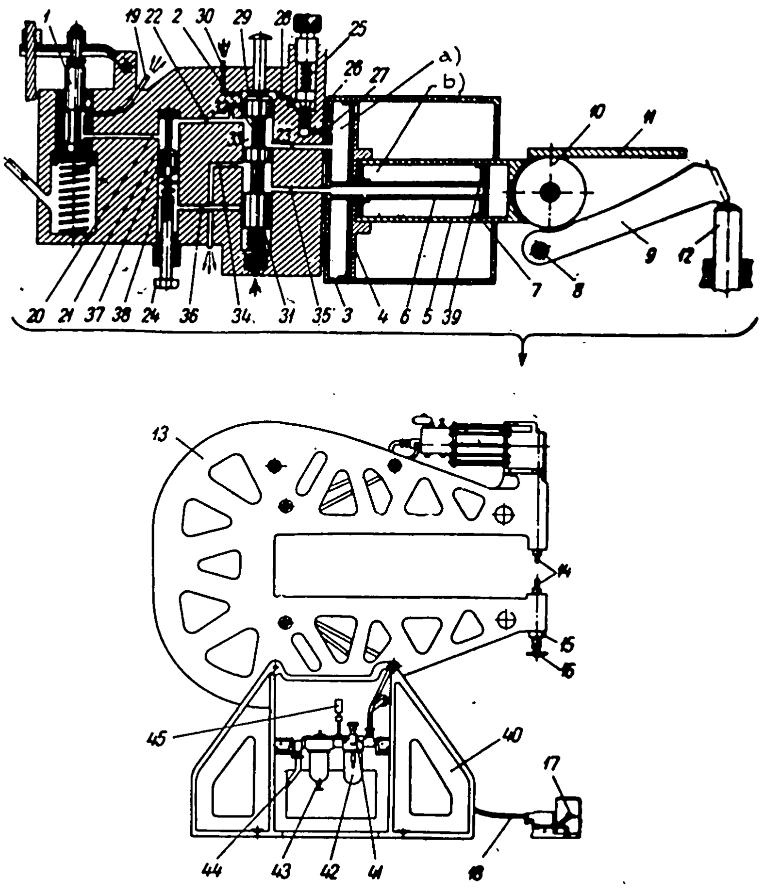

Fig.158 - Press KP-204 with Power Head

1 - Starting valve; 2 - Slide valve; 3 - Power stroke cylinder; 4,7 - Pistons; 5 - Reverse travel cylinder; 6 - Rod; 8 - Shaft; 9 - Lever; 10 - Rollers; 11 - Bearing plate; 12 - Plunger; 13 - C-frame; 14 - Riveting dies; 15 - Die holder; 16 - Screw; 17 - Pedal; 18 - Cable; 19,20,22,23,27,28,30,32,34,35, 36 - Channels; 21,29,33,38, - Chambers; 24 - Regulator; 25,31 - Springs; 26 - Valve; 37 - Piston; 39 - Holes; 40 - Housing; 41 - Throttle for regulating rate of oil supply by the automatic lubricator; 42 - Automatic lubricator; 43 - Filter; 44 - Hose for supply of compressed air from the main system; 45 - Pressure gage

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a) Power stroke chamber; b) Reverse-travel chamber

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to withdraw the tools. In such cases use must be made of the left pedal of the press.

4. Stationary Presses for Single Riveting

Presses for group riveting of the type KP-602, KP-510, KP-501A, KP-503, KP-405 and others perform group riveting on various components, panels, and assembly units of large size. However, the construction of particular components of products made from light alloys does not permit economic use of these presses, and it becomes necessary to make use of stationary and portable presses adapted for single riveting.

Type KP-204 stationary presses are in wide use in the industry for single riveting.

Lever-Type Pneumatic Press KP-204 (Fig.157) operates on the kinematic principle C, illustrated in simplified form in Fig.139. The riveting process of this press is analogous to the process illustrated graphically in Fig.140. The press is intended for riveting components of intermediate and small size that have no seams of excessive length.

Technical Characteristics of the Press

Force on the riveting die at 5 atm compressed-air pressure	5000 kg
Greatest diameter of duralumin rivets	6 mm
Steel	5 mm
Travel of plunger:	
Power stroke	7 mm
Idle stroke	53 mm
Number of strokes per minute	15 - 25
Depth of C-frame	1100 mm
Height of C-frame	260 mm
Overall dimensions	1700 × 800 × 1800 mm
Weight of press	~1000 kg
Consumption of air per stroke	0.012 m^3

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The press consists of the following components: a power head with compressed-air distributors, brackets, housing, control pedals, and filter with an automatic lubricator.

The Power Head (Fig.158) is the principal component of the press, used for providing the necessary working pressures and shifting of the plungers during the riveting operation.

This head is composed of the following parts:

1) A distributor head with a starting valve (1), a slide valve (2), holes, channels, and recesses for conducting air alternately to the working cylinder and to the reverse travel cylinder.

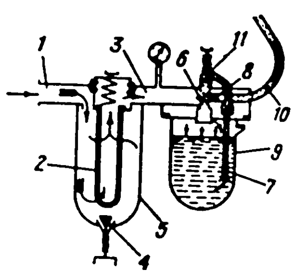

Fig.159 - Filter with Automatic Lubricator

1 - Connecting pipe; 2 - Filter; 3 - Opening for passage of cleaned air; 4 - Butterfly valve; 5 - Body of filter; 6 - Check-valve ball; 7 - Tubing; 8 - Opening for compressed-air passage; 9 - Body of lubricator; 10 - Hose; 11 - Oil-feed regulator

2) A power-stroke cylinder (3), in which the piston (4) moves. The latter is rigidly connected with the reverse travel cylinder. Inside the reverse travel cylinder (5) is the stationary hollow rod (6), through which compressed air flows for effecting the return travel. One end of the rod is threaded and is screwed into the body of the air distribution box, while the other end is fastened to the piston (7) with a cup. The piston is stationary during operation, and the reverse travel cylinder is shifted relative to the piston to the right and to the left. STAT

3) A steel casting on which the lever (9) turns about the shaft (8), under the action of a spring and the pulleys (10). One pulley rolls on the bearing plate (11) and another on the lever (9). The lever

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exerts a pressure on the riveting die over the plunger (12).

The cast steel frame (13) has two holes in its upper part, into one of which the plunger with the die (14) is fitted. The lower part of the frame has an adjustable threaded die holder (15). On turning the screw (16), the die holder is displaced vertically, which permits adjustment of the press for various thicknesses of

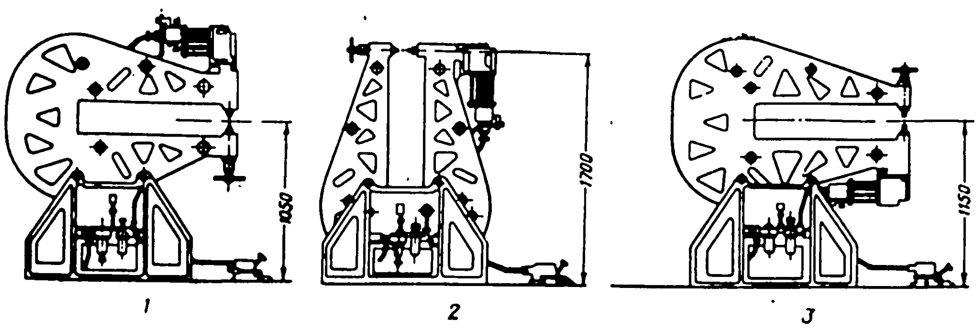

Fig.160 - Possible Positions of the C-frame of the Press KP-204, in Riveting

the stack and for height of the clenched head. The frame is fastened to the housing by means of two dowel pins.

The press is operated by means of a control pedal (17). To prevent accidental starting of the press, the pedal is protected by a safety cover.

The filter of the press (Fig.159) is intended to clean the compressed air as it comes from the main lines to the air distribution device. Compressed air from the main lines goes to the filter through the connecting pipe (1). Foreign matter contained in the compressed air is retained in filter (2). The cleaned air is passed through the port (3). The foreign matter is removed through the drain cock (4) located in the lower part of the filter (5).

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The automatic lubricator saturates the compressed air with oil, which lubricates the working surfaces of the pneumatic cylinders. From the filter to the automatic lubricator the compressed air passes through the port (3), forcing back the ball in the check valve (6). Under the pressure of the air, oil rises through the tube (7) to the regulator (8) which controls the oil feed. From here, through the

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hose (10), the compressed air with suspended oil particles is fed to the intake valve of the air-distributing device.

Operation of Press KP-204 (see Fig.158). On applying pressure to the pedal (17), the cable (18) causes the piston in the valve (1) to lower, which normally covers the channel (19), connecting the power-stroke chamber for exhaust to the atmosphere. Compressed air from the main system goes through the groove in the valve (1) along the channel (20) into the chamber (21). Then passing along the channel (22), through the recess in the valve (2) and the channel (23), the compressed air enters the power-stroke chamber. Rapid filling of the working chamber with compressed air is controlled by means of a regulator (24) which increases or decreases the aperture of the channel (22). Compressed air, as it enters the power-stroke chamber, pushes the piston (4) forward and shifts the reverse-travel cylinder and pulleys (10) to the extreme right position. During this movement, one pulley bears against the lever (9), thus turning it about the shaft (8) causing the plunger (12) to lower.

At a predetermined pressure, whose magnitude is regulated by the spring (25), the piston in the valve (26) is lifted. The compressed air from the power-stroke chamber passes along the channels (27) and (28) into the chamber (29), which is at all times connected for exhaust to the atmosphere through the channel (30) which has a small cross section.

At the instant when the compressed air entering the chamber (29) and the compressed air passing through the channel (30) from the chamber to the atmosphere are mutually balanced as to the pressure needed for compressing the spring (31), the piston in the valve (2) is lowered and the channel (32) is opened. An additional quantity of air from the chamber (21) enters the chamber (29) through the channels (22) and (32), increasing the pressure there and causing the piston in the valve (2) to shift to low position. Thereby the channel (22) is overlapped, cutting off the supply of air into the chamber (33), and into the power-stroke chamber; this

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connects the channel (23) with the channel (34), and exhausts the air to the atmosphere.

While this takes place, the channel (35) is connected with channel (36). The compressed air in the chamber (21) compresses the spring and causes the piston in the valve (37) to come down. Compressed air enters the chamber (38) and, through the channels (35) and (36), also enters the hollow rod (6), and thence, through the four ports (39) in the hollow rod, enters the reverse-travel chamber, causing the

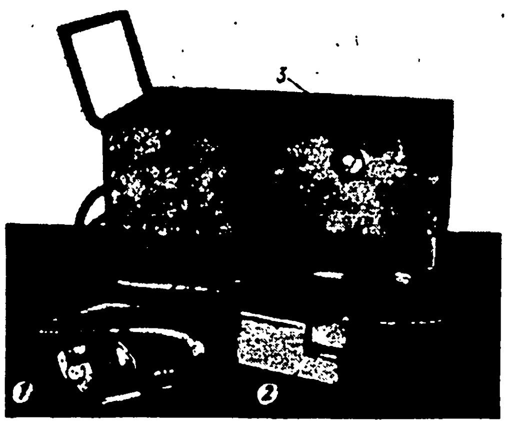

Fig.161 - Setup for Riveting with Portable Hydraulic Presses
1 - Portable hydraulic press; 2 - Booster of type MG-7-45;
3 - Portable hydraulic station of type PGS-08-65

entire system to return to its initial position. From the chamber (29) the air is exhausted to the atmosphere through the channel (30), thus completing the work cycle.

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The next step is to change the position of the workpiece to the next rivet, and the work cycle of the press is repeated.

To make proper use of the press KP-204 for riveting panels and components of various sizes, with rivets set from the top, from below, or from the side, these conditions are anticipated in the design of the press by permitting installation of

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the C-frame on the housing in various positions (Fig.160).

5. Portable Presses

Portable presses are used for riveting assembled units held in assembly fixtures (jigs) and on workbenches, i.e., under conditions that do not permit the use of stationary presses.

According to the design of the power head, portable presses may be grouped as being of the pneumatically operated lever type, hydraulic type, and combination pneumatic-hydraulic.

Table 50 shows the technical characteristics of pneumatic presses of the lever type used for riveting structures of light alloys in the assembly section of industrial plants. One of the disadvantages of portable pneumatic presses of the lever type is their comparatively heavy weight and large size, which makes them cumbersome to handle and contributes to the fatigue of the workmen.

Portable Hydraulic Presses*, whose characteristics are shown in Table 51, are of comparatively lower weight and smaller size; however they develop considerable power, sufficient to do riveting work with rivets up to 8 mm diameter. Furthermore, hydraulic presses permit riveting stacks of variable thickness (with tapered fittings) without special adjustment of the press.

The presses shown in Table 51 are operated either from the main hydraulic system or from a portable hydraulic station feeding oil under a pressure of 40 - 50 atm. At this pressure, the oil enters a booster from where it leaves under a much higher pressure to enter the working cylinder of the press that performs the riveting. A general view of the installation (press, booster and hydraulic station) is shown in Fig.161.

The C-frames of the presses shown in Table 51 are manufactured in two types:

*Work projects carried out by Engineer V.E.Shamarov.

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in the shape of "pincers" and in the shape of "loops".

Adoption of either of one or the other type is dictated by conditions of accessibility to the work.

The Press of Type KPG8-35-55K (Fig.162) with a C-frame of the "pincer" type is intended for riveting with rivets up to 8 mm in diameter on stacks having a thickness up to 35 mm. The overhang of the press, equal to 55 mm, permits riveting work along the edges of the components.

The press consists of a C-frame (1) which absorbs the riveting force, a piston (2), a lever (3) which transmits the force from the piston to the plunger (4) and a clamp bushing (5).

The Press of Type KPG8-35-55B (Fig.163) with a "loop" type C-frame has no levers, since the center line of the piston coincides with that of the plunger (2). In this press, the C-frame (3) is interchangeable, depending on the requirements of the component being riveted.

The Hydraulic Booster MG-7-45* (see Fig.161) converts the relatively low pressure of the oil, supplied at the site of the hydraulic station, into the high pressure required at the press cylinder. In this manner, the booster permits riveting stacks of variable thicknesses without additional adjustment, and also permits the use of rivets of different diameters by a simple change of the setting.

The Portable Hydraulic Station PGS-08-65, shown schematically in Fig.164, consists of the carriage (1) carrying the electric motor (2) with a power rating of 1.7 kw and a rotational speed of n = 930 rpm; the vane-type hydraulic pump (3) type LIF-8 with a delivery of 8 ltr/min, developing an oil pressure of 65 atm; the oil

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* The designation "MG-7-45" is decoded as follows: "MG" denotes the hydraulic booster; the figure 7 shows by how much the oil pressure at the booster outlet exceeds that at the inlet; the figure 45 stands for the volume of oil in cm^3 at high pressure which the booster can deliver to the working cylinder of the press.

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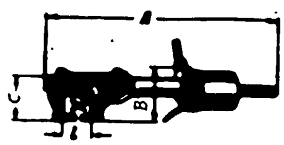
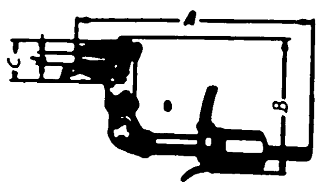
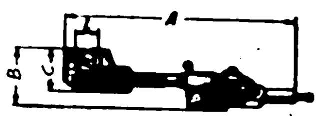
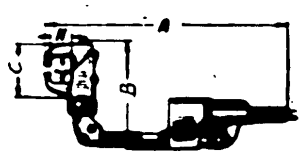
Table 50

Technical Characteristics of Lever-Type Pneumatic Presses

a)	b)	c)		d)
		e)	f)	
KP-106		3	2	1400
KP-107		3	2	1400
KP-101 KP-201		4 6	3 5	1900 4100
KP-102 KP-202		4 6	3 5	1900 4100

a) Type of press; b) Sketch; c) Maximum diameter of rivet used, in mm; d) Force on die in kg at a pressure of 5 atm; e) Duralumin; f) Steel

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Table 50 (continued)

g)	h)	i)		j)			m)	n)
		k)	l)	A	B	C		
30	15	60	30	490	155	130	4,0	0,004
30	15	80	35	475	300	130	4,5	0,004
30 20	8 12	60 90	10—50 50—90	660 840	190 270	120 190	6,0 13,2	0,005 0,0065
30 20	8 12	60 100	40—80 60—100	600 770	300 400	150 210	6,7 14,8	0,005 0,0065

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g) Number of power strokes per minute; h) Power stroke of die, in mm; i) Dimensions of C-frame, in mm; j) Overall dimensions, in mm; k) Overhang H; l) Throat l; m) Weight, in kg; n) Consumption of air per stroke, in m^3

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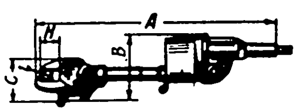
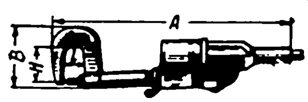
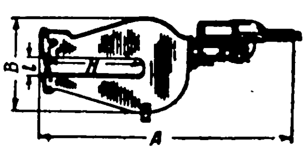
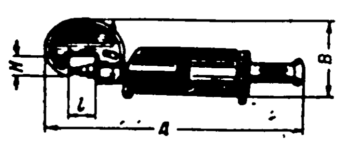
Table 50 (continued)

a)	b)	c)		d)
		e)	f)	
KP-103		4	3	1900
KP-104		4	3	1900
KP-105		4	3	1900
KP-110		3,5	2,6	1600

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a) Type of press; b) Sketch; c) Maximum diameter of rivet used, in mm; d) Force on die in kg at a pressure of 5 atm; e) Duralumin; f) Steel

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Table 50 (continued)

g)	h)	i)		j)			m)	n)
		k)	l)	A	B	C		
30	8	120	40	600	230	200	7,5	0,005
30	8	60	10 - 30	600	200	—	6,4	0,005
30	8	300	60	835	320	—	30	0,005
30	16	100	55	518	160	160	4,9	0,0018

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g) Number of power strokes per minute; h) Power stroke of die, in mm; i) Dimensions of C-frame, in mm; j) Overall dimensions, in mm; k) Overhang H; l) Throat l ; m) Weight, in kg; n) Consumption of air per stroke, in m^3

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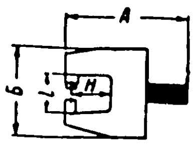
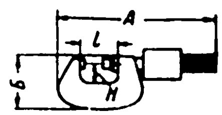
Table 51

Technical Characteristics of Portable Hydraulic Presses

Type of Press		KPG5-18-45K	KPG6-25-50K	KPG8-35-55K	KPG8-40-55B
Design					
a)		5	6	8	8
b)		3800	5000	9000	9000
c)		to 20	to 20	to 15	to 15
d)		24	28	25	40
Dimensions of C-frame in mm	Overhang H	45	50	65	55
	Throat l	24	35	50	62
Overall Dimensions in mm	A	225	168	280	460
	B	130	172	170	170
Weight in kg		2,6	3,9	8,0	9,0

a) Maximum diameter of rivet used, in mm; b) Power on die in, kg; c) Number of strokes per minute; d) Power stroke of die, in mm

Note: In the given case, the code designations of the riveting presses are as follows: letters "KPG" denote hydraulic press; The first figure refers to the largest permissible diameter of the duralumin rivet, in mm; the next two figures refer to the greatest thickness of the stack or the height of any protruding element on the surface of the component that can be accommodated by the throat opening; the last two figures refer to the overhang, in mm; the letter "K" indicates C-frame of the "pincer" type; the letter "B" signifies that it is of the "loop" type.

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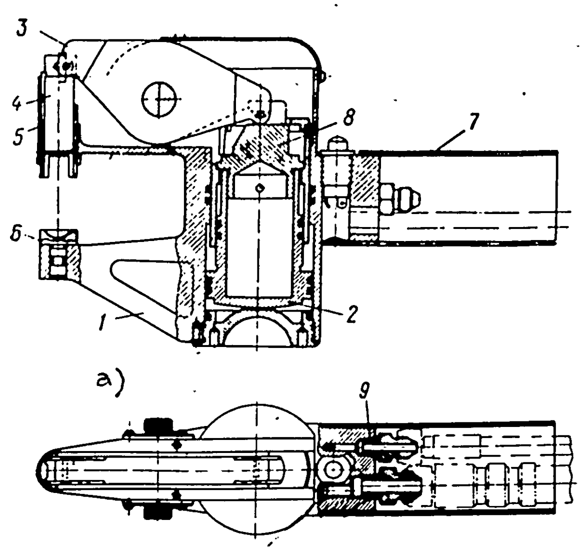

Fig.162 - Hydraulic Press KPG8-35-55K

1 - C-frame; 2 - Piston; 3 - Lever; 4 - Plunger; 5 - Bushing; 6 - Die;

7 - Handle; 8 - Support; 9 - Pipe connection

a) Cover removed for better view

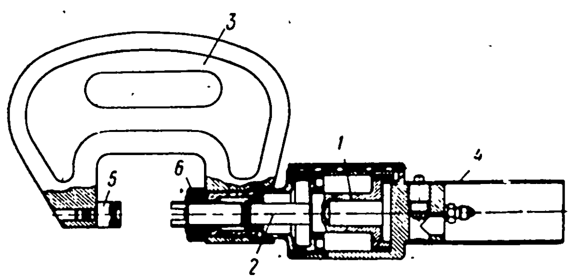

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Fig.163 - Hydraulic Press KPG8-35-55B

1 - Piston; 2 - Plunger; 3 - C-frame; 4 - Press handle; 5 - Die; 6 - Bushing

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tank (4) of 60 liter capacity; and the pressure gage (5).

Up to five portable hydraulic presses may be connected to one hydraulic station, with which riveting can be done within the limits of the length of the connecting

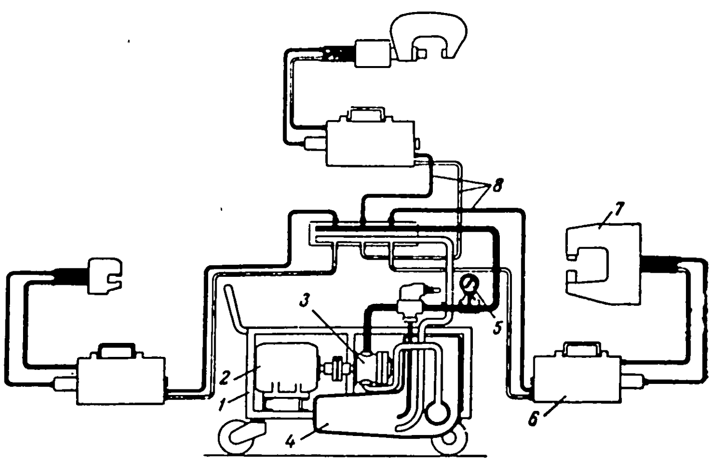

Fig.164.- Schematic Diagram of the Portable Hydraulic Station PGS-08-63, Connected to the Portable Hydraulic Press

1 - Carriage; 2 - Electric motor; 3 - Hydraulic pump; 4 - Oil tank; 5 - Oil gage; 6 - Booster; 7 - Hydraulic press; 8 - Pipe conduits

hoses. The usual length of the hose is up to 10 m, with an inside diameter up to 8 mm. When the riveting must be done at a distance greater than 10 m from the hydraulic pressure source, hose with an inside diameter greater than 8 mm should be used.

The hydraulic presses shown in Table 51 are analogous in construction and are operated with the same power unit (booster). They differ only in design of the C-frame and overall dimensions, and for this reason a description of their operation is given by using the press KPG8-35-55K as a typical example.

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A schematic work diagram of the portable hydraulic press is shown in Fig.165.

After the booster is connected with the main hydraulic system (Fig.165a) the

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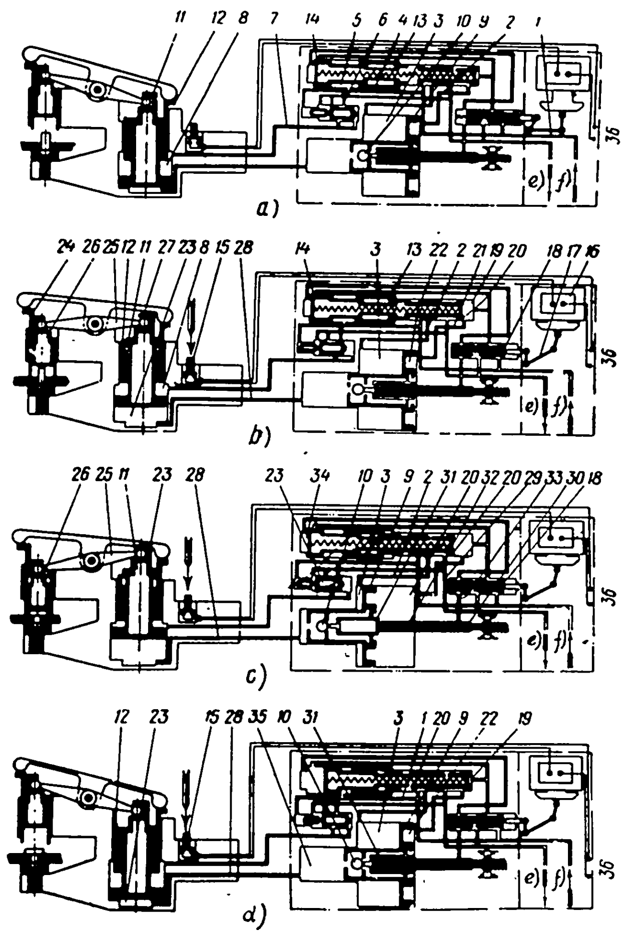

Fig.165 - Schematic Work Diagram of the Portable Hydraulic Press KPG8-35-55K and the Booster MG-7-45

a - Booster and press connected to the hydraulic system, with the press ready for riveting; plunger in the initial position; b - Starter pushbutton has been depressed, squeezing the stack together, and plunger is in contact with the rivet; c - Booster switch for forming the clenched head; riveting; d - Booster is changed-over for reverse travel, plunger returned to its initial position. 1, 2, 4, 6, 7, 21, 28, 29, 32, 33 - Channels; 3, 5, 8, 19, 22, 23, 34, 35 - Chambers; 9, 11 - Pistons; 10 - Valve; 12, 13, 24, 31 - Bushings; 14, 18, 20 - Slide valves; 15 - Pushbutton; 16 - Electromagnet; 17, 25, 27 - Levers; 26 - Plunger, 30 - Rod

e) Discharge; f) From pump

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oil is fed to the chamber (3) through the channels (1) and (2), to the chamber (5) through the channels (1) and (4), and to the chamber (8) through the channels (1), (4), (6), and (7). The oil entering the chamber (3) displaces the piston (9) to the extreme right position, and thus causes the valve (10) to open. The oil entering the chamber (8) displaces the piston (11) to its lower position, thus forcing the bushing (12) against the upper support. The oil entering the chamber (5) causes the bushing (13) to move to the extreme right position, and the valve (14) to its extreme left position. In that position, the press is considered ready for operation.

When the starter button (15) (Fig.165b) is depressed, the electric current is turned on, with the result that the electromagnet (16), via the system of levers (17), shifts the valve (18) to the right; this permits the oil to enter the chamber (19) and shift the valve (20) to the left until it is against the bushing (13). The oil enters the chamber (22) through the channel (21). At the same time, the valve (20) closes the channel (2), with the result that a hydraulic cushion is created in chamber (3), which enables the oil to enter the chamber (23).

Under the action of the oil pressure, the piston (11) and the bushing (12) are raised upward until they make contact with the clamp bushing (24) which squeezes the stack together. On contact with the stack, the bushing (24) stops moving, while the piston (11), together with the lever (25) and the plunger (26), will keep moving until the plunger contacts the body of the rivet shank. The oil in the chamber (8) exerts pressure on the bushing (12) which, acting on the lever (27) and the bushing (24), tightens the stack being riveted. The tightening force reaches up to 130 kg. When the motion of the piston (11) stops, the pressure increases in the chamber (8), the channels (28) and (21) and in the connected chamber (19), with the result th STAT the valve (20) is shifted to the support in the valve (14). After this, the groove at the right of the valve (20) (see Fig.165c) connects the channels (2) and (29), and the chamber (3) to discharge. In that case, the piston (9) begins to shift to the left and the valve (10) closes.

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The oil to the left of the valve (10) is forced through the channel (28) into the chamber (23); in that state, the pressure of the discharged oil is seven times greater than the pressure of the oil supplied. This is due to the difference in the areas between the right and the left ends of the piston (9).

Under the action of the high oil pressure, the piston (11) is put into motion and, over the lever (25) and the plunger (26), performs the riveting.

Control of the booster, when riveting with rivets of various diameters, is obtained by changing the travel of the piston (9) by means of the control rod (30). During travel of the piston (9), the rod (30) is stationary; when the face of the bushing (31) coincides with the groove in the rod (30), the oil from the chamber (22) goes through the channel (32) and (33) and enters the chamber (34) (Fig.165d); as a result, the valves (12) and (20) shift to their extreme right position, forcing the oil from the chamber (19) into the channel (1).

The valve (20), in its extreme right position, connects the chamber (22) to discharge, and the chamber (3) with the pump; this causes the piston (9) to shift to the right. When the piston reaches the support, the bushing (31) opens the valve (10), with the result that the chamber (35), the channel (28), and the chamber (23) are connected to discharge.

This completes the full cycle of operation of the press and booster. After this, the press is moved to the next rivet, and the cycle is repeated by depressing the starter button (15).

Along with the portable presses described above, combination pneumatic-hydraulic presses are used for duralumin rivets up to 14 mm in diameter.

6. Tools for Mounting in Presses for Group and for Single Riveting

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Presses for riveting parts and components with various configurations are provided with sets of interchangeable tools (such as dies for presses used for single riveting and die blocks for group riveting) and also with special riveting equipment,

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as required. The principal purpose of the tools is to cause preliminary tightening of the stack being riveted and to head the rivets to the correct shape and dimensions.

Tools used in group riveting have additional functions, the principal ones of which are as follows:

1) Providing a mechanical impulse for automatically stopping further deformations of the rivet at the instant the clenched head has the required height.

2) Imparting motion to the follow-up device during automatic riveting of radially converging seam.

Tools for presses used in group riveting are classed in the following groups:

1. Tools for riveting in open places of structures;
2. Tools for riveting in semiopen places of structures;
3. Tools for riveting in places of difficult access.

In selecting the size and type of riveting tools it is necessary to take into consideration the shape of the workpiece, the number of rivets being riveted simultaneously during one stroke of the press, the lateral pitch of the rivets, and the pitch between rows. The length of the working part of the tool is restricted, depending on the number of rivets being riveted during one stroke of the press, and must not exceed the diameter of the plunger by more than 50%. If this condition is not observed, the tool may start skewing, with the result that the clenched heads are tilted, and the tool gets out of line.

In construction, the tool used for group riveting is made with cleats and with thrust journals. The latter are used in riveting parts and components of odd configuration, i.e., structural parts where a tool with cleats cannot be used.

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Figure 166 shows a riveting tool with cleats intended for riveting in open places of structures. A tool of this type consists of lower and upper die blocks. The lower die block is installed and set in place in the lower tool holder (Fig.167) of the press in special guides (1) and fixed in place with the locking device (2).

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The guides of the lower tool holder may be turned, together with the dial (3), with reference to the stationary bushing (4), which is fastened on the plunger and is locked in place with the screw (5).

A tool holder of this design is employed in presses of types KP-405, KP-503 and KP-403.

The lower tool (see Fig.166) consists of the die block (1), to which side plates (2) are fitted, extending over the die block by 20 mm and continuously sub-

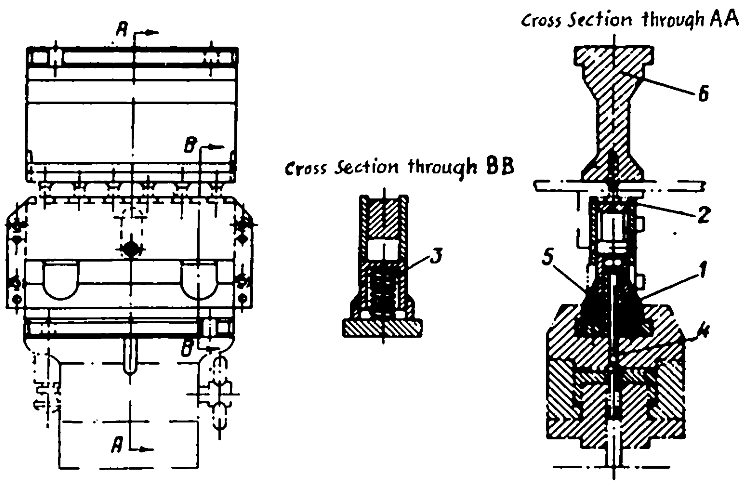

Fig.166 - Tool for Group Riveting

1 - Lower die block; 2 - Cleat; 3,5 - Clamps; 4 - Push rod;

6 - Upper die block

jected to the action of two springs (3). The plates serve for squeezing together the stack as the plunger is raised, and for transmitting the impulse for withdrawal of the plunger of the press from the workpiece at the instant the rivet is headed to the required dimensions. The push rod (4) is held in position by the spring (5).

The upper die block (6) consists of a single piece and is installed and fixed in place in the upper tool holder. The guides in the upper tool holder may be turned

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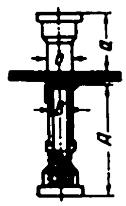
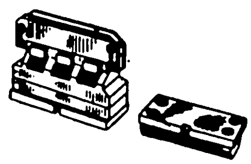
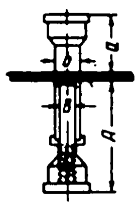
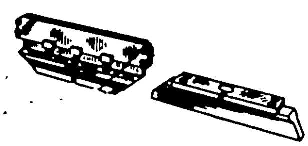
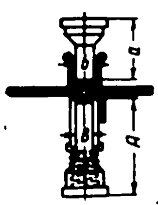
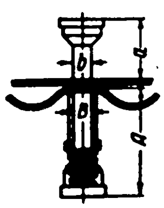
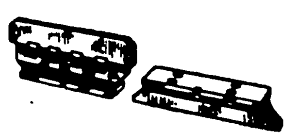
Table 52

Tools Used for Riveting in Open Places of Structures with Presses for Group Riveting

Sketch of Tool	General View of a Similar Tool	Principal Dimension of Tool			
		Lower		Upper	
		A	B	a	b
		130	10	85	25
		150	34	110	40
	—	130	20	85	20
		130	20	85	20

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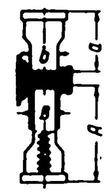
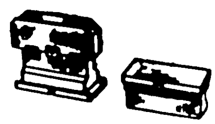
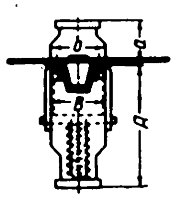
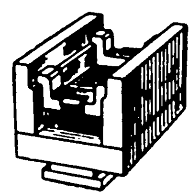
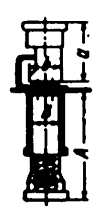
a)	b)	c)			
		d)		e)	
		A	B	a	b
		130	20	85	25
		160	70	110	80

a) Sketch of tool; b) General view of a similar tool; c) Principal dimensions of tool; d) Lower; e) Upper

Table 53

Tools Used for Riveting in Semiopen Places of Structures with Presses for Group Riveting

a)	b)	c)			
		d)		e)	
		A	B	a	b
		130	25	85	30

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a) Sketch of tool; b) General view of a similar tool; c) Principal dimensions of tool; d) Lower; e) Upper

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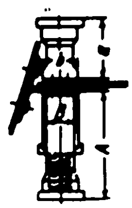
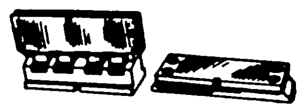
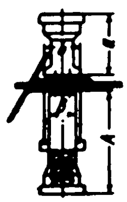
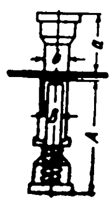
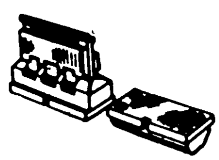
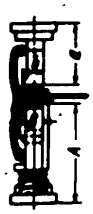
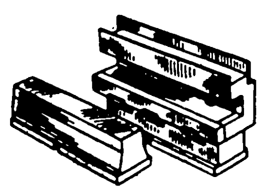
a)	b)	c)			
		d)		e)	
		A	B	a	b
		130	25	85	30
		130	25	85	30
		130	15	85	25
		130	25	85	30

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a) Sketch of tool; b) General view of a similar tool; c) Principal dimensions of tool; d) Lower; e) Upper

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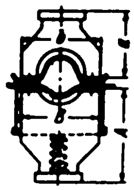
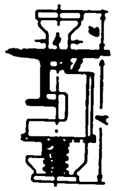
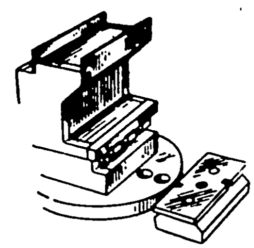
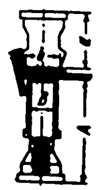
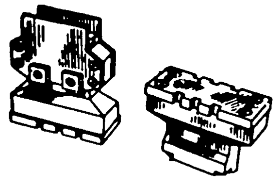
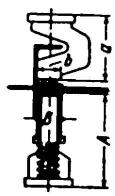
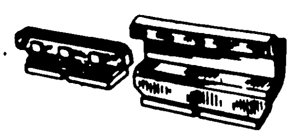
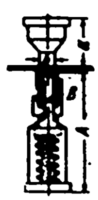
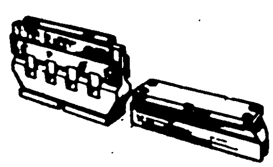
a)	b	c)			
		d)		e)	
		A	B	a	b
	—	115	65	70	80
		130	30	55	40
		130	25	85	30
		130	15	85	20
		150	10	110	80

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a) Sketch of tool; b) General view of a similar tool; c) Principal dimensions of tool; d) Lower; e) Upper

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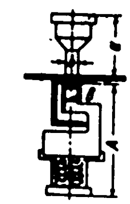
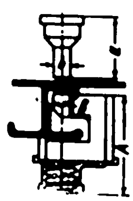
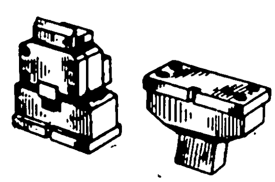
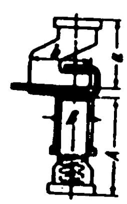
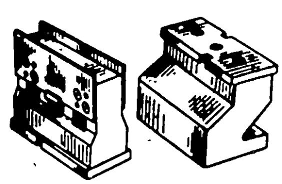
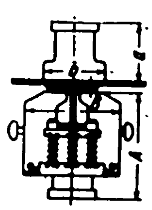
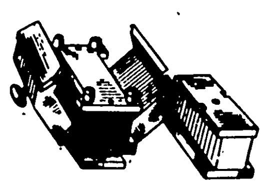
Table 54

Tools Used for Riveting in Places of Difficult Access with

Presses for Group Riveting

a)	b)	c)			
		d)		e)	
		A	B	a	b
	—	130	15	85	15
		130	20	85	20
		130	25	85	50
		110	120	70	80

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a) Sketch of tool; b) General view of a similar tool; c) Principal dimensions of tool; d) Lower; e) Upper

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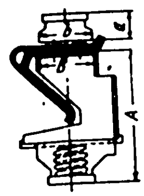
Sketch of Tool	General View of a Similar Tool	Principal Dimensions of Tool			
		Lower		Upper	
		A	B	a	b
	—	160	60	60	60

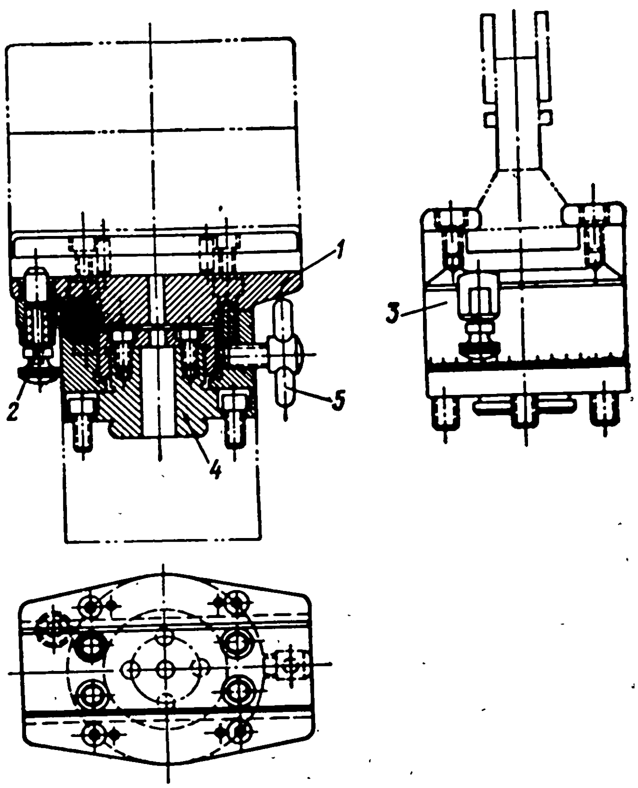


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Fig.167 - Tool Holder

1 - Guides; 2 - Locking device; 3 - Dial; 4 - Bushing; 5 - Locking screw

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with respect to the stationary bushing, which is fastened to the flange of the C-frame of the press.

Similar types of die blocks for riveting various structures and their characteristics are given in Table 52.

For riveting parts of a complicated configuration, with single rows and multiple rows of rivets, special tools are employed, examples of which are illustrated in Tables 53 and 54.

When it becomes necessary to do riveting work on components with large protruding elements, special die blocks of the type shown in Fig.168 are used.

Whatever type of tool may be employed, the working surfaces of the upper and

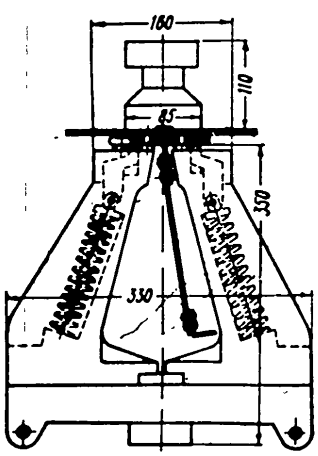

Fig.168 - Tool for Presses Used for Group Riveting of Components with Large Protruding Elements

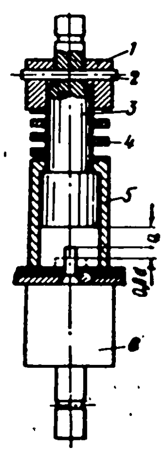

Fig.169 - Riveting Tool (Die) for Single-Riveting Presses

1 - Shoe block; 2 - Pin; 3 - Upper die; 4 - Spring; 5 - Buffer; 6 - Lower die

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lower die block must be well ground and polished, and the clamping attachments, such as the plates and dowels, must not have sharp tool marks in order to avoid damage of the surface of the parts being riveted.

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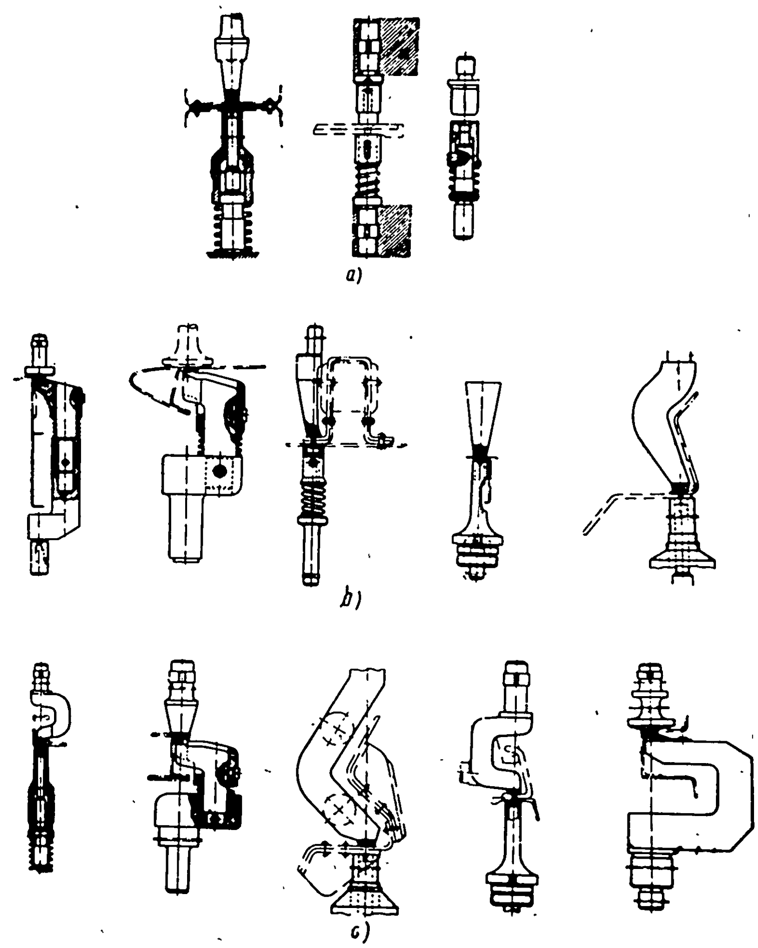

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Fig.170 - Tools for Single-Riveting Presses

a - For riveting in open places of structures; b - For riveting in semiopen places of structures; c - For riveting in places of difficult access

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The design of the tool must be such as to assure rapid interchangeability of the tools whenever there is a change in the riveting work on workpieces of different configurations. Furthermore, the interchangeable tools must fit perfectly in place on any press used in group riveting work.

The quality of riveting work done on a seam depends to a considerable extent on how much pressure is applied to squeeze the stack together before heading of the rivets; this pressure must be different for various thicknesses of the stack and for different diameters of the rivets.

Cylindrical springs are used for the necessary tightening force to squeeze the stack together; these springs are located within the die block of the press. The required squeezing force is provided beforehand during the assembly of the riveting tool, by adjusting the compression of the springs.

Figure 169 illustrates the construction of the die for the press KP-204. It consists of the upper die (3), which slides in the buffer (5) and is acted on by the spring (4), and the lower die (6).

The spring is between the buffer (5) and the shoe block (1) in a state of compression, fixed by the pin (2).

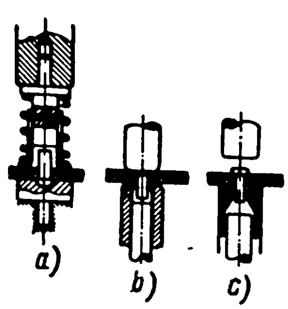

Fig.171 - Centering of Rivets with Reference to the Dies in Press Riveting
a - Centering rivets with half-round heads; b - Centering rivets with reference to the punched hole for flush riveting; c - Centering rivets with flat heads

As in the case of tools for group riveting presses, tools used for single riveting are likewise classed in the following groups:

1. Tools for riveting in open places of structures (Fig.170a);

2. Tools for riveting in semiopen places of structures (Fig.170b);

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3. Tools for riveting in places of difficult access (Fig.170c).

The use of various types of tools is determined by the shape of the parts to be riveted and by the diameter of the rivets.

The correct installation and centering of the rivets with reference to the center line of the upper and lower dies has a considerable effect on the quality of the

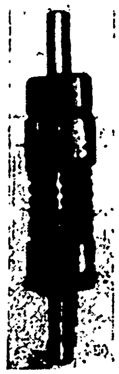

Fig.172 - Tool for Riveting Anchor Nuts

Fig.173 - Riveting on of an Anchor Nut to a Bulkhead

riveting work. When rivets with half-round heads are used, the centering is done with reference to the original rivet head. After the rivet is inserted into the hole of the workpiece, it is aligned in the press in such a manner that the original rivet head fits correctly into the cavity of the die (Fig.171a).

In riveting with flush-head rivets, the centering is done on the basis of the shape of the dimpled recess in the sheets (Fig.171b), while in the case of countersunk recesses, the countersunk recess itself is the basis for centering. When f STAT head rivets are used, the basis for centering is either the shank (Fig.171c) or the original rivet head. In the latter case, dies are used having a cavity conforming to the dimensions of the original rivet head.

The punch mark made for the purpose of centering the shank correctly with ref-

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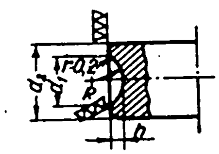
erence to the die should be of such size and shape that it will not distort the shape of the original rivet head, nor form cuts in the part being riveted. The sur-

Table 55

Dimensions of the Working Surfaces of Dies for Riveting with Rivets Having Half-Round Heads

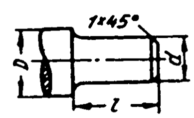


a)	b)			
	h	R	d_1	d_2
2,6	$1,3_{-0,04}$	$2,86^{+0,04}$	4,79	6,5
3	$1,5_{-0,05}$	$3,3^{+0,05}$	5,53	7,5
3,5	$1,75_{-0,05}$	$3,85^{+0,05}$	6,45	8,5
4	$2,0_{-0,05}$	$4,4^{+0,05}$	7,36	10
5	$2,5_{-0,06}$	$5,5^{+0,06}$	9,2	12,5
6	$3,0_{-0,06}$	$6,6^{+0,06}$	11,05	15
7	$3,5_{-0,06}$	$7,7^{+0,06}$	12,9	17,5
8	$4,0_{-0,06}$	$8,8^{+0,06}$	14,7	20

a) Rivet diameter d in mm; b) Dimensions in mm

Table 56

Shank Dimensions of Dies for Single-Riveting Presses



a)	b)		
	d	l	D
KP-204	$10^{+0,005}$	35	25
KP-310	$20^{+0,01}$	45	25
KP-201; KP-101 и KP-102	$9^{+0,005}$	25	18
KP-106; KP-107 и KP-103	$9^{+0,005}$	20	14
KP-104	$6^{+0,005}$	15	12
KPG5-18-45к	$8^{+0,005}$	14	12
KPG6-25-50к	$8^{+0,006}$	26	14
KPG8-35-55к	$8^{+0,005}$	19	20
KPG8-40-55к	$8^{+0,005}$	10	22

a) Type of press; b) Dimensions in mm

face of the punch mark must be carefully smoothed to avoid scratches and roughness of the rivet head.

Table 55 gives the dimensions of the working surfaces of dies used on presses for riveting with half-round rivet heads. Dimensions of the shanks of dies used in stationary and portable presses for single riveting are given in Table 56.

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For riveting of anchor nuts, special tools of the type shown in Fig.172 are employed. In that case two rivets are being riveted at the same time, as shown in

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Fig.173.

7. Press Work with Auxiliary Equipment

Design and Characteristics of Auxiliary Equipment

The efficiency of press riveting can be considerably increased by providing the presses with conveying and work-support equipment. Such equipment eliminates the necessity of holding the workpiece by hand, does away with the need of assistants, facilitates the installation of the workpiece between the riveting tools, and improves the quality of the riveting work.

Following are the principal requirements which equipment for conveying and for supporting the workpiece should meet:

1) The equipment devices must align the parts to be riveted and relocate their position automatically for group riveting.

2) The equipment must be such that parts of various sizes and shapes can be readily installed and handled.

3) The equipment must permit to relocate the parts during the riveting in two mutually perpendicular planes.

4) The conveyer mechanism must be such that the parts to be riveted can be fastened to it in the proper position for riveting.

5) Ready access to the equipment must be provided during servicing of the press and of the operating controls for riveting.

6) The mechanisms of the equipment must operate smoothly without jerks, and the parts being riveted should be easily relocated between the riveting tools of the press.

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7) The equipment must be such that the parts to be riveted are easily installed before riveting and just as easily removed after riveting.

8) The equipment must have the necessary number of support points to prevent rocking and bending of the parts during riveting.

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Auxiliary equipment used for aligning and shifting of the parts being riveted may be classed in the following groups, depending on their degree of mechanization and their arrangement with respect to the riveting presses:

1. Equipment which aligns and shifts large-size parts and components automati-

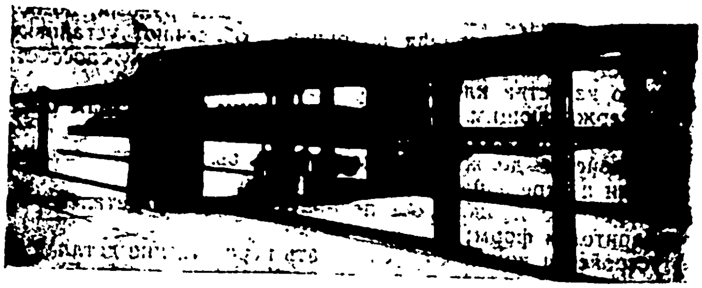

Fig.174 - Supporting and Conveying Equipment for the Press KP-602

cally in group-riveting procedure, and is tied in directly with the kinematics of the press.

2. Equipment for aligning and shifting large-size parts and components for

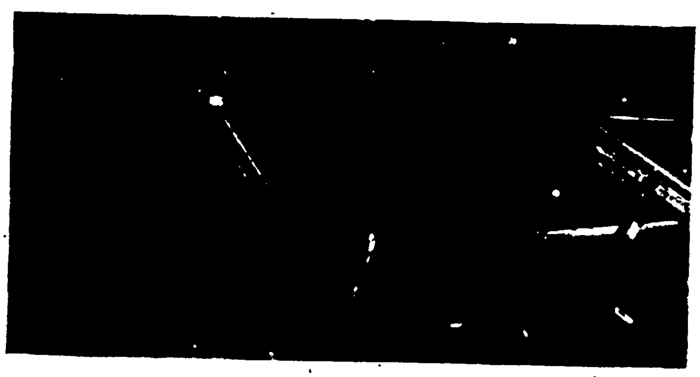

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Fig.175 - Automatic Aligning and Conveying Equipment VU-1

group-riveting procedure, and which is installed on the housing part of the press.

3. Equipment in the form of carriages located close to the press, with the

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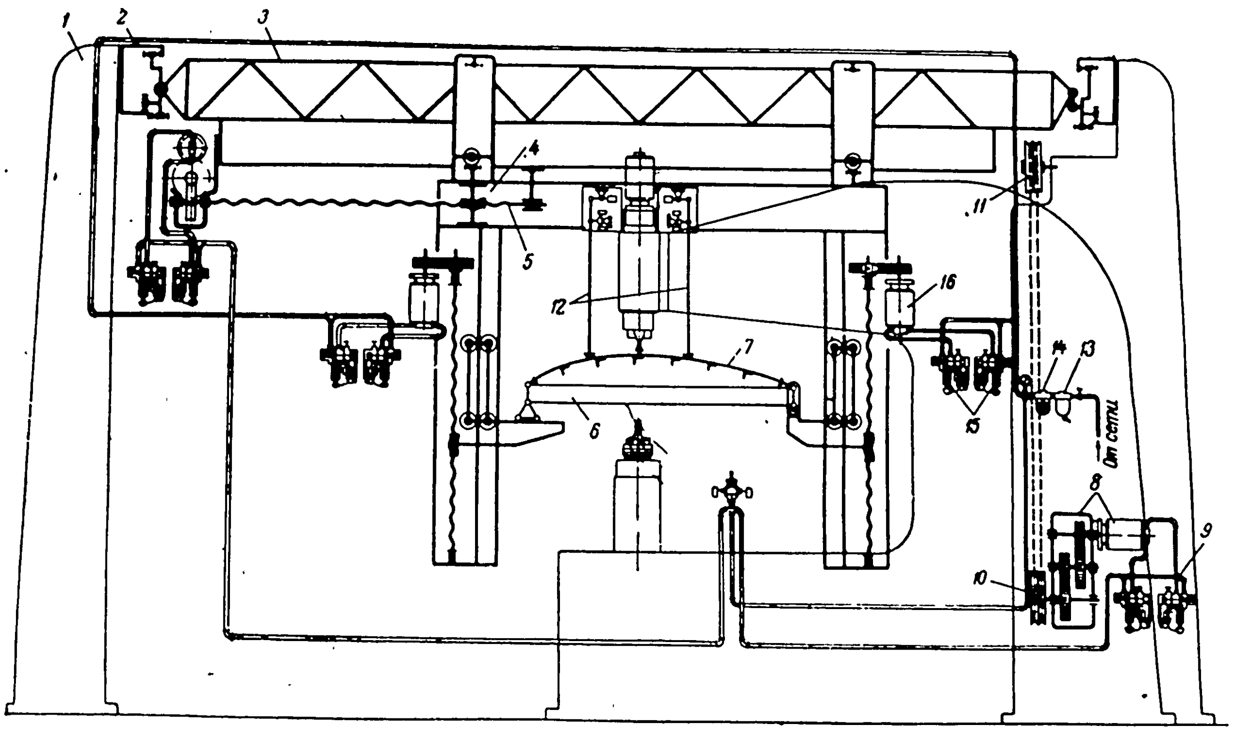

Fig.176 - Kinematic Scheme of the Automatic Aligning Equipment VU-1

1 - Upright columns; 2 - Guides; 3 - Longitudinal carriage; 4 - Transverse carriages; 5 - Screw; 6 - Frame; 7 - Part being riveted; 8 - Mechanical drive; 9,15 - Electro-pneumatic starting devices; 10 and 11 - Pulleys; 12 - Electric pickups; 13 - Filter; 14 - Automatic lubricator; 16 - Pneumatic motor
a) From main line

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shifting of the workpiece being done by hand.

4. Monorails mounted to the overhead structure of the workshop.

5. Equipment attached directly to the housing parts of the press.

6. Girders and roller conveyers.

Equipment belonging to the first and second groups are utilized to best advantage in combination with presses for group riveting that have a large overhang and throat of the C-frame, i.e., in combination with presses of the KP-503 and KP-403 type, and also with portable presses which can be used for riveting large parts.

The First Group of supporting and transporting equipment includes the equipment for the press KP-602, shown in Fig.174. This equipment provides automatic alignment of the workpiece perpendicularly to the vertical center line of the riveting tools, and also automatic relocation of the workpiece in group riveting. The operation of the automatic mechanism of the equipment is coordinated with the operation of the press mechanism, so that depressing one starter pushbutton on the central control panel of the press, will permit riveting a seam up to 15 m in length.

The equipment consists of a frame to which the workpiece, a panel, is attached, a hoisting mechanism for the frame, a carriage, a drive for the carriage, guides on which the carriage travels, and a tension device for the hoisting mechanism of the carriage.

The frame consists of two longitudinal girders of welded construction and four transverse hinged ties. The workpiece is fastened to the frame with the aid of special clamps. The frame, with the workpiece, is placed on the four brackets of the hoisting mechanism. Installation of the workpiece perpendicularly to the center line of the riveting heads is accomplished by raising or lowering the frame wit STAT workpiece by changing the position of the hoisting-mechanism cantilever bracket.

The position of the brackets is changed by means of lead screws operated by a reversible pneumatic motor, which is controlled by the four pickups in the upper riveting head. The hoisting mechanism is mounted to the movable stand of the car-

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riage.

The carriage has four vertical struts coupled rigidly lengthwise with tubular members. The travel of the carriage is effected over the common drive. The carriage drive is located under the floor, at the front side of the press.

The drive consists of a reversible pneumatic motor turning a horizontal shaft with two pulleys, which transmit the travel of the carriage through cables over special guides to the frame. The tension of the cables and the relative position of the pairs of braces of the carriage are controlled by a special tension-control device. The upper and lower guides for the carriage travel are mounted to four girders which go through the opening in the press, perpendicularly to the guides of the housing. The press housing serves as the central support point for the carriage guides.

An outline of the technical procedure of riveting on the KP-602 press, using aligning and support attachments, is given in Table 49.

The Second Group of supporting and conveying equipment comprises equipment of the VU-1 type, shown in Fig.175. This assembled unit is intended for automatic aligning and shifting of the workpiece with respect to the working tool of the press. The presence of special hoisting devices in the alignment portion permits fuller use of the feature of presses of the type KP-503 and KP-403 to do riveting on parts with variable contours. In the presses mentioned, equipment of the type VU-1, with some modifications, may be used in combination with presses that have a large overhang and throat of the C-frame, and also in combination with presses of the portable type for riveting of large parts.

With the equipment shown, riveting can be done on components with ordinary curvature. The greatest dimensions of the workpiece installed on the frame are 10,000 in length and 1300 mm in width. The weight of the workpiece should not exceed 250 kg.

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Equipment of the type of VU-1, for which a kinematic diagram is presented in

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Fig.176, consists of upright columns with guides for the longitudinal carriage, longitudinal carriage and a transverse carriage, hoisting devices, frame, drive :

Technical Characteristics of Aligning Equipment of the Type VU-1

Dimensions of aligning equipment, in mm:	
Length of guides of longitudinal carriage	22,400
Overall height of equipment	3,150
Height above floor level	2,700
Distance between uprights	4,500
Floor space occupied by the equipment, in m^2	100
Greatest travel of longitudinal carriage, in mm	10,200
Greatest travel of transverse carriage, in mm	1,500
Greatest travel of hoisting devices, in mm	950
Distance from floor to axis of frame holding the part being riveted, in mm:	
Greatest	1,500
Least	850
Time interval for aligning the workpiece, in m/min:	
Time interval for longitudinal alignment	0 - 13.5
Time interval for vertical alignment	1.1
Time interval for transverse alignment	0.75
Air pressure in compressed-air system, in atm	4 - 5
Voltage of current supplying the automatic electric device, in volts	36

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the transverse carriage, tension device, electric pickups, and a control panel for the pneumatic and electric systems.

The gantry (1) is designed in the form of a semigantry to whose columns the guides (2) for the longitudinal carriage are attached. The base of the upright columns is in the form of two beams, connecting every pair of columns. For greater

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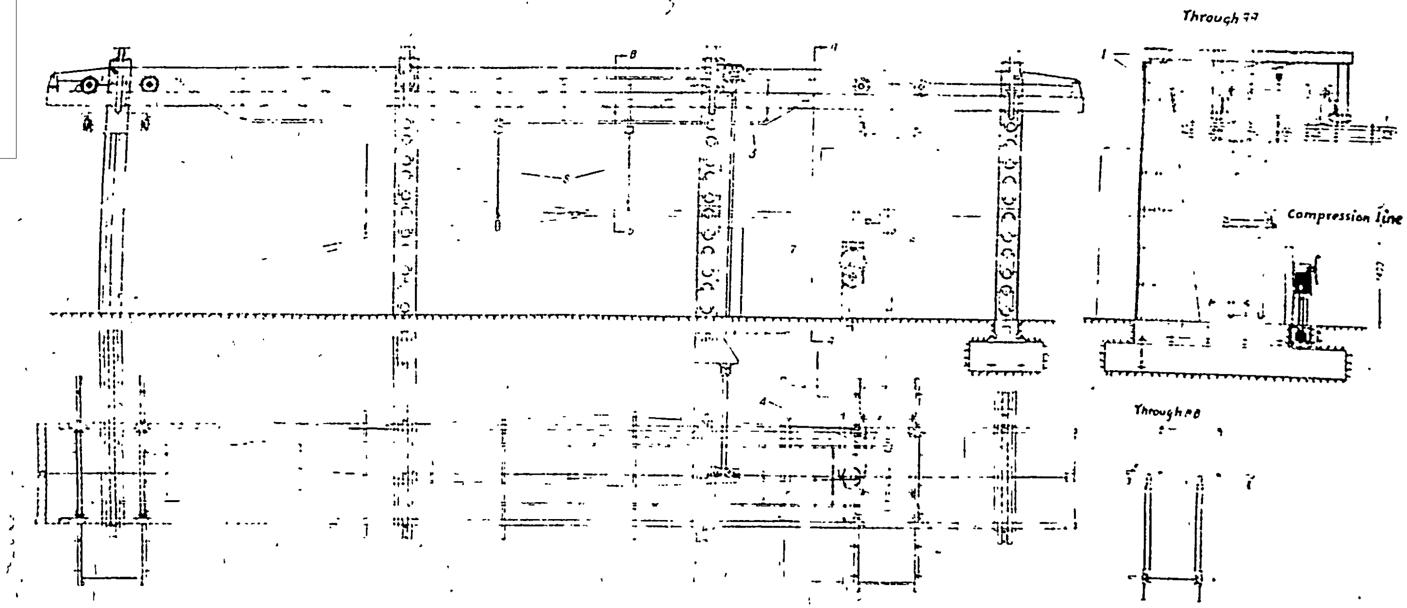

Fig.177 - Semiautomatic Aligning Equipment for the Press KP-501A for Riveting of Longerons with Components in Two Mutually Perpendicular Planes

1 - Frame; 2 - Longitudinal carriages; 3,4 - Girders; 5 - Transverse carriages
6 - Hoisting devices; 7 - Control panel; 8 - Supporting rods

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strength, the uprights are installed below the floor level to a depth equal to the height of the transverse carriage.

The longitudinal carriage (3) is designed as a rigid latticed frame consisting of two transverse girders. To the transverse frame are attached guides over which the transverse carriage (4) travels. The longitudinal girders have brackets at their underside, on which the carriage wheels are mounted, which facilitates travel of the carriage along the guides.

The transverse carriage (4) serves for aligning the workpiece in a vertical plane. The transverse carriage has a beam with hoisting devices at each end. Both sides of the edges of the base of the transverse carriage are provided with two brackets to which are attached two hinged lower brackets for facilitating the travel of the transverse carriage along its guides.

Hoisting devices are mounted to the base of the longitudinal beams, for aligning the parts being riveted. The transverse carriage travels along the guides by means of the screw (5), located between the support surfaces of the elevating devices and the base of the carriage.

The frame (6) serves for installing the workpiece and for aligning it with respect to the riveting tool. The frame consists of a welded girder of latticed construction. The transverse girders of the frame have hinged connections to both transverse beams of the frame, so that the frame, together with the part to be riveted, can be set to any desired position in a vertical plane, relative to the riveting tool. The part being riveted (7) is placed into the frame on special channels, whose ends carry hooks by which the channels are suspended from the frame.

The control compartment contains the mechanical drive (8) of the longitud:STAT carriage and also the electric and pneumatic starting devices (9). The drive for the transverse carriage consists of a pneumatic motor and a single-stage speed-up gear, connected over the longitudinal shaft with a worm gear reducer. The worm gear unit, connected to a lead screw, imparts motion to the transverse carriage. The

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drive for the longitudinal carriage consists of a two-stage reducing gear, whose whose drive shaft carries a pulley (10) which, by means of a cable and drive pulley (11), transmits motion to the longitudinal carriage.

The tension device consists of two movable blocks connected by a strip. Each block has four clasps, three of which are intended for fixing the electric cables and the fourth for the air hose.

The electric pickups (12) are installed in the upper part of riveting presses. (In presses of the type KP-503 and KP-403, the pickups are located in the upper part of the riveting support units.)

The supply of compressed air to the pneumatic motors of the longitudinal and transverse carriages, as well as to the hoisting devices, is from the main pneumatic system. The pneumatic system consists of the filter (13), the automatic lubricator (14), electro-pneumatic starting devices (15), and pneumatic motors. For convenience of adjustment, each electro-pneumatic device is equipped with a shut-off valve, by means of which the supply of air from the main lines to the starting devices may be by-passed.

Before starting the riveting work with the aid of the aligning and support equipment of the type mentioned, the part to be riveted, with pre-drilled holes, countersunk recesses, and inserted rivets, is placed on the channels of the frame, which is originally located away from the working area of the riveting press.

Alignment of the parts being riveted is accomplished from the control panel. After switching the starter to the "start" position, the workpiece is lifted to the level of the pickups; by means of the central handle the workpiece is then placed between the riveting tools of the press. The alignment of the workpiece may be done either manually or automatically. In the automatic cycle, placing the workpiece perpendicularly to the tools of the press is effected by means of the pickups, which transmit an impulse to the electro-pneumatic starting devices of the hoisting mechanism.

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The relocation of the workpiece in longitudinal and transverse directions is effected by manipulating the central manual control handle located on the control panel.

Considerable difficulty is created in riveting components on which riveting has

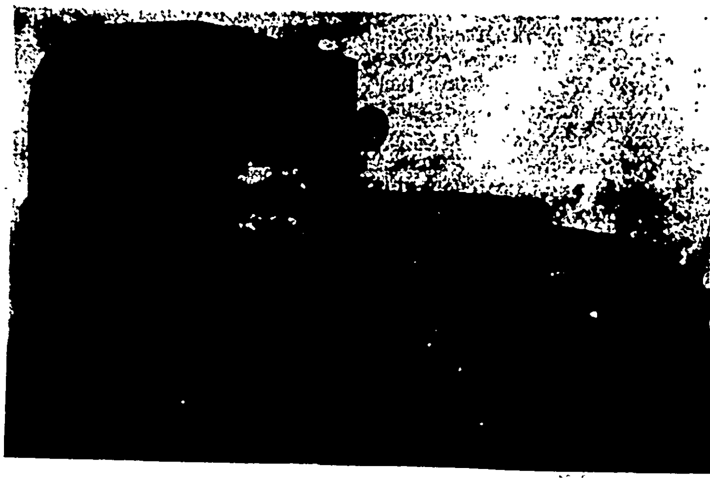

Fig.178 - Riveting of a Panel on the Press KP-501A, Equipped with a Special Carriage

1 - Table; 2 - Guides; 3 - Carriage for longitudinal travel; 4 - Channel; 5 - Carriage for transverse travel; 6 - Cable

to be done in two mutually perpendicular planes. In that case, special equipment is employed.

Figure 177 shows the semiautomatic aligning equipment for riveting longerons on the press KP-501A. STAT

The equipment shown consists of the frame body (1) made from standardized cast columns on which guide rails are fastened. Two longitudinal carriages, rigidly interconnected by means of girders (3) and (4), move along the rails and serve the purpose of locating the longeron in the required position along the press.

Rails are located on each longitudinal carriage, over which the transverse

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carriages (5) with the hoisting devices (6) travel. The transverse carriages serve the purpose of locating the longeron in the desired transverse direction. The movement of the hoisting devices of the longitudinal and the transverse carriages is effected from the control panel (7). The longitudinal travel is thereby effected with a hand-wheel over cables.

The control of the movement of the transverse carriages, and the hoisting devices is by pushbutton, and is effected by electromechanical transmission. In order to protect the longeron against buckling during riveting, suspension rods (8) with quick-release clamps are employed.

Outside of automatic support and alignment equipment, a third group of equipment is also employed, in the form of carriages of simple construction and located near-by to the presses. Such equipment is designed and built up taking into consideration the shape of the parts to be riveted.

Figure 178 shows press KP-501A, equipped with a special carriage which facilitates the proper placement and relocation of a panel during the riveting operation. The table (1) is provided with guides (2), along which the carriage (3) moves in a longitudinal direction. On two sides of the carriage are channels (4), over the guides of which the carriage (5) moves in a transverse direction. The cable (6), tied with the carriages and with a hand-wheel, is used for smooth location and shifting of the workpiece during the riveting operation.

With the aid of such equipment it is possible to do riveting on flat panels and also on panels with ordinary curvature of various radii. The construction of the equipment is such that the channels may be changed to conform to the shape of the workpiece.

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The construction of the support and conveying equipment shown in Figs.179 and 180 is similar to that described above. In the given case, the technical process of riveting is somewhat modified; namely, drilling of the holes, countersinking of the recesses and riveting of the panel is done on the press KP-310. For this purpose,

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the electric motor (1) is installed on the movable part of the bracket of the press, which transmits the rotary motion to the combination drill and countersinking tool fitted to the spindle (2) of the head of the press.

The press is operated in the following manner: The panel, consisting of rigid elements and planking, is assembled on the bench guided by the assembly holes and pinned with control rivets. With the holes in the frame as a guide, holes are drilled in the lining. The panel is placed on the support, and the conveying equipment (3) is fastened to it. With the pre-drilled holes as a guide, holes are drilled in the stack of parts to finished dimensions, and at the same time recesses are countersunk in the planking. The operation of drilling and countersinking is done in the same manner as on ordinary drill stands.

Rivets are inserted in the drilled and countersunk holes and, after changing the combination drill and countersink tool with an ordinary die, the riveting is performed. A lamp (4) (Fig.180), attached to the bracket of the press, and a lamp (5), attached to the lower part of the support equipment, furnish sufficient lighting at the working station.

The Third Group of support and conveying equipment also includes the equipment illustrated in Fig.181. As in the case of the above-described equipment in this group, the panel to be riveted (1) is located on the channel (2), which has cut-outs to fit the rigid elements of the panel. The channels are then fastened to the carriage (3), which travels along the guides (4). The guides (4), together with the carriage and panel can move in a longitudinal direction along the rails (5) that are fixed on table (6). For better observation of the quality of riveting work done on the press, light (7) is available.

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A similar carriage, designed and built at one of the plants and intended for riveting panels with the portable press KP-30-4, is shown in Fig.182. The unit KSA-403 is utilized as the power head in this press, while the riveting support unit KPA-403 is used as the support head. On this press, it is possible to do riveting

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work on large-size units, since the press opening is of considerable dimensions.

Figure 183 shows support and conveying equipment for riveting large panels on the press KP-501A. The panel (2) is mounted to the carriage (1) with the clamps (3).

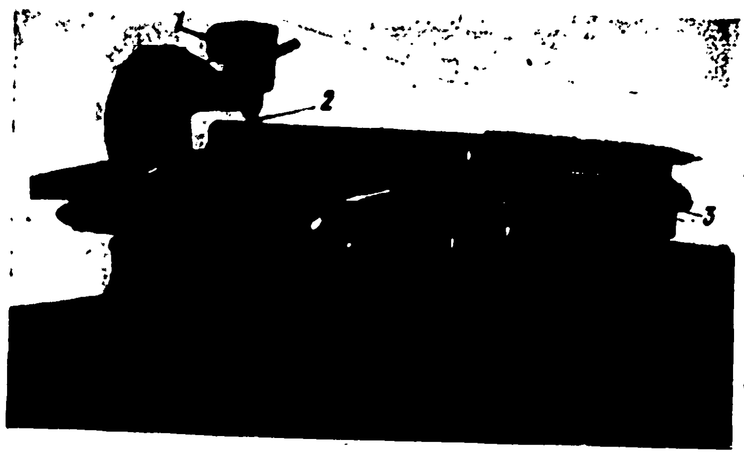

Fig.179 - Drilling, Countersinking, and Riveting of a Panel on the Press KP-310, Using Support and Conveying Equipment

1 - Electric motor; 2 - Spindle; 3 - Support equipment

The carriage (1) travels in a transverse direction over the rails (4), which are fixed on the carriage (5). The carriage (5) travels in a longitudinal direction over the rails (6) on the table (7). The travel of the carriage with the panel, in a longitudinal direction is effected by means of the hand wheel (8). On turning the hand wheel, the cable (9) attached to the carriage is wound on the drum (10) and thus moves the carriage in a longitudinal direction.

The various constructions of support and conveying carriages depend on the STAT and the structure of the parts to be riveted, the type of presses, and on a number of other factors. Figure 184 shows the riveting of a longeron on the press KP-310, with the aid of twin carriages, which permits shifting the workpiece in two directions perpendicular to each other. Figure 185 shows the riveting of a panel on the

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press KP-503, using equipment that permits aligning the seam to be riveted perpendicularly to the axis of the riveting tool, by virtue of the fact that the frame is of

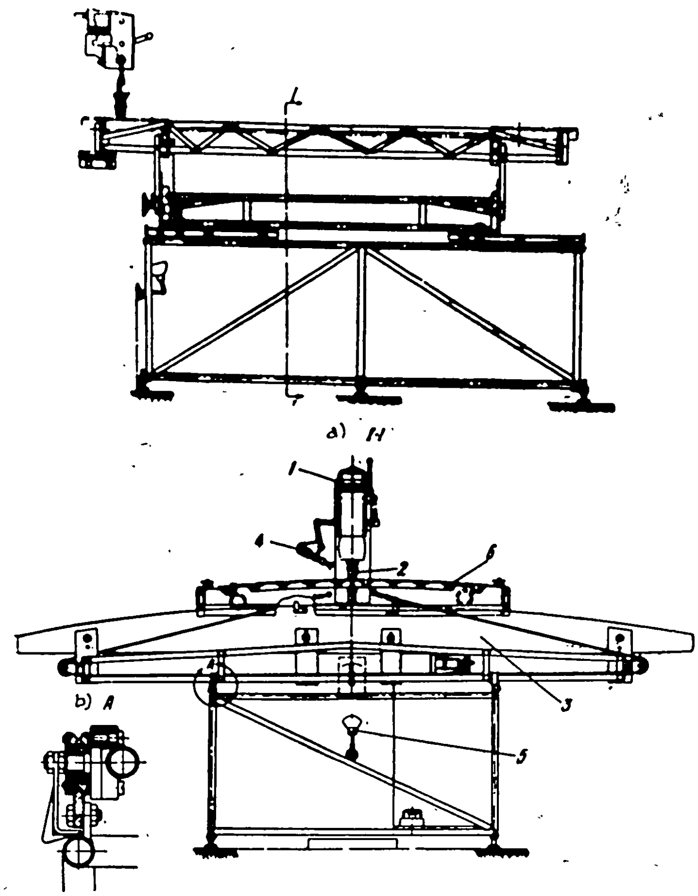

Fig.180 - Construction of Support and Conveying Equipment for Drilling, Countersinking, and Riveting of a Panel on the Press KP-310

1 - Electric motor; 2 - Spindle; 3 - Support equipment; 4 and 5 - Lights; 6 - Panel in work

a) Cross section through I-I; b) Assembly A

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the swinging and rocking type. Shifting of the panel in a longitudinal direction is effected by means of the carriage.

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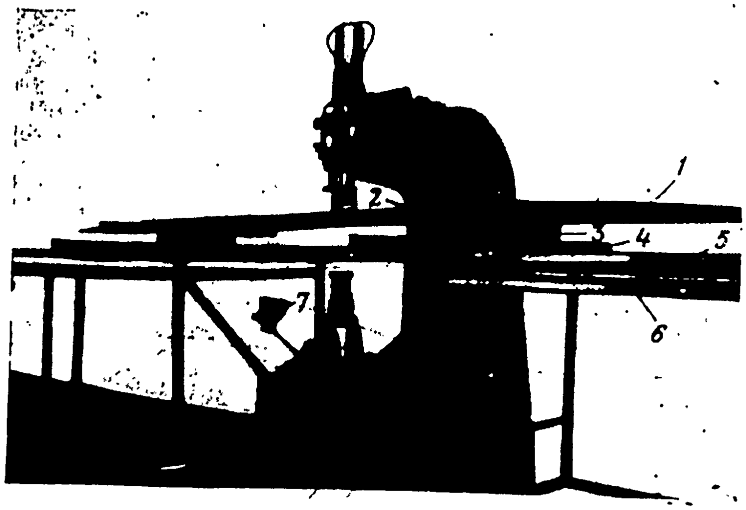

Fig.181 - Riveting a Panel on the Press KP-503, Using a Support and Conveying Carriage.

1 - Panel being riveted; 2 - Channel; 3 - Carriage; 4 - Guides; 5 - Rails; 6 - Table; 7 - Light for illuminating the riveting place

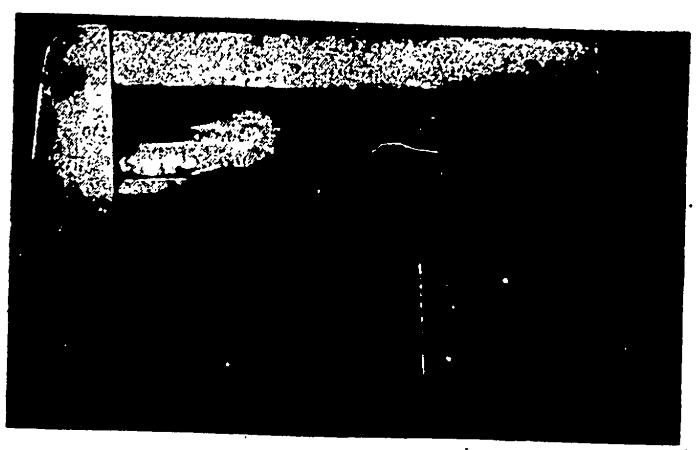

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Fig.182 - Riveting a Panel on a Portable Press with the Aid of a Carriage Located within the Press Opening

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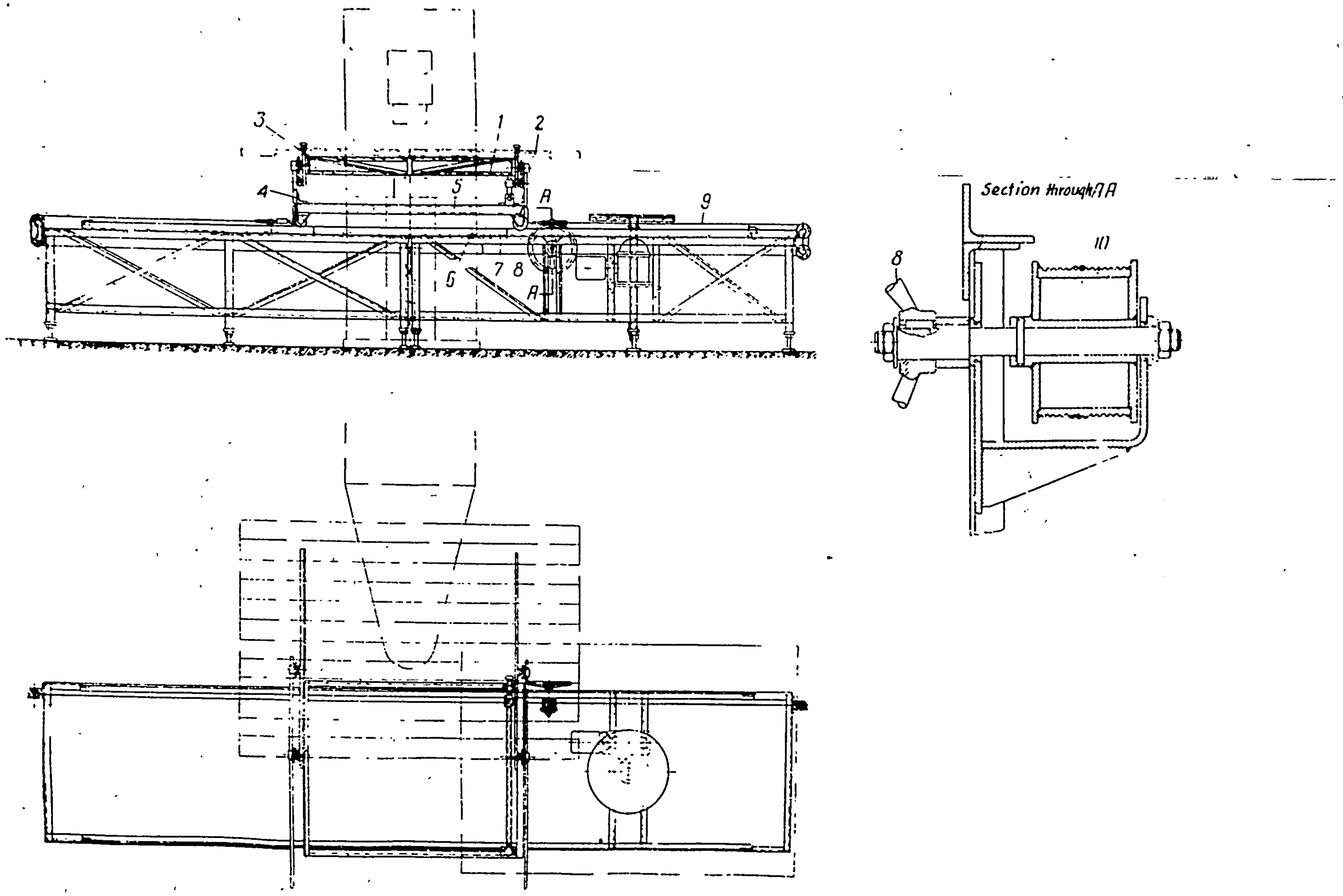

Fig.183 - Support and Conveying Equipment for Riveting Large-Size Panels on the Press KP-501A

1 - Carriage for transverse motion; 2 - Panels; 3 - Clamps; 4,6 - Rails; 5 - Carriage; for longitudinal motion; 7 - Table; 8 - Hand wheel; 9 - Cable; 10 - Drum

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The Fourth Group of support and conveying equipment includes monorails attached to the overhead structures of the plant. The use of overhead equipment results in economy of working space and makes it possible to move the workpiece easily and

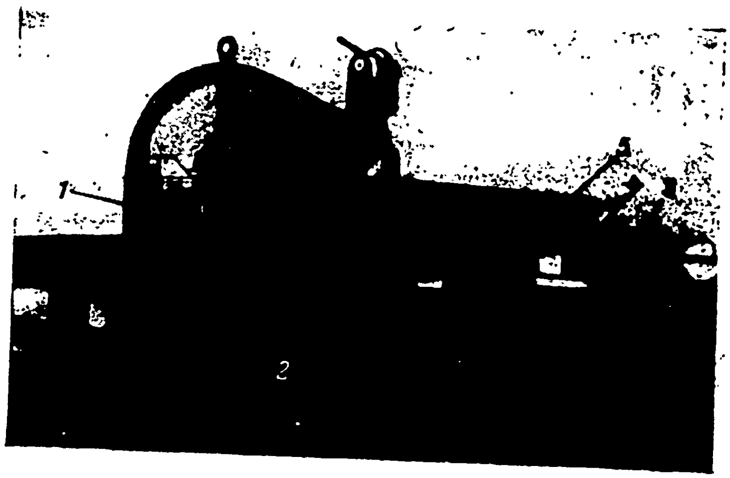

Fig.184 - Riveting a Longeron on the Press KP-310 by Means of Twin Carriages

1 - Carriage; 2 - Cable; 3 - Hand wheel for moving carriage;

4 - Rails; 5 - Longeron

smoothly, as may be required for the riveting operation, without blocking access to the place where the riveting work is done.

One type of such equipment is shown in Fig.186. On the two monorails (1) slides a trolley (2) connected with a second trolley (3) by means of a balancing spring (4). The frame (5), on which the part to be riveted is placed, is moved along by the trolley (3) during the riveting, in a transverse direction.

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The equipment shown in Fig.187 is intended for the support and shifting of a longeron along the press KP-510. Over the two monorails (1), attached to the overhead structure of the plant, travels a carriage (2) moving the longeron longitudinally. Movement of the longeron in a transverse direction is effected by carriage (3) traveling over the carriage guides (2). From the carriage (3) a balance beam (4)

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with a channel (5) is suspended. The longeron being riveted is shifted to the required height relative to the working surfaces of the riveting press tools, by means of the balancing spring (6). The original heads of the rivets are in close contact

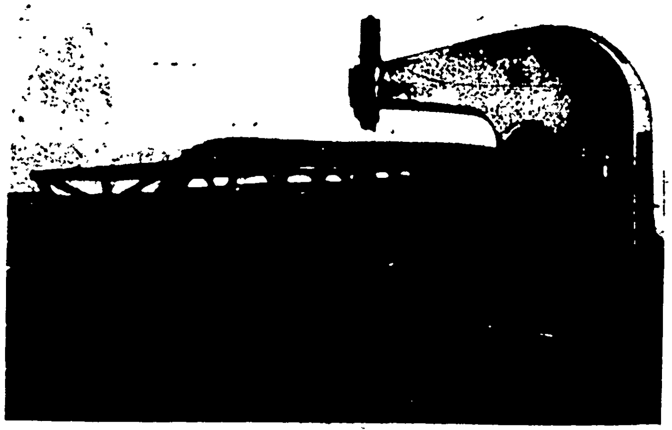

Fig.185 - Riveting a Panel on the Press KP-503 by Means of Conveying and Aligning Equipment with Turning Frame

with the surface of the part being riveted. The alignment of the longeron in height is effected by means of the screw (7).

Figure 188 shows equipment of the type employed for riveting panels which have some curvature. On two monorails (1) attached to the overhead structure of the plant, travels the carriage (2) with the upright bars (3). The panel is placed on the channels (4) and is fastened to them with the clamps (5). The segment (6) STAT d to bars (3), centers the row of rivets with respect to the dies of the press.

In riveting with portable presses in jigs, the presses themselves are suspended. Figure 189 shows equipment for suspending portable presses over assembly fixtures. Over the monorail (1), located above the jig, travels a carriage (2), from which a swinging arm (3) is suspended. One end of the swinging arm carries a cable with a shock absorber (4) for suspension of the press, and the other end carries a counter-

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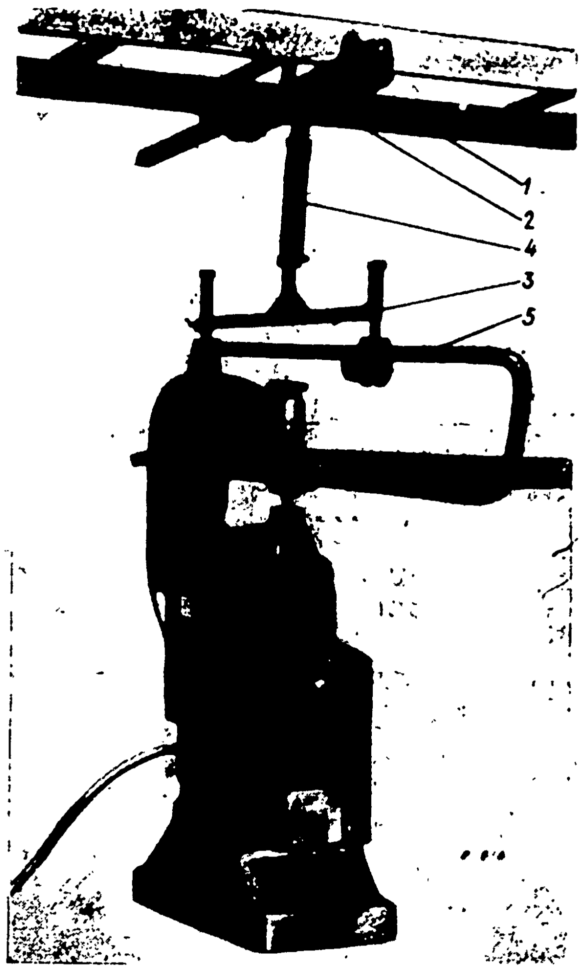

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Fig.186 - Overhead Suspension Device for the Press KP-310

1 - Monorail; 2,3 - Carriage; 4 - Balancing spring; 5 - Frame

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weight (5), to provide equilibrium for the system.

In riveting parts and components with seams of large extent on assembly fixtures, several swinging arms are installed and riveting is done with several presses. The extra blocks and weights necessary for balancing the system in special conveying

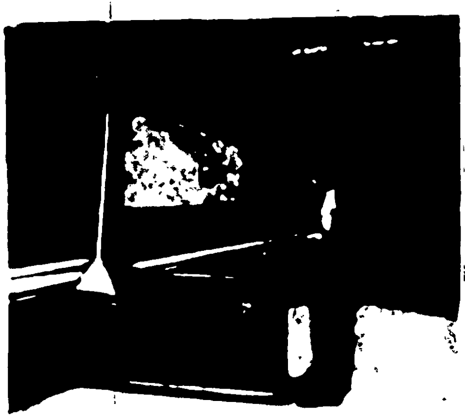

Fig.187 - Riveting of a Longeron on the Press KP-510 by Means of Suspended Equipment

1 - Monorail; 2,3 - Carriages; 4 - Rocking bar; 5 - Channel; 6 - Balancing spring; 7 - Screw

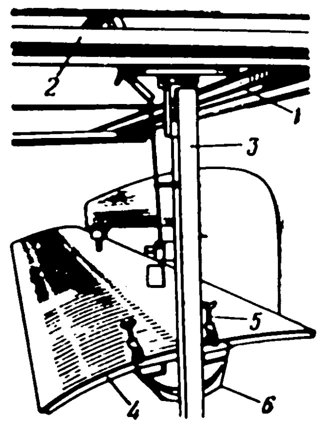

Fig.188 - Riveting of a Panel on the Press KP-510 by Means of Suspended Equipment

1 - Monorail; 2 - Carriage; 3 - Upright bar; 4 - Channel; 5 - Clamps; 6 - Segment

and aligning equipment, block the working space near the assembly fixtures and cause inconvenience. The use of general purpose swinging arms eliminates these disadvantages and facilitates the work with suspension-type equipment.

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The Fifth Group of support and conveying equipment comprises all equipment mounted directly to the housing of the press.

Figure 190 shows equipment for the support and conveying of a cowling cover. Two columns (1), located on the bracket of the press KP-310, carry the shaft (2), to which the clamp (3) is attached with four bolts.

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Figure 191 shows the support equipment used for riveting the semicircular portion of the cowling cover on the press KP-204, mounted to the bracket of the press.

The part to be riveted can be shifted in two directions: along the circular part corresponding to the radius of the workpiece, and across the press. For the

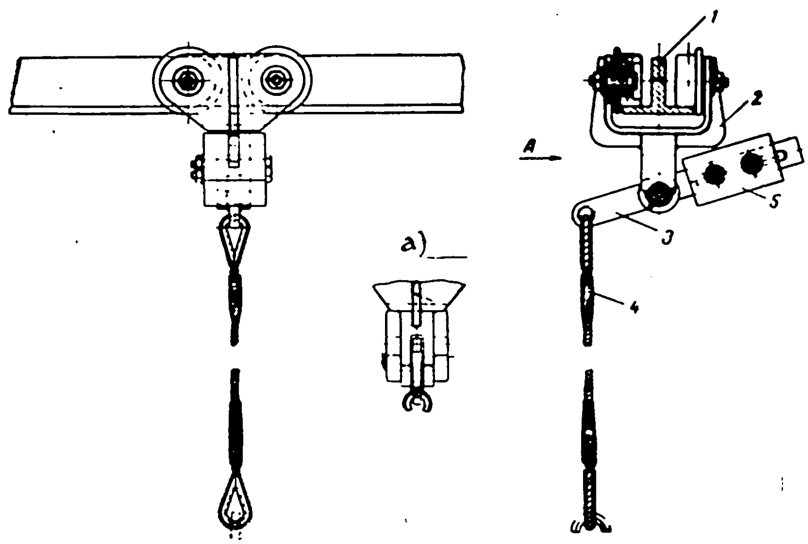

Fig.189 - Equipment for Suspension of Portable Presses Over Assembly Fixtures

1 - Monorail; 2 - Carriage; 3 - Balance arm; 4 - Shock absorber; 5 - Counterweight

a) View in direction of the arrow A

purpose of shifting the workpiece peripherally, the equipment is provided with a tubular support section. Before starting to rivet, the part is placed on the tubular section and fastened with the clamps (2). The tubular section with the workpiece is rotated about the shaft (3) to which a counterweight (4) is attached. The travel of the workpiece with the tubular section in a longitudinal direction takes place along the guides (5), situated on the upper part of the press.

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<u>The Sixth Group</u> of support and conveying equipment includes devices in the form

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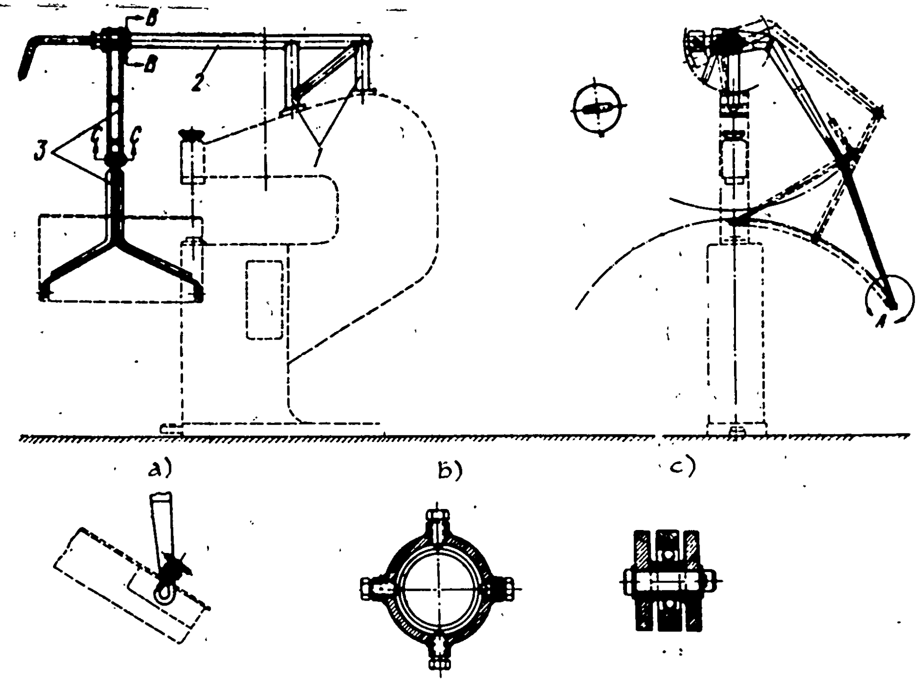

Fig.190 - Equipment Mounted to the Housing of the Press for Support and Conveyance of a Cowling Cover

1 - Columns; 2 - Shaft; 3 - Bracket

a) Assembly A; b) Cross section through B-B; c) Cross section through C-C

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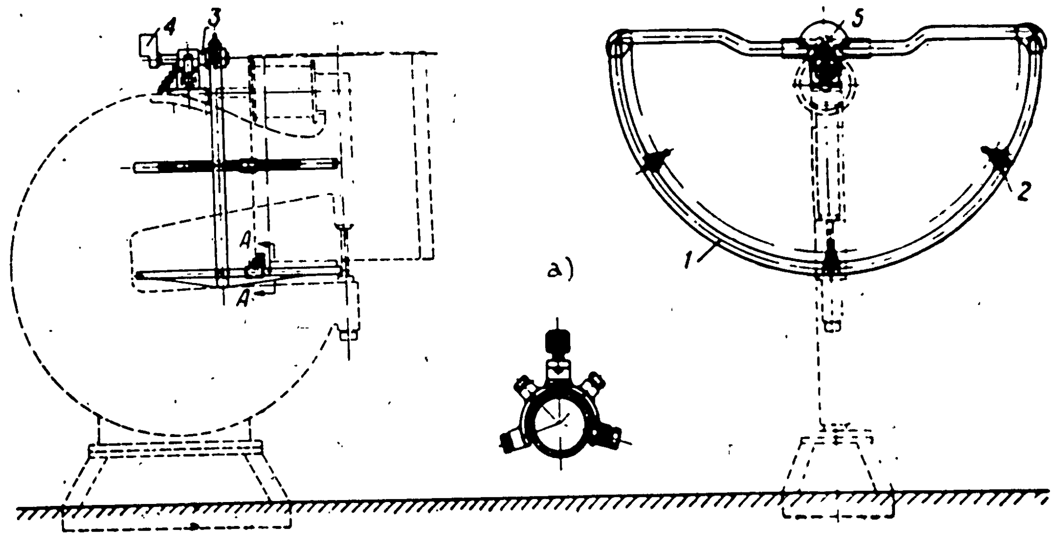

Fig.191 - Support and Conveying Equipment Mounted to the Housing of the Press KP-204 for Riveting the Semicircular Section of the Cowling Cover

1 - Tubular section; 2 - Clamps; 3 - Shaft; 4 - Counterweight; 5 - Guide

a) Cross section through A-A

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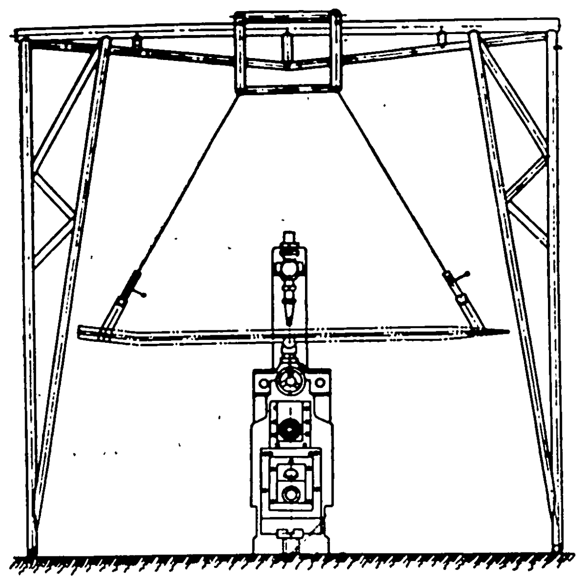

Fig.192 - Example of Utilizing Movable Girder Structures for Suspension and Conveying of a Longeron for Riveting on the Press KP-310

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Fig.193 - Riveting of a Longeron on a Group-Riveting Press, Using a Roller Conveyer

1 - Table; 2 - Carriage; 3 - Frame of carriage; 4 - Rollers; 5 - Longeron; 6 - Hand wheel; 7 - Cable

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of girders and roller conveyers.

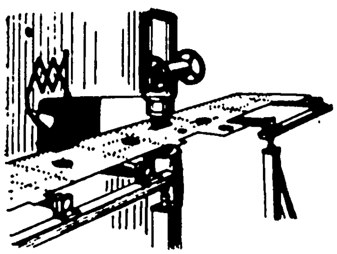

Fig.194 - Riveting of a Panel on the Press KP-501A, Using a Roller Conveyer

Fig.195 - Roller Conveyer Consisting of Separate Roller Units

Fig.196 - Roller Conveyer for the Press KP-503 for Riveting Parts of Moderate Dimensions

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of girders and roller conveyers.

A movable girder (Fig.192) represents one of the simplest structures of support and conveying equipment. The girder is of relatively light weight and has a comparatively large capacity for lifting heavy weights. It is readily shifted from one type of equipment to another.

Roller conveyers are of great convenience as supports in riveting work. The roller conveyer shown in Fig.193 consists of the table (1) with the carriage (2) consisting of the frame (3) with the rollers (4). The rollers, on which the longeron (5) to be riveted is placed, cause it to move lengthwise. Transverse movement of the longeron is provided by the carriage (2) which, in turn, is moved by the hand wheel (6) over the cable (7) and over a system of rolls.

A similar type of equipment for riveting panels is shown in Fig.194.

Figure 195 shows a roller conveyer for the support and shifting of a longeron being riveted on the press KP-510. It consists of self-contained separate roller units. The change-over of such a roller conveyer to accomodate various riveting work is very simple.

The number of roller units is determined by the length of the workpiece, with their spacing being so selected that there will be no buckling during the riveting.

A simple design of a roller conveyer is shown in Fig.196 for use in riveting parts of smaller dimensions. The roller units, in this case, are installed directly on the press housing.

Of all types of support and conveying equipment, those of the first, second, and third groups are of greater utility from the point of view of greater productivity and convenience as well as from the point of view of improving the quality of riveting work as a whole.

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Riveting Procedure

Regardless of what type of press or auxiliary equipment is used, the parts to

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be riveted should be so arranged that the original rivet heads are on top of the workpiece. This is made possible by inserting the rivets beforehand.

Should the working conditions be such that the original rivet heads are below, each rivet has to be inserted separately just before riveting; this interferes with

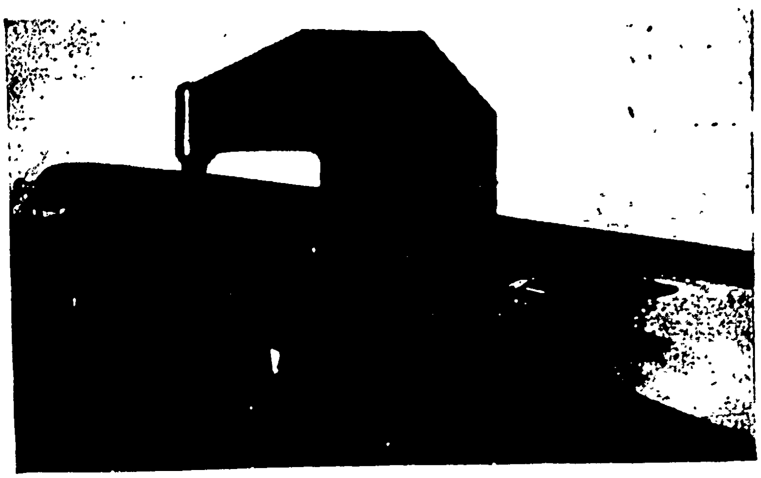

Fig.197 - Riveting of a Panel on the Press KP-501A. The Panel is Delivered to the Press with the Rivets Inserted Beforehand

maintaining the rate of production and results in a poorer utilization of the press facilities. The rivets may be installed beforehand, but in that case they can be prevented from falling out only by using adhesive tape, a procedure that results in higher cost and loss of working time.

In order to utilize to best advantage the available presses in single riveting of various components and assembly units in which the rivets are inserted in the holes from the top, from the side, or from below, in particular situations whiSTAT cannot be avoided, a study should be made of the possibility of mounting the C-frame of the riveting unit to the press housing in various positions, as was done on presses of the type KP-204, thus providing ready access to the working area of the job.

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Large-size components, panels and assemblies with portions of the seam of considerable length and in a straight line, are riveted by the group-riveting procedure on stationary presses, and the parts are delivered to the press with the rivets inserted beforehand (Fig.197). The duty of the riveter then consists of operating the riveting press and of observing the quality of the riveting work in progress.

The quality of work and the rate of production on riveting presses depends to a considerable degree on how well the working area is laid out. The working area about the press should be arranged in such a manner that there will be easy access by the riveter to the press and to the auxiliary equipment.

It is preferable to have the riveter operate the press in a sitting position from which he could observe the quality of the riveting work in progress, similar to that provided in the press KP-602 (Fig.198). In the vicinity of the press there should be two racks: one for storing the assembled parts to be riveted, and the other for parts already riveted. The press should be supplied with the necessary interchangeable tools (for riveting particular components of various shapes that may require special tools) for possible spot riveting.

In press riveting it is advisable to divide the work among several groups of workmen. One group should do the assembling, drilling, and countersinking; a second group should be charged with operation of the riveting press, and a third group be responsible for the finishing operations, i.e., aligning the rivets in places to which access is difficult and rejection of defective rivets by replacing them with good rivets. Such an organization of work will considerably increase the production in sections of the plant where assembly riveting is done. Considerable difficulties occur in riveting tubular longerons on presses, due to the inconvenience of inserting the rivets in the drilled holes and the impossibility of using standard riveting dies. At one of the plants it was suggested to rivet such structures by group riveting employing a special wedge-type support, and inserting the rivets into the holes of the stack by a pneumatic device.

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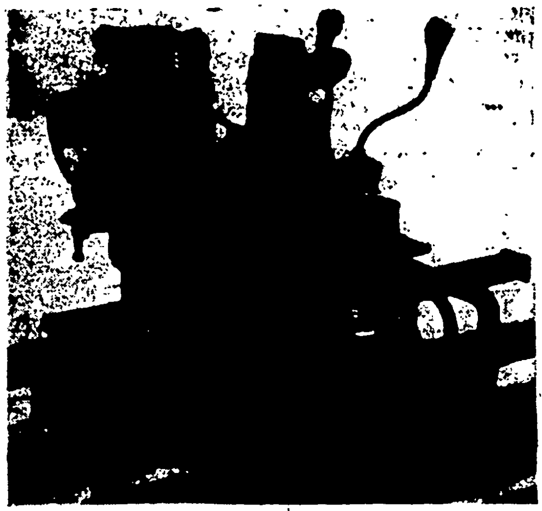

Fig.198 - Control Pulpit of Press KP-602. The Riveter Works Sitting Down and Thus Can Observe the Quality of the Riveting Work

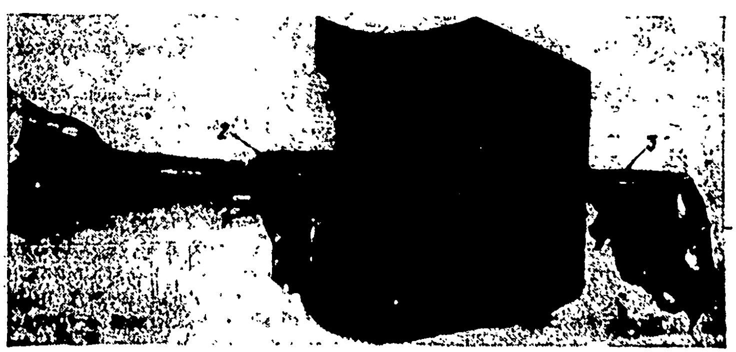

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Fig.199 - Riveting of a Tubular Longeron on a Press for Group Riveting with a Wedge-Type Support and Pneumatic Device for Insertion of Rivets

1 - Wedge support; 2 - Tubular longeron; 3 - Pneumatic device for inserting rivets

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Figure 199 illustrates how group riveting on a tubular longeron is done with the aid of a wedge-type support and a pneumatic device for inserting the rivets. We will analyze the construction of these devices for explaining their operation.

The Pneumatic Device (Fig.200) for inserting the rivets from the inside surface of the tubular longeron consists of the handle (1) with a starting mechanism, the

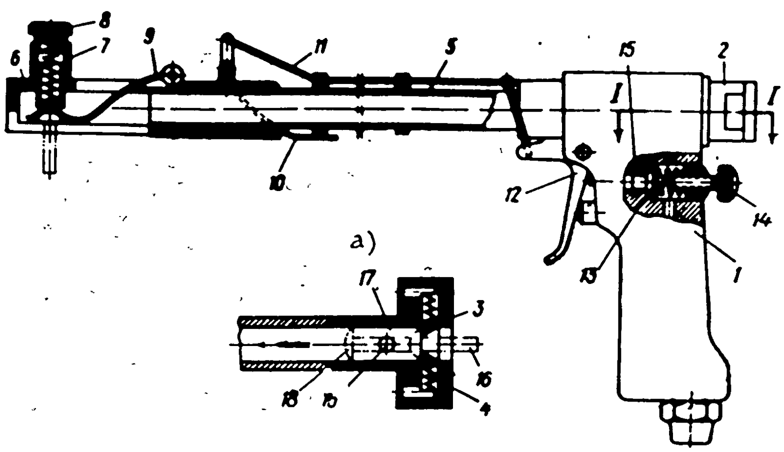

Fig.200 - Pneumatic Device for Insertion of Rivets in Tubular Structures

1 - Handle; 2 - Adapter head; 3,9 - Cut-Offs; 4 - Springs; 5 - Shank; 6 - Body of head; 7 - Tip; 8 - Regulator; 10 - Bracket; 11 - Cable; 12 - Trigger; 13 - Valve; 14 - Screw; 15 - Channel; 16,18 - Rivets; 17 - Chamber

a) Section through I-I

adapter head (2) [containing the cut-off segments (3) and two springs (4)] and the shank (5) of a length determined by the dimensions of the tubular longeron. The head (6) fits on the shank, and consists of the tip (7), the regulator (8), and the cut-off (9). To protect the inner surface of the longeron from damage during insertion of the device, a textolite bracket (10) is provided, which by means of the cable (11) and the trigger (12) is released from the tube. The screw (14) regulates

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the volume of air passing through the opening in the valve (13).

The insertion of the rivets in the stack of sheets with the aid of this device is effected in the following manner:

After inserting the shank and the tip inside the tube, two rivets are inserted

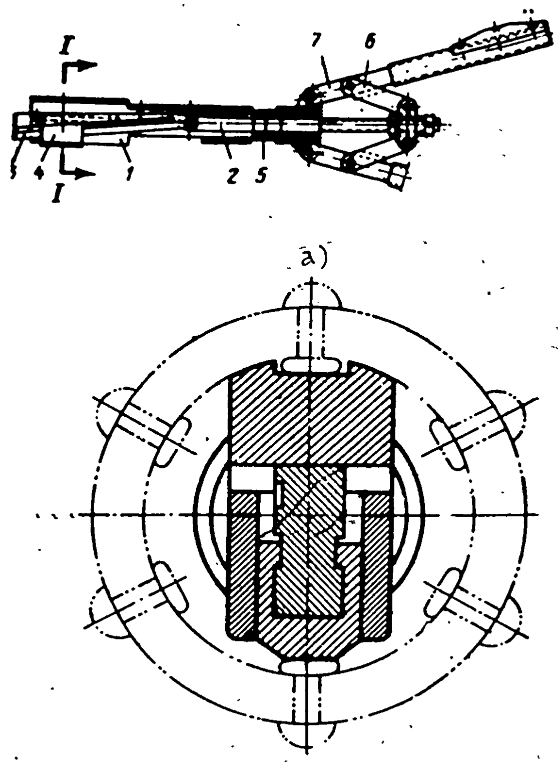

Fig.201 - Wedge-Type Support for Press Riveting of Tubings

1 - Head; 2 - Connecting rod; 3 - Wedge; 4 - Support; 5 - Tube;

6 - Toggle joint; 7 - Lever arms

a) Section through I-I

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into the adapter head (see section through I-I). Then pressure is applied to the trigger (12), permitting compressed air from the main compressed air system to enter the channel (15) through the valve (13). Under the action of the compressed air,

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the rivet (16) is forced against the cut-off segments (3) and thereby closes the channel against the escape of compressed air. Sufficient pressure is built up in the chamber (17) to move the rivet (16) along the channel of the shank (5). This motion of the rivet goes on until it reaches the cut-off lever (9). Under the action of the compressed air, the rivet releases the pressure on cut-off lever (9), shifts ahead and takes up the position best suitable for its insertion into the holes of the stack. Then, another rivet is inserted into the adapter head and the entire cycle of operation is repeated.

The Wedge-Type Support (Fig.201) consists of the head (1) in which, by means of the connecting rod (2), the wedge (3) is movable, with its grooves sliding in the thrust support (4). The rod (2), movable along the tube (5), is connected by means of the toggle joint (6) with the lever arms (7).

The operation of the support device is carried out in the following manner: after inserting the rivets in the holes of the stack by means of the pneumatic device, the support device is pushed into the tube. To do this, the lever arms (7) are spread apart causing the toggle joint (6) to push the connecting rod (2) and the wedge (3) to the extreme left position, whereby the thrust support (4) is lifted upward, thus reducing the height of the head (1). When the thrust support (4) touches the rivet heads, the lever arms (7) are pressed together; This causes the wedge (3) to move to the right and the support (4) to be in tight contact with the original rivet heads while the opposite side of the head (1) is in contact with the ends of the rivet shanks. This is the initial position of the support wedge for riveting. When the press is started, the riveting is performed during the power stroke on a group of rivets from opposite sides of the tube, as shown in Fig.199. The gr STAT in the head (1) (see section through I-I) regulate the height of the clenched rivet heads.

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CHAPTER IX

RIVETING WITH RIVETING HAMMERS AND AUXILIARY TOOLS

1. Pneumatic Hand Hammers

In addition to the equipment used in press riveting of light alloy structures, percussion type tools are also employed in the form of multiblow and single-blow pneumatic hammers.

Pneumatic riveting hammers are in wide use for riveting components and assembled units, their advantage being in that they are small in size, do not have much weight

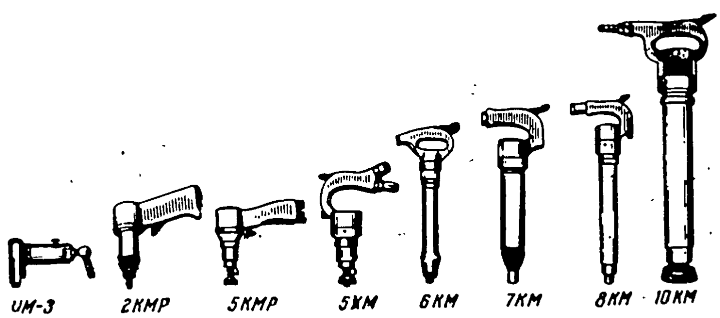

Fig.202 - Types of Multiblow Pneumatic Riveting Hammers

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and make it possible to do riveting work in whatever position required either in assembly fixtures or in comparatively crowded locations. It is to be noted, however, that because of the many shortcomings inherent in pneumatic hammers, their employment should be limited, with preference given in all cases where possible to group

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or single press riveting and also to portable riveting presses with which seams of higher quality are obtained.

Pneumatic hammers are manufactured to various designs and in various sizes. The multiblow pneumatic hammers shown in Fig.202 differ by their power rating, overall dimensions, and shape of the handle, all of which determines their suitability for riveting with rivets of various diameters and located in various places of the workpiece.

Table 57 gives the technical characteristics of pneumatic hammers that are used most widely. The operating principle of pneumatic hammers is based on the action of compressed air admitted into the cylinder of the hammer and causing displacement of a piston which transmits the force as an impact blow on the die to perform the riveting operation. Reciprocating motion of the piston is effected by means of an air-distributing device whereby compressed air is delivered alternately to the upper and lower chambers of the cylinder. The air distribution in the hammer may be by means of slide valves or by means of poppet valves.

Hammers with slide valves are in principle use in aircraft production. The construction of one of these hammers is shown in Fig.203.

Hammer 8KM consists of a handle and a cylinder. Inside the handle is the mechanism for the air inlet, which is controlled by the trigger (1). The handle is attached to the cylinder (2) by a threaded screw connection. The slide valve (3) is located at the upper part of the cylinder, which distributes the air through the air distribution channels in the walls of the cylinder.

At the beginning of the riveting work, the pipe plug (23) is connected to the main compressed-air system by means of a hose. In order to perform the riveting STAT operation, a die (4) is inserted in the hammer; if the riveting is by the reverse method, the shape of the die is to conform to the original rivet head, while if the riveting is done by the direct method the die is to conform to the stem of the rivet. By applying pressure on the trigger lever, the ball (6) is displaced by the rod (5),

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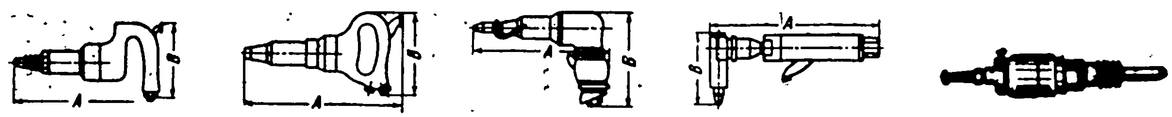
Table 57

Technical Characteristics of Multiblow Pneumatic Hammers



1. 2. 3 4. 5.

a)	b)	c)	d)	e)	f)	g)	h)	i) A	i) B	j)
2KM	I	2,0—3,0	0,05—0,1	4000	0,23	5	1,5	300	150	1
UM-1				5500	0,17		1,4	250	100	4
M-1				3000	0,25		1,0	184	134	3
2KM-P				3800	0,25		1,0	170	140	3.
UM-3				4000	—		1,06	160	82	4.
5KM	II	3,5—5,0	0,2—0,3	2500	0,30		1,1	210	188	1
5KM-P				2500	0,30		2,0	145	188	3.
4KM				2600	0,35		2,8	330	200	1.
KB-5				2300	0,50		1,9	270	190	1.
MA-1				3700	0,45		2,4	205	180	1.
MA-1K				—	—		1,3	220	80	5.
6KM	III	5,0—6,0	0,5—0,7	1000	0,40		2,3	290	226	2
M-3				2500	0,58		2,8	250	180	1.
MA-3				2600	0,50		3,8	280	200	1.
7KM	IV	7,0—8,0	0,8—1,0	1100	0,67		4,0	330	200	1.
PB-54				1500	0,65		5,0	470	200	2.
PB-58				1250	0,65		6,0	510	200	2.
8KM	V	9—10	2,0—3,0	380	0,30		4,5	450	210	1.

1. Straight type; 2. Closed type; 3. Pistol type; 4. Corner type; 5. Short type; a) Type of hammer; b) Power group; c) Rivet diameter, in mm; d) Work energy of one blow, in kg-m; e) Number of blows per minute; f) Consumption of air, in m^3/min; g) Working pressure of air in compressed air system, in atm; h) Weight of hammer, in kg; i) Overall dimension, in mm

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admitting air from the main line to the hammer. Compressed air entering through t radial channels (7), fills the upper working chamber of the cylinder and exerts a pressure on the piston (8) which causes a blow by the die.

The valve piston (3) moves upward as a result of the fact that, in filling the upper working chamber of the cylinder, compressed air is admitted to the lower chamber of the slide valve through the channels (9), (10), and (11), causing the valve piston to move upward.

In moving from its lower to its upper position, the piston of the slide valve covers the channels (7), thus cutting off the compressed air from the upper working chamber of the cylinder and, at the same time, opening the exhaust channels (12) which connect the upper working chamber to the atmosphere through the channels (13) and (14).

In its extreme upper position, the slide valve overlaps the exhaust channels (13) which connect the lower working chamber (15) to the atmosphere, and the compressed air, through the channels (16), the lower chamber of the valve (17) and the channels (18) and (19), is admitted under the piston, causing it to move upward (Fig.203b).

During the upper travel of the piston, at the moment when the upper edge of the piston comes in contact with the slide valve, the exhaust ports (12) are overlapped by the piston, whereby the upper chamber (20) is disconnected from the atmosphere. The air trapped in this chamber is compressed during the further travel of the piston forming an air cushion which acts as a brake until the upward travel of the piston ceases completely, thus avoiding the possible striking of the handle by the piston.

With increased pressure in the upper chamber (20), the air exerts a presSTATn the face of the slide-valve piston, causing it to move to its extreme low position. After the valve piston is in its extreme low position, the chamber (15), through the channels (18) and (19), the upper valve chamber (21) and the exhaust channels (22), (12) and (14) become connected with the atmosphere. With the direction of travel

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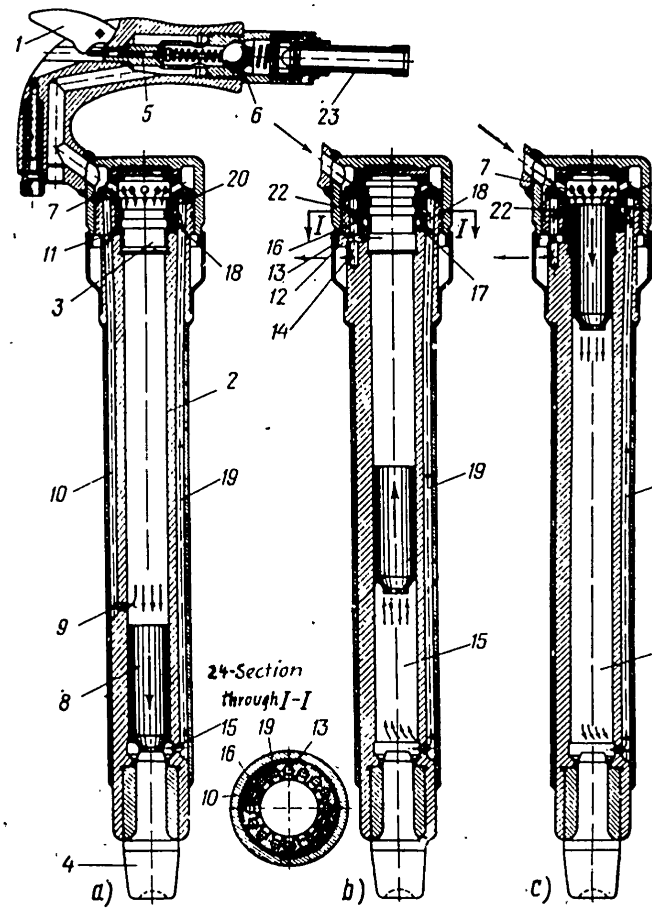

Fig.203 - Schematic Drawings of Operation and Design of the

Pneumatic Hammer 8KM

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a - Instant of blow; b - Reverse travel of piston; c - Initial position of piston for striking

1 - Trigger lever; 2 - Cylinder; 3 - Slide valve; 4 - Die; 5 - Connecting rod; 6 - Check ball; 7 - Radial channels; 8 - Piston; 9, 10 and 11 - Channels operating the slide valve; 12, 13, 14, 22 - Exhaust ports; 15 - Lower working chamber; 16, 18, 19 - Channels; 17 - Lower slide valve chamber; 20 - Upper chamber; 21 - Upper working chamber of slide valve; 23 - Pipe plug; 24 - Section through I-I

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reversed, under the action of compressed air entering through the channels (7), t[illegible] piston moves downward (Fig.203c) and produces a blow on the die at the end of its travel.

With this the cycle is completed, which subsequently repeats constantly.

Figure 204 shows the angle-type pneumatic hammer UM-3, intended for riveting in crowded places of structures, with rivets up to 3.5 mm in diameter.

The hammer UM-3 consists of a body and a handle. Inside the body (1) are located: the piston (2), the cover (3), the dowel (4), the valve ring (5), the valve bushing (6), the valve (7), and two cylindrical dowels (8).

Inside the handle (9) are located; the air-inlet mechanism which consists of the connecting rod (10), the valve cock (11), the bushing (12) and the valve spring (13), parts for connecting the air hose which fits over the plug (14), the bushing (15), and the threaded fitting (16). The body and the handle have a threaded connection. The spring ring (17) is to prevent possible turning of the handle with respect to the body. The die (18) made to fit the original rivet head, is installed before beginning to work with the hammer.

Applying pressure on the pushbutton of the connecting rod (Fig.205), air from the main line system, through the plug, the rotary bushing and valve cock, is admitted to the distribution section of the valve, which consists of the valve bushing and the valve. From there part of the air, through the channels (1), (2), (3), and (4) enters the lower working chamber under the piston of the hammer, and part of the air fills the inner parts of the valve. In the extreme low position of the piston, the port (4) is covered, and the upper working chamber, through the port (5), is connected to the atmosphere. Under the action of the compressed air, which is STAT mitted under the piston from the inner part of the valve through the channels (6), (7), (8), and (9), the piston is moved upward. Thereby the exhaust ports (5) are covered (Fig.205b) and the port (4) is opened, which increases the supply of air under the piston, while the air in the upper part over the piston goes to the atmos-

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phere through the channels (10), (11) and the port openings in the valve.

During the further travel of the piston upward, the lower working chambers be- comes connected to the atmosphere through the channel (12). The inertia of the pis-

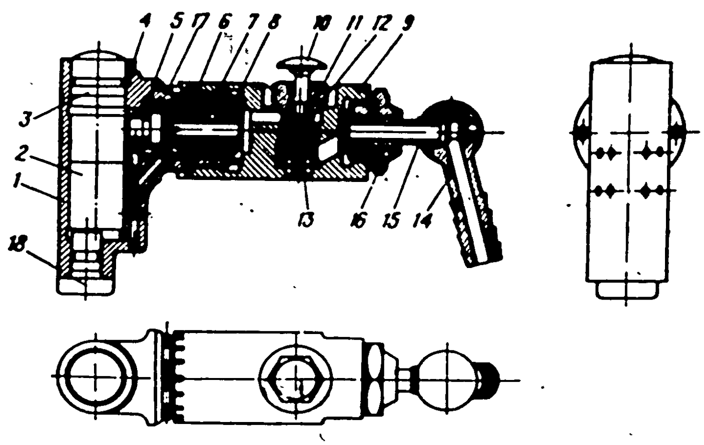

Fig.204 - Design of Multiblow Angle-Type Pneumatic Hammer UM-3

1 - Body; 2 - Piston; 3 - Cover; 4 - Dowel; 5 - Valve ring; 6 - Valve bushing; 7 - Slide valve; 8 - Dowel; 9 - Handle; 10 - Connecting rod; 11 - Valve cock; 12, 15 - Bushings; 13 - Clamp; 14 - Plug; 16 - Stud; 17 - Ring; 18 - Die

ton carries it over the channel (10) and covers it, thus stopping the exhaust of compressed air from the upper working chamber. The entrapped air is compressed, forming an air cushion which arrests the travel of the piston. When the piston is at the upper dead center, the valve shifts to the left, so that the left chamber of the valve is connected to the atmosphere through the channels (13), (4), and (12).

Compressed air from inside the valve is admitted to the upper working chamber through the channels (14), (10), and (11) (Fig.205c), with the results that the piston moves downward. During its downward travel, the piston overlaps the port (4) that supplies air to the lower working chamber, and also the exhaust port (12) (Fig.205d). From that moment, exhaust of the air from the lower working chamber takes place only through the channel (9), (8), and the ports in the valve.

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Under the action of the compressed air that flow through the channels (1), (2), (3), and (13), the valve is shifted to the right, at which instant the piston strikes the die (Fig.205e). Thereafter, the cycle of operation of the hammer repeats.

Multiblow pneumatic hammers produce 300 - 5000 blows per minute, with anywhere from 10 to 30 blows for each riveting operation. In contrast to this, single-blow

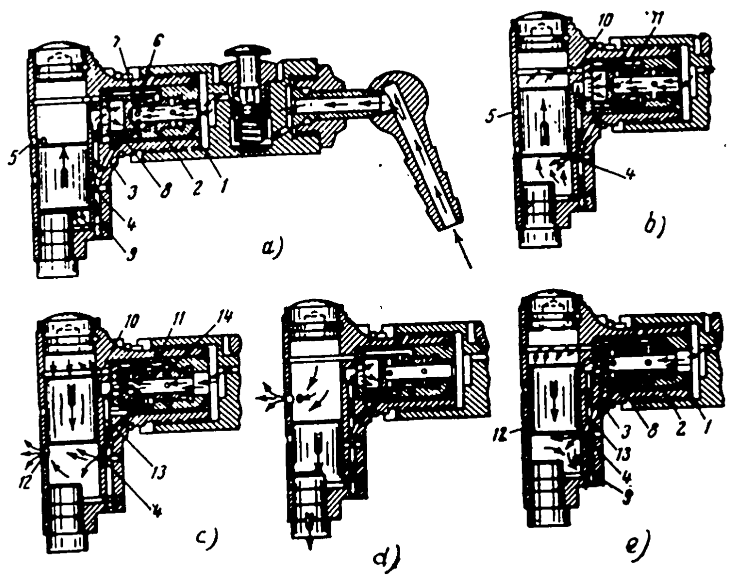

Fig.205 - Schematic Drawings of the Operation of Angle-Type Pneumatic Hammer UM-3

a - Instant of air inlet into the hammer; b - Upward travel of piston; c - Initial position for blow; d - Downward travel of piston; e - Instant of blow

1 - 14 - Channels

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pneumatic hammers produce one blow when the trigger lever is pressed, and it usually takes from 1 to 3 blows on each rivet, depending on the power rating of the hammer used.

Single-blow pneumatic hammers possess some advantages over multiblow pneumatic

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hammers. They are less noisy in operation, and the quality of the riveting work is better, since the upsetting of the rivet shank with one or two blows is better, and the rivet heads are not work-hardened. However, single-blow hammers possess a number of essential disadvantages, among the principal ones being the following:

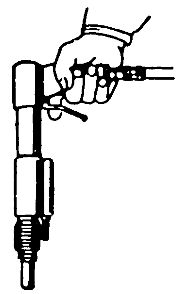

Fig.206 - Single-Blow Pneumatic Hammer 2KM-0

1) Fatiguing for the operator who, with every stroke, must press sharply on the trigger with his index finger.

2) When riveting with single-blow hammers it is particularly important that the hammer is placed correctly along the axis of the rivet, to prevent the rivet shank from tilting under the blow.

3) Heavier props are required when working with single-blow hammers.

Because of these disadvantages, single-blow hammers have not found wide application in continuous production work. If a hammer of this type could be mounted in a

Technical Characteristics of Single-Blow Pneumatic Hammers

of Type 2KM-0 (Fig.206)

Greatest diameter of clenched duralumin rivets	4.0	mm
Possible number of blows per minute	16 to 20	
Consumption of air during one blow	0.0035	m^3
Weight of hammer	1.6	kg
Length without die	245	mm STAT
Width along the handle without plug	140	mm

stationary position on special fixtures, its application would be worthwhile.

Figure 207 illustrates the operation of a hammer of this type. Compressed air from the main lines is supplied to the hammer through a rubber hose to the pipe con-

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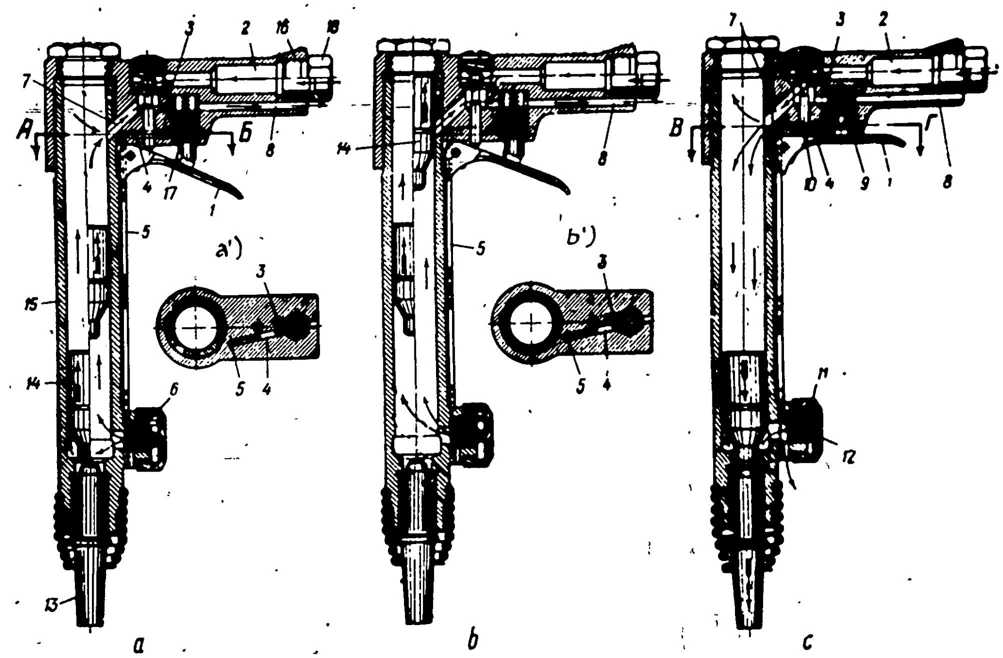

Fig.207 - Schematic Drawings of Design and Operation of the Single-Blow Pneumatic Hammer 2KM-O

a - Instant of air inlet into hammer; b - Initial position of piston for the blow;

c - Instant of blow

1 - Trigger; 2,3,4,5,7,8 - Channels; 6 - Valve; 9 - Valves; 10 - Starter valve; 11 - Valve spring; 12 - Nut; 13 - Die; 14 - Piston; 15 - Cylinder; 16 - Handle; 17 - Operating valve; 18 - Pipe connection

a') Section through A-A; b') Section through B-B

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nection (18). As pressure is applied to the trigger (1), air flows along the channels (2), (3) and (4) and farther along the channel (5) through the port in the valve (6) into the chamber under the piston when it is in its extreme low position.

Under the action of compressed air, the piston moves upward, forcing the air above it into the atmosphere through the channels (7) and (8) (Fig.207a). The piston remains in its extreme upper position so long as no pressure is applied to the trigger. Pressing the trigger (Fig.207c) causes the valve (9) to lift, which discon-

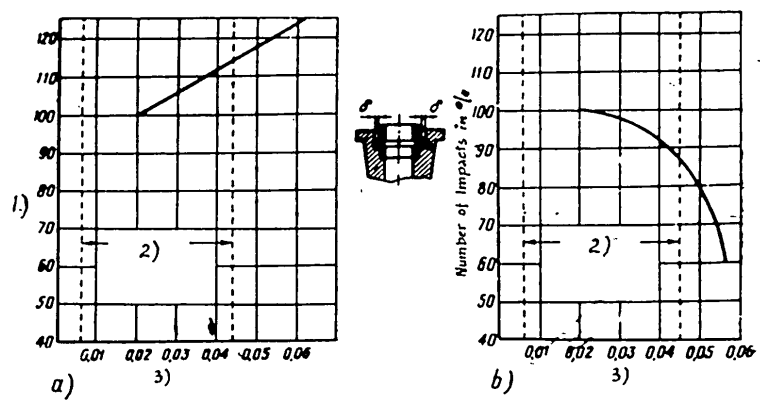

Fig.208 - Effect of the Degree of Valve Alignment on the Change in Operating Characteristics of Pneumatic Hammers

a - Curve for the dependence of the air consumption on the degree of valve alignment; b - Curve for the dependence of the number of blows on the degree of valve alignment

1) Consumption of air in %; 2) Clearance 2δ allowed by design drawings; 3) Clearance 2δ in mm

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nects the channels (3) and (4) through which air is admitted under the piston. At the same time, the valve covers the port (8), whereby the upper chamber of the cylinder is disconnected from the atmosphere and the channel (8) is connected to it, uncovering the starter valve (10), and letting in the air into the upper part of the cylinder through the channels (2) and (7). This results in the piston moving down-

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ward. Simultaneously, the channel is opened and a stream of compressed air continues pushing the piston with force until it strikes the shank of the die. The air under the piston shifts the valve (6) and is exhausted to the atmosphere. After the pressure on the trigger is released, the piston resumes its initial position.

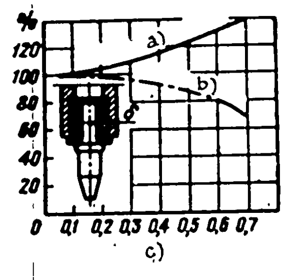

Fig.209 – Curves for the Dependence of the Air Consumption and Power of the Hammer on the Clearance Between Die Shank and Bushing of the Hammer

a) Consumption of air; b) Power; c) Clearance δ, in mm

The nature of the riveting work to be done has been considered in the design of this hammer by providing means for regulating the force of the blow on the die. Changing the force of the blow is effected by changing the compression of the spring (11) of the valve by means of the nut (12), which results in greater or lesser resistance to the descending piston.

The utility of pneumatic riveting hammers depends to a considerable degree on the quality of machining of the separate parts of the hammers, the cleanliness and finish of the mating surfaces, and the allowances for wear, which in turn, depends on the finish of the parts and the clearances between them. It is to be seen from the graphs in Fig.208b, that, as the clearance is increased between the valve and the cylinder, the number of blows becomes less and the consumption of air increases (Fig.208a).

The curves (Fig.209) show that when the clearance between the shank of the die and the bushing of the hammer is increased, the air consumption is increased arSTATe power of the hammer is decreased. It is to be observed that there is no direct relation between the air consumption and the power. For example, increasing the clearance by 0.25 mm over that specified in the design drawings (specified within the limits of 0.05 to 0.1 mm), i.e., with a clearance of 0.3 mm, the air consumption

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increases by 9% and the power decreases by 4%. Increasing the clearance by 0.25 mm more, i.e., with a clearance of 0.55 mm, the air consumption rises by 26% and the power drops by 14%. In the curves shown, the air consumption and the power were

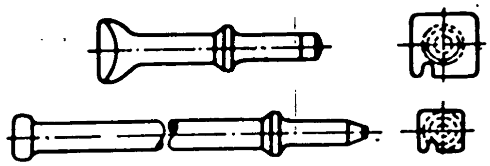

Fig.210 - Dies for Riveting Plankings on Open Profiles by the Direct Riveting Method

taken as 100% when the clearance is in accordance with that specified in the design drawings.

The curves show that the technical operating characteristics of pneumatic riveting hammers may change, depending on the manufacturing accuracy of the component parts. For this reason, the mating parts must be accurately machined and finished,

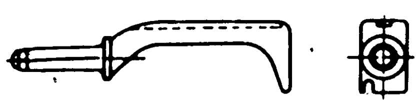

Fig.211 - Dies for Riveting Plankings on Semiopen Profiles by the Direct Riveting Method

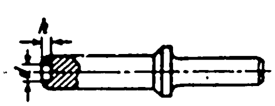

Fig.212 - Die With a Recess Under the Clenched Head for Riveting by the Direct Method

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especially in the passages of compressed air.

2. Types of Dies and Props Employed

The operating efficiency and the quality of riveting work of components and assembled units greatly depends on the proper choice of dies and props and on the

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parts together, thus using the [illegible]

quality of their manufacture.

A die is a tool that is inserted in the pneumatic hammer. There are two parts to a die: the shank inserted in the bushing of the pneumatic hammer and the working surface of the body of the die. The working surface of a die is smooth and has a spherical curvature or recess to fit the rivet head. The shape and dimensions of the

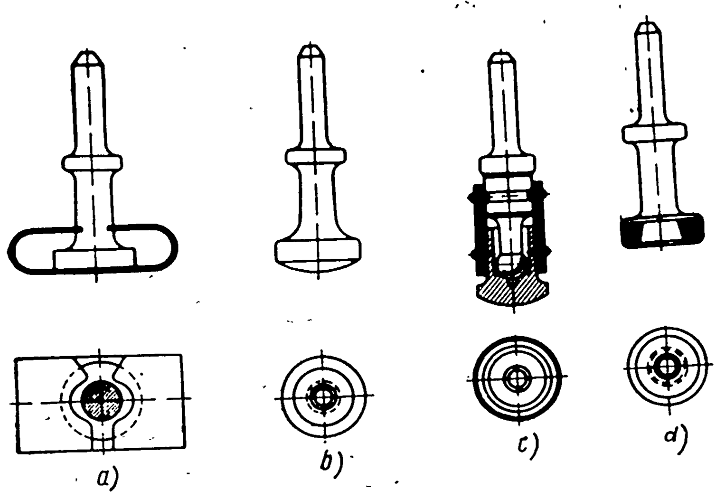

Fig.213 - Types of Dies Used for the Reverse Method of Riveting

a - Die with plate; b - Die with spherical working surface;

c - Ball-type die; d - Smooth die with a rubber buffer

dies depend on the design of the components being riveted, the conditions which govern access to the place of riveting, the diameter and type of rivets used, and the type of hammer employed.

In flush riveting by the direct method, straight dies are used of the tSTAT shown in Fig.210 for riveting open contours of the airframe and skin. Dies of a curved shape, such as shown in Fig.211, are used for riveting the skin on box-like frames of semiopen contour. Since, in the direct riveting method it is necessary to squeeze the part together, the die has a slot cut in its working surface of a width corresponding to the rivet diameter. With this slot it is possible to squeeze the

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parts together, thus using the same tools to perform two operations, namely, for tightening and also for riveting.

When riveting by the direct method, a hole is made on the surface of the die in some cases (Fig.212), whose shape and dimensions must correspond to the diameter and height of the clenched head. This hole prevents slipping of the die over the rivet shank in riveting.

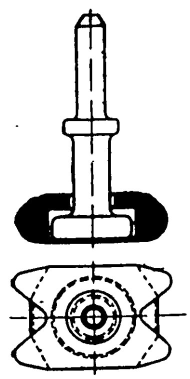

Fig.214 - Die With Rubber Insert

In flush riveting by the reverse method, use is made of dies with plates, dies with spherical surfaces, ball-shaped dies, and dies with rubber buffers (Fig.213).

The use of dies with plate attachments (Fig.213a) results in a considerable improvement of the surface quality. The polished steel plate attached to the body of the die protects the surface from damage, such as cuts, indentations, and other defects which may develop during riveting. However, the type of die shown has the inherent drawback, that the plate is jarred at every blow of the hammer, which occasionally leads to its breakage. To eliminate this shortcoming, it is advisable to add another part in the form of a rubber insert which absorbs the vibration during riveting. A die with a rubber insert (Fig.214) should find wide applicatSTATn riveting assembly units with especially high requirements as to surface finish, relative to streamlining of the surfaces exposed to the air flow. When riveting with dies having a spherical surface on components and panels with some curvature, the

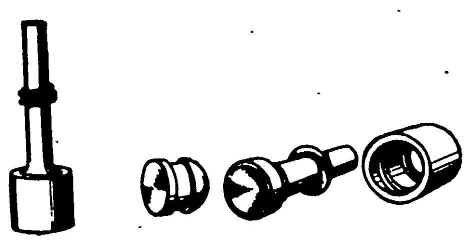

Fig.215 - Ball-Type Die, Exploded View

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hammer is rocked from side to side, thus smoothing the original rivet heads to the contour of the workpiece.

Ball-type dies are used in places of structures which are of difficult access i.e., where it is difficult to align the hammer with the die perpendicularly to the surface on which riveting is done. One of these dies is shown in Fig.213c. The constituent parts of this die are shown in Fig.215. The ball joint in the die assembly permits tilting the hammer at some angle to the surface of the workpiece, thus avoiding indentations in the surface.

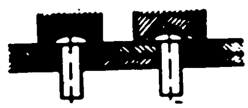

Fig.216 - Position of the Die on a Half-Round Original Rivet Head

Another type of die, used in flush-riveting by the reverse method, is a die with a rubber buffer of type I-92 (see Fig.213d). The rubber ring is placed over the shaped part of the die body, overlapping slightly the working surface, to permit its proper aligning and to prevent sliding over the planking while riveting.

Of all described dies for riveting by the reverse method, the most effective, in the sense of improving the quality of the skin surface, is a die with attached plate and rubber insert (see Fig.214).

Particular attention should be given to the finish of the working die surfaces. In dies for riveting by the direct method, the working surface is made slightly spherical for preventing slip during riveting. In dies for riveting by the reverse method, the working surface is polished, to protect the surface of the workpiece from damage.

Dies used for rivets with half-round original heads are made with recessed faces. The recessed working surface must be polished and correspond in dimensions to the original rivet head (see Table 55). Nonconformity of the recess dimensions with the dimensions of the rivet head (Fig.216) results in indentations and cuts either on the rivet head or on the surface of the workpiece.

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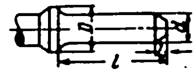
As already stated, in working with pneumatic riveting hammers the accuracy with which the mating parts of the hammers are made has a great influence on the quality of the work. The accuracy in length and diameter of the die shank also affects the

Table 58

Dimensions of Die Shanks for Various Types of Hammers



a)	b)				c)
	D	d (X_3)	l	l_1	
2KM	18	10	35	6	0,1
M-1	15	10	17	1	0,1
M-1	25	14	51	6	0,2
2KM-P	18	10	35	6	0,1
M-3	20	10	18	—	—
5KM	18	10	22	8	0,1
5KM-P	18	10	22	8	0,1
4KM	24	14	50	5	0,2
KB-5	24	14	51	5	0,2
MA-1	25	14,26	51	5	—
M-3	24	14	50	6	0,2
MA-3	34	17,26	60	6	0,3
7KM	30	18	50	5	0,3
PB-54	17	15	84	5	0,3
PB-58	25	15	36	5	0,3
8KM	30	18	50	5	0,3
2KM-O	22	12	36	5	0,1

a) Type of hammer; b) Dimensions, in mm; c) Weight of die, in kg

operating efficiency and the quality of the riveting work. For example, an increase in the dimensions of the die shank over those specified in the design drawings leads to improper air distribution and results in a lessening of the hammer blows and in lowering its power.

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Wear or incorrect machining of the die shank as to diameter also results in a lower number of blows, in a greater air consumption, and an increase of the working time over that necessary for normal riveting. For these reasons, it is essential that the diameter and length of the die shank be checked during its manufacture and

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also during its use.

Table 58 gives the dimensions of die shanks for various types of hammers, together with the data on the weight of dies for various hammers.

In designing special dies for pneumatic hammers, an effort should be made to reduce their weight as much as possible, for the reason that a portion of the useful

Table 59

Weight of Props for Use with the Direct Method of Riveting

a)	2,6	3,0	3,5	4,0	5,0	6,0
b)	5	6	7	8	10	12

a) Diameter of rivet used, in mm; b) Weight of prop, in kg

work done by the piston of the hammer is absorbed by the mass of the die, which leads to an increase in riveting time, which, in turn, contributes to the cold-hardening of the rivet material.

The effect of the weight of the die on the operation of the hammer can be shown

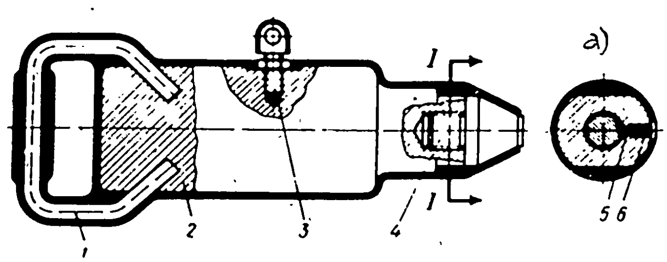

Fig.217 - Typical Design of a Prop for Riveting by the Direct Method

1 - Handle; 2 - Body; 3 - Eye bolt; 4 - Head; 5 - Plug; 6 - Set screw STAT

a) Section through I-I

by the following example: If the time of the riveting work is taken as 100% for a die weighing 200 gm, then an increase in weight of the die to 260 gm will increase the riveting time with the same hammer and under the same conditions to 140%.

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When it becomes necessary to use a die of greater weight than recommended in Table 58 (as is the case when having to use a die of great length in riveting by the direct method), a hammer of the next group of power rating should be employed.

Props. Props serve as supports for absorbing the blows of the pneumatic riveting hammer. The shape, dimensions, and weight of props depend on the structure of the component or assembly unit being riveted, on the diameter of the rivets used, and also on the selected method of riveting.

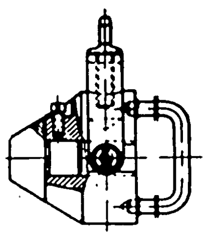

Fig.218 - Prop for Riveting by the Direct Method

With the direct method of riveting, solid props of 5 - 10 kg weight are employed, depending on the diameter of the rivets used (Table 59).

The working surface of such props is polished and the edges are rounded to prevent scratches. To prevent damage to the surface of the part being riveted, in case the operator drops the prop while the hammer is in operation, the body of the prop has to be protected.

One of the many designs of props for riveting by the direct method is shown in

Table 60

Minimum Weight of Props Corresponding to the Diameter and Material of the Rivets in Use

a)	b)	2,6	3,0	3,5	4,0	5,0	6,0	8,0	9,5	10
c)	e)	1,3	1,5	1,75	2,0	2,5	3,0	4,0	4,75	5
d)		2,6	3,0	3,5	4,0	5,0	6,0	—	—	—

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a) Rivet material; b) Diameter of rivet used, in mm; c) Aluminum alloys; d) Steel; e) Minimum weight of prop, in kg

Fig.217. The prop consists of the solid body (2) with the handle (1) and the head (4), mounted to the body by means of the plug (5) with the set screw (6). To facili-

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tate working with the prop, an eye bolt (3) is screwed into the body, by which the prop may be suspended from a balancing bar or some other device installed in the riveting fixture. A similar type of prop is shown in Fig.218.

The working part of these props is interchangeable, which permits easy and rapid exchange of the part whenever it becomes worn or damaged.

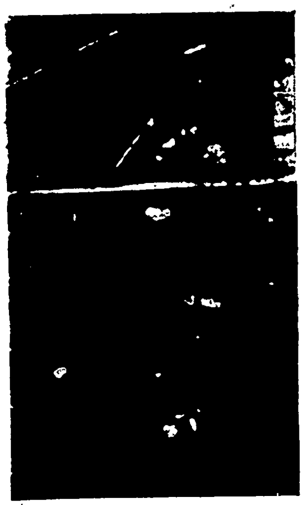

Fig.219 - Stand for Assembling Major Units by the Direct Riveting Method, with the Prop Suspended from a Spring Balancer

When skin is riveted in assembly fixtures to large-size parts, the prop should be so arranged that it can be readily moved over the entire working surface of the workpiece. For this, the most suitable arrangement is a balancing device (Fig.219) installed in assembly fixtures on a carriage that rolls along rails and thus provides longitudinal travel of the prop. Movement of the prop in a vertical direction is provided by the spring of the balancing device, which equalizes the weight of the prop.

In some cases, the balancing devices are replaced by special devices with counterweights, and the raising and lowering of the prop to the level of the work is controlled by means of a trigger in the body of the prop itself.

When riveting work is done by the reverse method, the working surface of STAT prop must be slightly spherical in shape, to avoid slipping of the prop over the rivet shank during the riveting process.

To make sure that the clenched rivet head has the correct shape and dimensions, a prop of corresponding weight for each rivet diameter must be used, based on the

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data given in Table 60. A prop of a weight lower than recommended for the particular rivet diameter will result in faulty seams, incomplete upsetting, or other defects.

Various types of props are in use, depending on the manner in which the seams to be riveted are located on the workpiece.

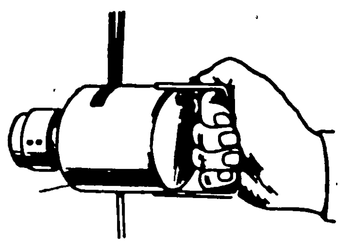

Fig.220 - Prop with a Regulator for Riveting by the Direct Method

The type shown in Fig.221 is used for riveting in open places of structures. These props are of relatively simple form and of moderate dimensions.

Props of the type shown in Fig.222 are used for riveting in semiopen places of structures. These props have a more complicated form and are of comparatively greater dimensions. The employment of such props makes it somewhat more difficult to do riveting work on account of the springiness of the prop and the eccentric direction of the hammer blow. Props in which the center of gravity is concentrated closer to the rivet shank are considered more suitable from the standpoint of improving the quality of the riveting work and of increasing the rate of production.

For riveting in deep places of structures which are difficult of access, props of two basic types are employed: pressure type and inertia type. The design of one of the props of the pressure type is illustrated in Fig.223. It consists of two blocks, the lower of which (6) is rigidly connected to the tube (7). To the opposite end of the tube, the casing (8) with the handle (1) is rigidly attached. The upper block (4) has a ball connection with the brace (5) and a link (3), the latter being connected with the inner tube (2). On turning the movable handle (9), the tube (2) is shifted together with the link (3), thus causing the block (4) to come nearer to the stationary block (6), or to move away from it, depending in which direction the movable handle is turned.

Riveting in tubes or in closed structural shapes with the aid of this prop is

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accomplished in the following manner: At the start, the prop is introduced into the tube, the rivet is inserted from the top, and the movable handle is spread outward until the upper movable block is in contact with the rivet shank. Then the pneumatic

Table 61

Principal Dimensions of Pressure-Type Props for Riveting Tubes of Various Diameters (see Fig.223)

Inside diameter D of tube being riveted, in mm	Principal dimensions, in mm		
	Peripheral diameter circumscribed about the enclosure of the blocks d	Length of the movable block, l	Overall length of the prop, L
27 - 33	24	70	From 2000 to 8000
33 - 40	30	80	
40 - 48	35	100	
48 - 58	45	120	
58 - 70	53	120	
70 - 85	65	140	
85 - 100	75	160	
100 - 120	85	180	

hammer is started, which heads the rivet at the inside of the tube being riveted.

Props of similar types are manufactured to various dimensions, depending on the design of the parts being riveted, such as the diameter of the tube being riveted and its length. Table 61 gives the principal dimension of props of the pressure type for riveting tubes of various diameters.

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Inertia type of props are manufactured either with flat or with cylindrical springs.

Figure 224 shows an inertia-type prop with flat springs. Flat leaf springs (1),

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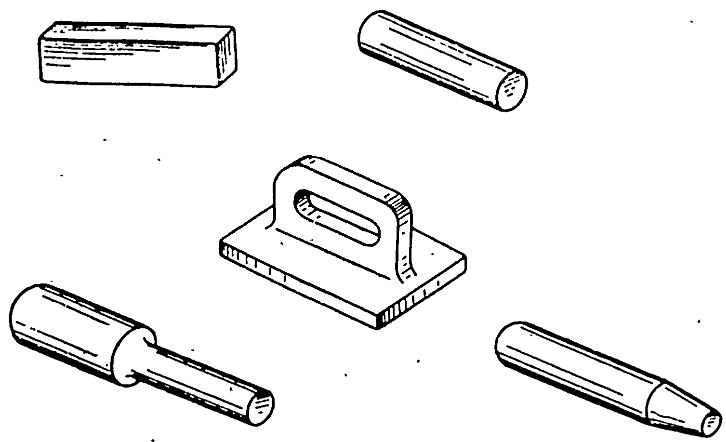

Fig.221 - Types of Props for Riveting in Open Places of Structures by the Reverse Method of Riveting

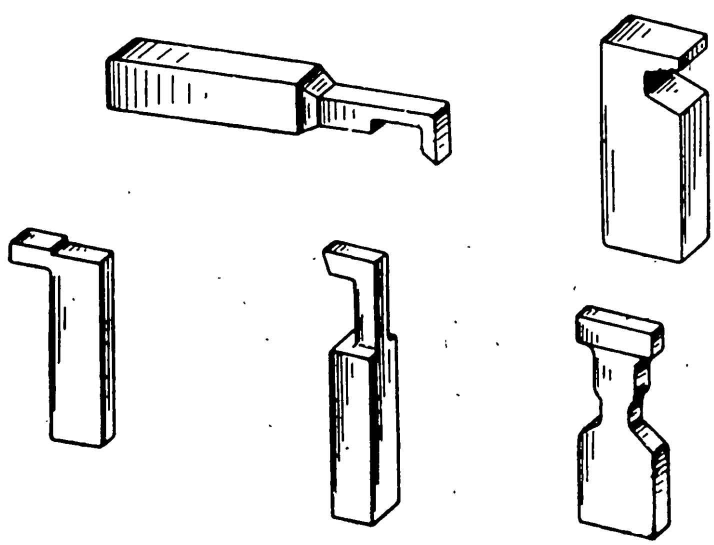

Fig.222 - Types of Props for Riveting in Semiopen Places of Structures by the Reverse Method of Riveting

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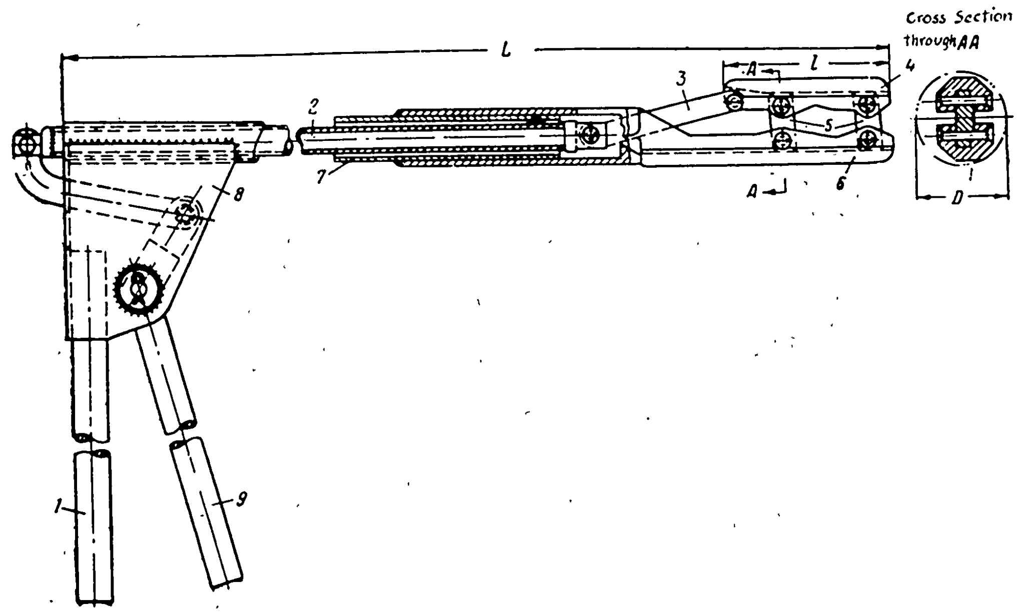

Fig.223 - Pressure-Type Prop for Riveting in Deep and in Difficultly Accessible Places

1 - Handle; 2 - Inner tube; 3 - Connecting link; 4 - Upper block; 5 - Brace;

6 - Lower block; 7 - Outer tube; 8 - Casing; 9 - Movable handle

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held together by clips (2), are joined to the block (4) by means of rivets. The bar (3) by which the required riveting spot is located, is mounted to the block (4). The number of leaves in the springs are varied to correspond to the diameter and material of the rivets used, which results in increasing or decreasing the inertia

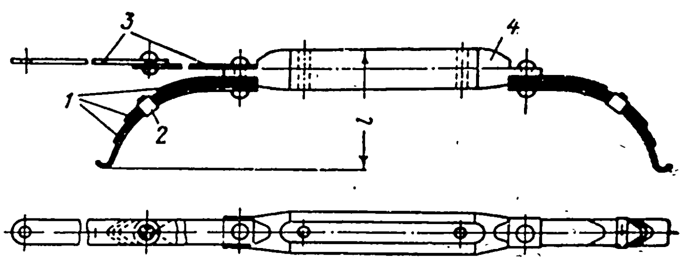

Fig.224 - Inertia-Type Prop with Flat Springs

1 - Flat springs; 2 - Clips; 3 - Bar; 4 - Block

force of the prop. The height of the prop l (see Fig.224) is chosen to correspond with the diameter of the tube to be riveted, or, in case of rectangular structural shapes, their inside dimensions are taken into consideration.

Inertia-type props are used not only for riveting in closed places of structures but are also suitable for riveting in semiopen and open places of structures. Inertia-type props for riveting in open places of structures are shown in Fig.225.

In some riveting processes, pneumatic props are employed. A pneumatic prop (Fig.226) consists of the body (1), the piston (2), and a starting device. A hole is provided in the piston (2) for insertion of a die. The opening under the shank of the die, depending on the design of the prop, can be located eccentrically to the axis (3) for reducing the distance from the axis of the prop to the edge, and thus make it possible to do riveting in crowded places. Such props are used for riveting in open places of structures.

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Before riveting is commenced, it is necessary to install a support at the center point (3). On turning the handle of the cock (4), compressed air is admitted

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under the piston (2) causing it to perform a power stroke. On turning the handle of the cock in the opposite direction, the bushing of the cock closes the air inlet and connects the chamber under the piston to the atmosphere, whereby the compressed air from the chamber is exhausted, and the piston, together with the die, returns to the initial position under the action of the spring (5).

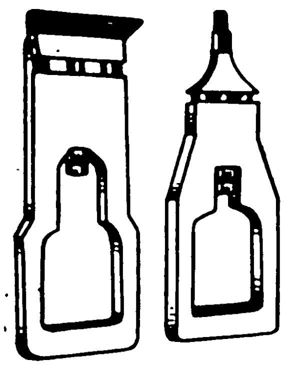

Fig.225 - Inertia Type Props for Riveting in Open Places of Structures

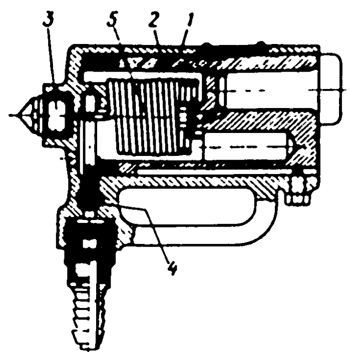

Fig.226 - Construction of a Pneumatic Prop

1 - Body; 2 - Piston; 3 - Center; 4 - Cock; 5 - Spring

Pneumatic props of a similar type operate from the main compressed-air system, at a pressure not lower than 4 - 5 atm. At the given pressure, the piston with the attached die provides a sufficiently tight fit of the clenched rivet head against the surface of the part being riveted. The use of similar supports lightens the work of the riveters and contributes to raising the quality of the workpiece being riveted.

3. Operation of Pneumatic Hammers

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The output of work and the quality of riveting largely depend on the correct choice of the hammer, on the work procedure, and on a well-organized program of labor utilization during the technical process of riveting. In choosing a multiblow pneumatic hammer, a number of factors must be taken into consideration, among which the

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most important ones are the diameter and the material of the rivets used.

If riveting is done with a hammer of a power insufficient for a given rivet diameter, the heading of the rivet is delayed, which results in work-hardening of the clenched head and in the development of cracks. The air consumption is also increased. If riveting is done with a hammer of greater power than necessary, over-riveting takes place, which also results in the formation of cracks and in increased air consumption. For these reasons, before starting a riveting job, it is necessary to become acquainted with the technical riveting process required for a given job, determine the diameter of the rivets to be used and the material from which they are made and, from Table 57, select the type of hammer, its weight, and the design of the props necessary to use with the rivets.

Riveting is usually done by a riveter assisted by a helper who holds the prop. The helper presses the prop against the end face of the rivet shank while the riveter directs the hammer blows on the original rivet head when working by the reverse method of riveting. In the direct method of riveting, the blows are directed on the end face of the rivet shank.

The work of the helper, holding the prop, is no less important than that of the riveter. He has the responsibility of observing the quality of the clenched heads, of holding the prop in the required position, and of notifying the riveter beforehand as to the likelihood of damage.

The riveter cannot always watch how the helper is performing his work (Fig.227), and therefore some conventional arrangement is made to give signals by means of lights or by tapping.

The efficiency of labor and the quality of riveting work depends largely o STAT arrangement of the program of work and on the layout of the place where the riveting work is done. Preparing a program of the work beforehand reduces the riveting time from 30 to 35% and even more as compared with the established norms. For example, in one of the plants, while riveting rows of flush rivets to attach the skin to an

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airframe in an assembly jig, the following results were obtained (see Table 62).

Table 62

Riveting Time per Single Rivet as Done by Experienced Female Riveters

Riveter's family name	Riveting time in seconds per rivet as set by norm MAP	Actual riveting time in seconds per rivet	In % of norm MAP
Motorina	3.5	2.17	62
Shlyakhova		2.76	79
Galayeva		2.88	83
Sukhareva		3.00	86

Note: Flush riveting in rows in assembly jigs; reverse method of riveting; position of riveters varied from open to crowded places.

The results obtained by the riveters were due to their using the following program:

a) Proper planning of the work, i.e., coordination between the work of the assemblers, drillers, and riveters;

b) Coordination of work between the riveter and her helper;

c) Release of the riveter from all subsidiary work;

d) Correct procedure of work according to the outlined program;

e) Proper arrangement of the working station.

The efficiency of the riveter's work depends largely on how well the place in which he works is organized, the ease of access to the work being riveted and the convenience of the position of the worker while riveting.

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During the process of riveting large parts and assembly units, the riveter and his helper are compelled to assume different positions, having to work standing up, kneeling, lying on the side, sitting, and so forth. The position of the worker

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during riveting has a considerable effect on the production rate. Table 63 gives experimental data on the effect of the position of the riveter on the time rate of production.

The data in Table 63 show that the rate of work output of the riveter is lowered

Table 63

Riveting Time per Single Rivet as Related to the Position of the Riveter

Position of riveter	Time per rivet, in sec
Standing up	2.0
Kneeling	3.1
Lying on side	4.9

by 1.5 times when in a kneeling position and by 2.5 times when working in a lying position.

The most convenient position for the riveter is standing up or sitting. For

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Fig.227 - Riveting of a Fuselage; the Helper is Inside the Fuselage While the Riveter is Outside

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this reason, the working place of the riveter and his helper should be provided with a stool, particularly when riveting in crowded places. In places where the riveting

Fig.228 - Riveting in an Assembly Jig. Platforms, Adjustable to the Required Height, are Provided in the Fixture

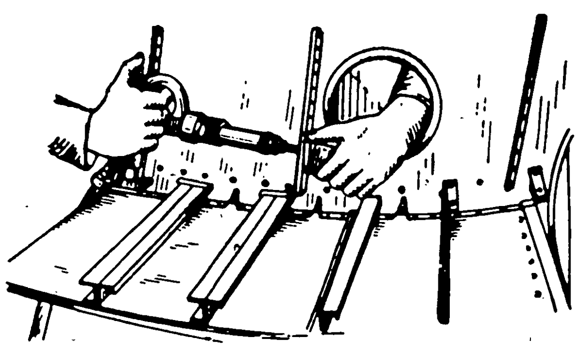

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Fig.229 - Example of Riveting Without a Helper

work is above the head of the workers, adjustable platforms are provided that may be raised or lowered.

There are many places in structures where the riveting work can be carried out

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by one riveter (Fig.229). In such cases, the riveter holds and directs the hammer with his right hand, while with the left hand he presses the prop against the rivet shank. By proper manipulation of their right and left hands, experienced riveters

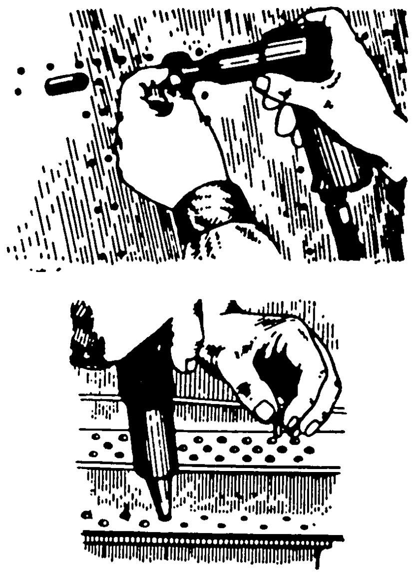

Fig.230 - Examples of Riveting Work. The Left Hand Inserts the Rivet; The Right Hand, Holding the Pneumatic Hammer, Does the Riveting

attain a considerable increase in labor efficiency. They choose to rivet in such a direction that the left hand is free to insert a rivet in the next rivet hole (Fig.230).

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CHAPTER X

DETERMINATION OF THE TECHNICAL CHARACTERISTICS OF RIVETING TOOLS AND EQUIPMENT

1. General Conditions

The determination of the quality of tools and equipment is carried out by tests. In the manufacturer's plants, the tests are made in experimental stations, while tests on their end-use are made in the maintenance shops of the plant. Such experimental stations and shops are equipped with special apparatus and devices for determining the actual technical and operating characteristics of the equipment and the tools, analyzing their construction, defining their shortcomings, and indicating possible improvements.

The principal properties characterizing the quality of equipment and tools that involve rotary, impact, and compressive action are given in Table 64.

2. Apparatus and Equipment for Carrying Out Tests and Methods of Testing

As is well known, the power developed in rotary motion is determined by the magnitude of the torque M, acting on the spindle of the hand drill or drill press, and the angular velocity ω, i.e., $N = M$. If the power is expressed in terms of STAT horsepower, the torque in kg-m, and the angular velocity in rpm, we obtain

$$N = \frac{Mn}{716,2} \text{ hp}.$$

In this manner, with the angular velocity known, the determination of the power

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developed consists in determining the magnitude of the torque of the spindle of the hand drill or the drill press. For determining the magnitude of the spindle torque of a hand drill, a device that will develop a certain braking moment must be erected.

Table 64

Principal Properties Characterizing the Quality of Equipment and Tools that Involve Rotary, Impact, and Compressive Action

a	b				
	c				
	d	e	f	g	h
Power, in hp	+	+	+	–	+
Rotational speed of spindle at idling, in rpm	+	+	+	–	–
Force developed by the press, in kg	–	–	–	+	–
Work energy of impact, in kg-m	–	–	–	–	+
Air consumption for one cycle, in m^3	–	–	–	+	–
Air consumption, in m^3/min	+	–	–	–	+
Number of working strokes per minute	–	–	–	+	–
Number of impacts per minute	–	–	–	–	+
Overall dimensions, in mm	+	+	+	+	+
Weight, in kg	+	+	+	+	+

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a) Principal properties determining the quality of equipment and tools; b) Kind of equipment and tools; c) Hand drills for hole drilling; d) Pneumatic; e) Electric; f) Drill presses for hole drilling; g) Presses for riveting; h) Pneumatic riveting hammers

A simpler device with a band brake is illustrated in Fig.231. The hand drill

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(1) under test is mounted to the stand which consists of the base (2) carrying the pedestals (3) with the shaft (4) having on one end a brake drum and a band brake (5). The other end of the shaft (4), over the clutch (6), is connected to the shaft to which the spindle of the hand drill to be tested is attached. The hand drill, being

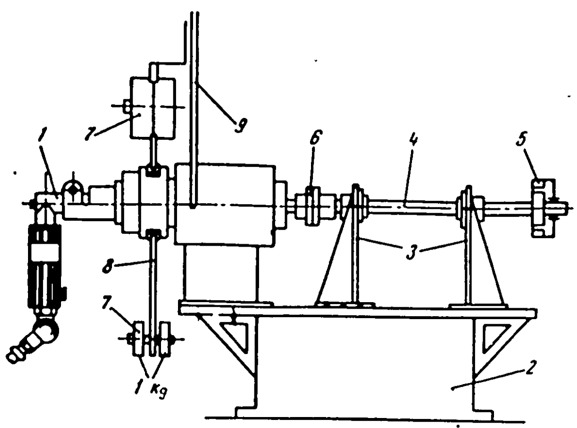

Fig.231 - Device for Measuring the Torque of a Hand Drill

1 - Hand drill; 2 - Base; 3 - Pedestals; 4 - Shaft; 5 - Band brake; 6 - Clutch; 7 - Counterweight; 8 - Rod; 9 - Dial

fixed in the device, is balanced by the upper weight (7) on the rod (8). During the process of testing, the hand drill is subjected to smooth braking by the band brake; the measurement of the torque is made according to the scale (9) at a constant load of 1 kg.

The torque of the spindle of the hand drill or the drill press, and also the power developed in rotary motion, depend to a considerable degree on the number STAT revolutions.

The curves in Fig.232, giving the ratio of the torque and power to the number of revolutions, show that an increase in rpm leads to a decrease in the torque, while the power reaches a maximum at a certain number of revolutions.

A tachometer is used for determining the rotational speed of a hand drill or

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drill press, which shows the speed by direct reading of a scale graduated in rpm. The tachometer shown in Fig.233 is intended for determining the angular velocity within the limits from 25 to 30,000 rpm, with the following six intermediate scales: 25 - 100; 75 - 300; 250 - 1000; 750 - 3000; 2500 - 10,000, and 7500 - 30,000.

The measurement of the air consumption is done by means of a floating type

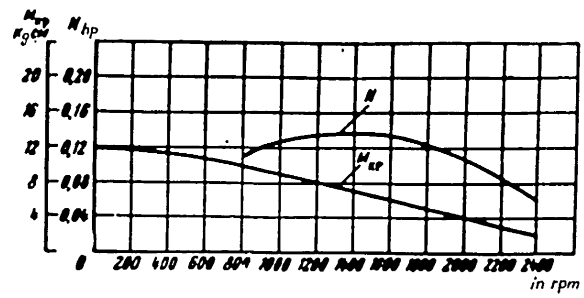

Fig.232 - Curves for the Dependence of the Torque and the Power on the Rotational Speed for the Drill D-1

aerometer which permits a direct reading in m^3/min of free air during the operation of pneumatic hand drills and hammers.

The floating type aerometer (Fig.234) consists of the body (1), the cylinder (2), and the piston (3). The cylinder (2) has a number of equidistant ports arranged in a spiral line. This is necessary in order that, during the travel of the piston (3) the cross section of the platform be directly proportional to the total area of the holes under it. The piston (3) is connected to the piston rod (4), whose lower end carries the dashpot piston (5). The upper end of the piston rod, going through the glass

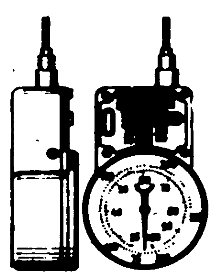

Fig.233 - Tachometer

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tube (6), serves as an index of the air consumption as read on the scale (7). The dashpot piston (5) serves the purpose of damping the vibrations of the connecting rod (4) while the meter is in operation, and its travel is in a reservoir filled with

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machine oil up to 0.6 to 0.8 of its height.

For measuring the quantity of air consumed by the hand drill or hammer under test, they are connected with a hose to the upper pipe coupling of the aerometer, while compressed air is admitted through the lower nipple.

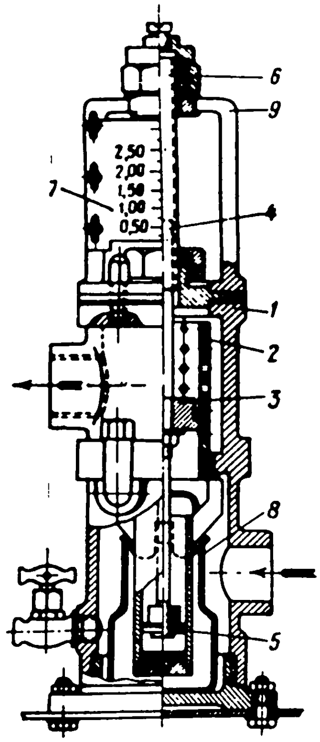

Fig.234 - Floating Type Aerometer

1 - Body; 2 - Cylinder; 3 - Piston; 4 - Rod indicator; 5 - Dashpot piston; 6 - Glass tube; 7 - Scale; 8 - Oil reservoir; 9 - Support Stand

On admittance of compressed air at the lower nipple, pressure is exerted on the piston (3), causing it to move upward, thus opening the ports in the cylinder (2), through which air is admitted into the space between the cylinder and the body, whence it goes to the tool being tested through the upper nipple. The travel of the piston continues upward until the pressure difference between inside and outside of the cylinder (2) is equalized; at that instant, the air consumption is read from the graduated scale, in m^3/min.

The recording of the air consumption is done after the drill is in full operation, i.e., after about 1 - 2 min from the start of work.

For determining the consumption of free air at various pressures of the STAT pressed air, it is necessary to connect an air gage between the lower nipple and the main compressed-air line over a reducing valve. A general outline of the arrangement of the devices for determining the torque, the air consumption, and the rpm, is shown in Fig.235.

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The specific air consumption is a very important characteristic which has a bearing on the quality of a given type of equipment or tool operated by compressed air. This factor is expressed by the ratio of air consumption Q to the maximum power developed by the hand drill or pneumatic hammer:

$$Q_{spec} = \frac{Q60}{N} \text{ m}^3/\text{hp}$$

Expansion of the compressed air during the operation of riveting hammers takes place by a process intermediate between the isothermic and the adiabatic processes; that is, according to a polytropic process (Fig.236). This is explained by the fact that the hammer is cooled during its operation by the compressed air, but this cooling is insufficient for the process to take place isothermally. The effect of cooling the hammer, however, produces a deviation from the ideal curve representing the process of adiabatic air expansion, and results in an intermediate polytropic process.

The intrinsic energy of 1 m^3 of compressed air is equal to

$$L_{theo} = \frac{L_{ad} + L_{iso}}{2} \text{ kg-m/m}^3$$

where L_{ad} is the intrinsic work energy of 1 m^3 of compressed air during adiabatic expansion;

L_{iso} is the energy of 1 m^3 of air during isothermal expansion.

At a pressure of 5 atm of compressed air, we have

$$L_{theo} = \frac{20,500 + 16,100}{2} = 18,300 \text{ kg-m/m}^3$$

The theoretical intrinsic energy expended during one impact by the air, STAT A_{theo} is determined by the formula

$$A_{theo} = \frac{QL_{theo}}{n}$$

where n is the number of impacts of the hammer.

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The available theoretical power of the hammer is determined by the formula

$$N_{theo} = \frac{A_{theo}\, n}{60.75} \text{ hp}$$

The relation between the actual power of the hammer to the theoretical intrinsic power available in the compressed air supplied, is determined by the efficiency of the hammer

$$\eta_{eff} = \frac{N_o}{N_{theo}}$$

where N_o is the power developed by the hammer, in hp.

The actual efficiency of pneumatic riveting hammers used in aircraft production varies within the limits of $\eta_{eff} = 0.1 - 0.2$, i.e., only 10 - 20%.

The power developed by the hammer is determined by the formula

$$N_o = \frac{A_{wi}\, n}{60 \times 75} \text{ hp}$$

where A_{wi} is the work at impact on the die, in kg-m and

n is the number of impacts per minute.

In testing pneumatic impact-type tools, one of the most important characteristics is the energy of the impact.

A simple method for determining the energy of one impact, sufficiently accurate for all practical purposes (± 5%) is the ball indentation method.

To determine the impact energy by this method, a special die with a hardened steel ball of 10 mm diameter is fitted into the hammer (Fig.237). The weight of this die should be the same as that of the die in normal use with the given type of hammer. This gives results that reproduce the corresponding actual operating coSTATons of the hammer in riveting.

The hammer under test with the special die is installed in the frame of the testing device shown in Fig.238. A smooth metal test plate is placed under the die with the ball. The top of the hammer handle carries springs for imparting a force of corresponding magnitude in the direction of the axis. In some designs the impact

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force is generated by pneumatic devices instead of by springs, which makes it possible to obtain various degrees of force on the hammer handle by throttling the compressed air. The first step is to install the hammer handle and the test plate in

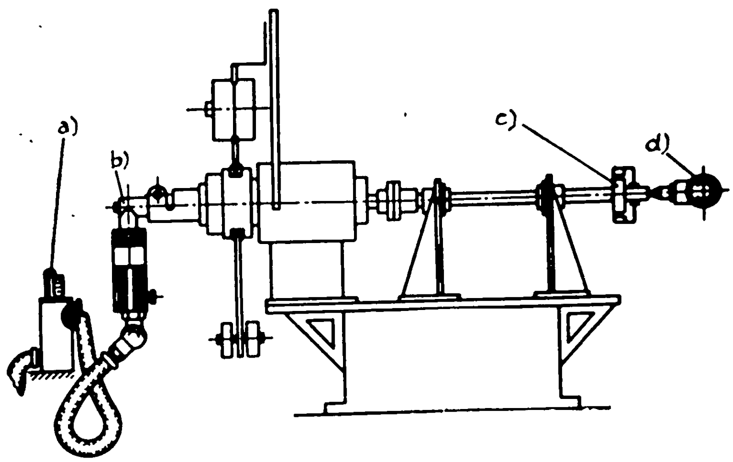

Fig.235 - Schematic Sketch of a Stand for Testing Hand Drills to Determine the Torque, Rpm, and Air Consumption

a) Aerometer; b) Hand drill; c) Band brake; d) Tachometer

the extreme position, then the hammer trigger is depressed, and the hammer is put into operation for several seconds in accordance with the specified program of procedure. The ball will then continue striking the same spot on the test plate. Next, after pulling out the hammer handle, the test plate is removed from under the die with the ball which forms an indentation in the plate by the individual blows on the die. The diameter of the indentations is then determined with the aid of a miSTAT scope.

The test plate has to be calibrated in order to establish the relationship between the diameter of the indentation made by the ball and the corresponding impact energy expended. The calibration is usually done by dropping a free load from a string in an impact testing machine. Since the load is dropped from various heights,

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a die with a ball similar to that used in testing the hammer is employed.

In dropping the die from various heights on the test plate, different indentations of various diameters are obtained, depending on the magnitude of the impact.

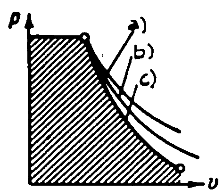

Fig.236 - Diagram of the Adiabatic Expansion Process a) Isometric; b) Polytropic; c) Adiabatic

The energy of the impact is determined from the expression

$$A = G(H - h) \text{ kg-m}$$

where G is the weight of the load, in kg;
H is the dropping height of the load, in m;
h is the height of the rebound of the load after striking, in mm.

Since the height of the rebound of the load h represents only 5 - 7% of H, in some cases this factor is neglected and it is considered that $A \approx G \cdot H$ kg-m. In this manner, on the basis of the tests mentioned, calibration curves (Fig.239) are plotted. The energy of the impact A_{wi} of the hammer is determined according to the diameter of the indentation and the material of the test plate.

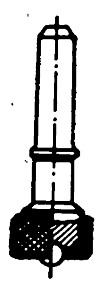

Fig.237 - Special Die with Ball for Determining the Impact Energy of Pneumatic Hammers

A second important index characterizing the energy developed by a pneumatic riveting hammer is the number of impacts per minute of the cylinder on the die.

The number of impacts can be determined by various means. One of the more simple portable devices for determining the number of impacts is the vibration-type tachometer (Fig.240), with which the number of blows may be readily determined under laboratory as well as under production conditions.

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The performance of the vibration-type of tachometer is based on the following

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principle: To the angle bar (2) a row of flexible strips (1), with loads attached on the free end, is attached. Depending on the length and on the weight carried, each strip responds to a specific rate of vibration per minute. When hammer blows are directed on a wooden block on which the vibration tachometer is mounted, the particular strip with a natural vibration frequency equal to the number of blows of the hammer per unit time, begins to vibrate intensely. The scale across the strips then shows the corresponding number of blows. The accuracy with which the number of blows can be determined by means of a vibration tachometer is ± 3%.

Fig.238 - Testing Device for Pneumatic Hammers to Determine the Energy of the Impact by the Method of Ball Indentation

1 - Pneumatic hammer; 2 - Die with ball; 3 - Test plate; 4 - Springs; 5 - Handle

Another important characteristic is the "specific weight" of the tool, which is expressed by the ratio of the weight of the tool G to its power, i.e.,

$$G_{spec} = \frac{G}{N_o} \text{ kg/hp}$$

The significance of eff, Q_{spec}, and G_{spec} for some hammers is given in Table 65.

The principal indices of the technical characteristics of a press are the following:

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a) Force developed by the press, in kg;

b) Number of working strokes per minute;

c) Air consumption for one cycle in m^3 or consumption of electric energy in kw-hrs;

d) Overall dimensions, in mm;

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e) Weight of press, in kg.

The force developed by the press can be determined either by means of elastic deformation dynamometers in regular use for the calibration of general-purpose test-

Table 65

Significance of N_{eff}, Q_{spec} and G_{spec} for Some Multiblow Pneumatic Hammers

a)	b)							c)
	2KM	4KM	M-3	M-1	7KM	PB-54	8KM	
d)	6	9	12	7	14	12	8	9,7
e)	272	155	120	210	110	120	187	168
f)	27	18	13	17	13	18	8	16

a) Indices; b) Type of hammer; c) Average value; d) Actual coefficient of efficiency eff in %; e) Specific consumption of air, Q_{spec}, in m^3/hp-hr; f) Specific weight of hammer, G_{spec} in kg/hp

ing machines, or by the ball indentation method, as it is adopted for determining the impact energy for pneumatic riveting hammers.

In determining the force developed by the press by the ball indentation method, a die with a ball, of the type used in testing hammers, is installed in the press in place of the regular die (see Fig.237). The test plate is placed on the lower die of the press, after which the press is started, causing the ball to make an indSTAT-tion in the test plate. The maximum power developed by the press is then determined from the calibration curves (Fig.241) for the same degree of plate hardness and corresponding to the diameter of the indentation.

The number of working strokes of the press per minute is determined by observation while riveting test specimens, and gives the greatest number of rivets within

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the capacity of a particular press.

It is to be noted that the rating of a press according to the number of working strokes is only approximate, since work on large units at spots of difficult access,

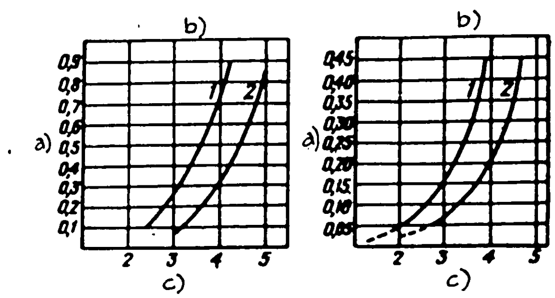

Fig.239 - Calibration Curves for Determining the Impact Energy of Pneumatic Riveting Hammers

a) Deformation work Ag, kg-m; b) Weight of die, 200 gm; c) Diameter of indentation, in mm; d) Weight of die, 100 gm

with the impediments offered by the auxiliary equipment, etc., create conditions under which it is impossible to reach the rated number of working strokes per minute.

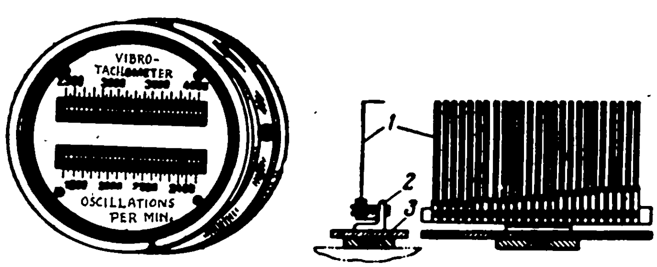

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Fig.240 - Overall View and Arrangement of Vibrotachometer

1 - Vibrating plates; 2 - Angle iron; 3 - Base

In such situations, a correcting factor is applied to take care of the reduced number of working strokes per minute.

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A third factor in the technical characteristics of a press is the air consumption determined with an aerometer (Fig.242) or calculated from the volumetric content of compressed-air tanks, with which the press is operated at power and idle strokes.

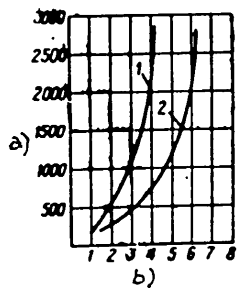

Fig.241 - Calibration Curves for Determining the Force Developed by a Press

1 - Material of the calibrated test plate, steel: H_B = 185 at a load of 3000; 2 - Material of calibrated test plate, bronze: H_B = 70 at a load of 1000

a) Force in kg; b) Diameter of indentation, in mm

Other very important factors determining the usefulness of the equipment and tools are the overall dimensions and weight and dimensions of the press (overhang and throat). For this reason, the factors mentioned must be considered in evaluating the technical characteristics of equipment and tools.

The testing of pneumatic riveting hammers and presses is concluded by making riveting tests with rivets of various diameter and of various materials on test specimens corresponding to the thickness and to the material of the workpiece.

3. Determination of the Riveting Force and the Deformation Work Required for Forming the Clenched Rivet Head

To obtain rational utilization of a given press or hammer, it is not enough to know the power developed by a press or the energy expended in one stroke of a hammer; the following additional data must be defined:

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1) The maximum force of the press $P_{max.riv}$, required for heading the rivets when using a press.

2) The work A_d of a hammer required for heading the rivet.

With these data at hand it is not difficult to proceed with the following tasks:

a) To select the type of press required for riveting with rivets of a specified

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diameter and material. The force developed by the press in that case must be greater or equal to the maximum force required for performing the riveting operation, i.e.,

$$P_{press} \geqslant P_{max.riv}$$

b) To determine the number of rivets n_{riv}, which can be riveted at one time

$$n_{riv} = \frac{P_{press}}{P_{max.riv}}$$

c) To select the type of hammer suitable for riveting with rivets of a definite diameter and material. The hammer work must then be greater or equal to the work $A_{d\ riv}$ done in heading the rivet.

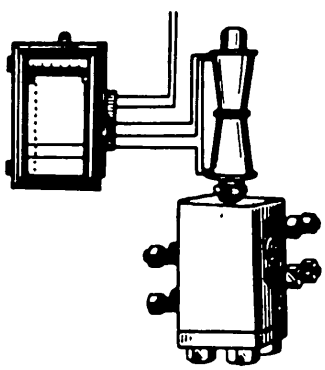

Fig.242 - Layout of Device for Determining the Air Consumption of the Press

d) To determine the time required for riveting a rivet of definite diameter, from the formula

$$T = \frac{A_d \cdot 60}{A_{d\ imp}\, n}$$

where T is the time of the spontaneous riveting, in sec;

$A_{d\ imp}$ is the work in kg-m done by the hammer heading the rivet;

A_d is the deformation work in kg-m necessary for heading the rivet;

n is the number of impacts of the hammer per minute.

For determining the maximum force required for heading the rivet, special-STATpurpose machines are used in upsetting the rivet shank (Fig.243). The device consists of the plate (8) to which is mounted the base (6), clamped to the plate with bolts. The specimen (16) with the inserted rivet (15) is placed in the bushing (3), which is fitted to the shank (4). Preliminary squeezing of the sheets is done by

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means of the springs (9) and the nut (5). The die (2) is fitted into the socket (1) and held in place by the screw (12). The device, together with the rivet to be upset, is placed on the table of the testing machine (Fig.244), after which the up-

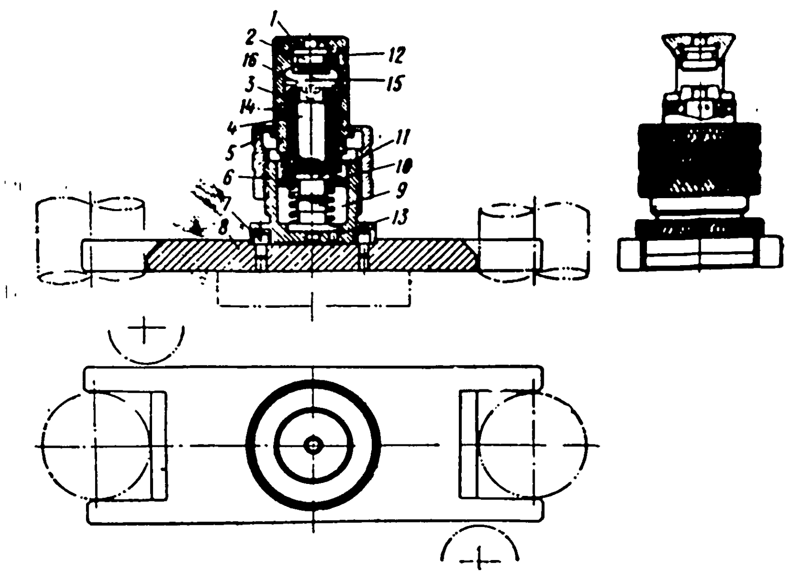

Fig.243 - Device for Determining the Force Developed by a Press

1 - Socket; 2 - Die; 3 - Bushing; 4 - Shank; 5 - Nut; 6 - Base; 7 - Clamping bolt; 8 - Plate; 9,10 - Springs; 11,13 - Dowels; 12,14 - Screws; 15 - Rivet; 16 - Specimen

setting of the shank is done for full formation of the clenched rivet head.

While the test is carried out, the amount of upsetting of the shank is measured by an indicator placed on the table of the testing machine, and a record is kept of the magnitude of the exerted force as indicated on the dial of a dynamometer. Readings of the magnitude of force are taken at every 0.1 - 0.5 mm of the upsetting of the rivet shank. The results of the measurements and calculations are incorporated in the test report.

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The reading obtained by measurements with the indicator, are converted into actual values by excluding the elastic deformation of the rivet shank, of the testing device, and of the mechanism of the indicator. This is done in the following manner: Knowing the overall length of the rivet before riveting as L_1, and after riveting as L_2, we obtain as the actual final upset of the shank a value $\lambda_{a \cdot f}$ as the difference, i.e.,

$$\lambda_{a \cdot f} = L_1 - L_2$$

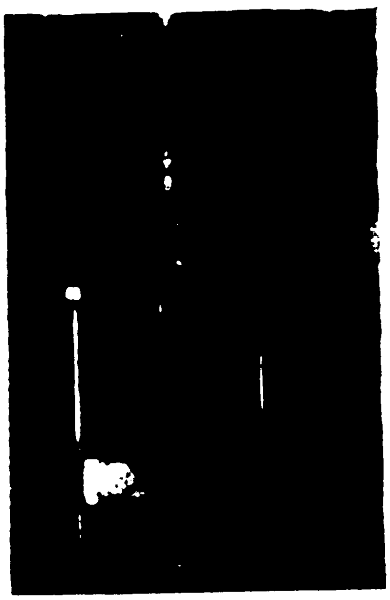

Fig.244 – Testing Machine with Arrangement of Device and Indicator for Determining the Force of the Press as a Function of the Degree of Upsetting of the Rivet Shank

The difference between the final upset value as measured by the indicator, $\lambda_{i \cdot f}$ and actual final upset $\lambda_{a \cdot f}$ gives a final correction factor $\Delta\lambda_f$, to account for the elastic deformation at the maximum force developed by the press, i.e.,

$$\Delta\lambda_f = \lambda_{if} - \lambda_{af}$$

The final correction factor thus obtained, is applied to the instantaneous values of the forces acting on the rivet shank during any instant of the upsetting operation, and which may be expressed, considering their average values, as

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$$\Delta\lambda_p = \frac{\Delta\lambda_f P_{k\,av}}{P_{k\,av}},$$

where $\Delta\lambda_p$ is the correction factor for the instantaneous value of upsetting as read by the indicator;

$\Delta\lambda_k$ is the correction factor on the final force of the press;

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$P_{p\ av}$ is the average value of the magnitude of the instantaneous force exerted during the process of deformation;

$P_{k\ av}$ is the average force of the press at the final stage.

The actual magnitude of upsetting λ_{ap} is determined as the difference between the corresponding instantaneous value of the upset operation as read on the indicator λ_{ip}, and the derived correction factor $\Delta\lambda_p$, i.e.,

$$\lambda_{ap} = \lambda_{ip} - \Delta\lambda_p.$$

On the basis of average forces and actual distance intervals during upsetting, curves showing "Force - Upsetting" values are constructed.

In Figs.245 and 246 are shown "Force - Upsetting" curves for rivets of various diameter, made from various materials. From these curves it is possible to determine

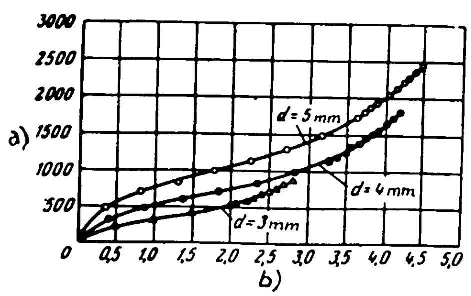

Fig.245 - Curves for the Relation Between the Force of the Press and the Degree of Upsetting for Rivets of Various Diameters. Rivet Material, AMg5

a) Force of press, in kg; b) Upsetting, in mm

the press force necessary for riveting at various progressive stages of upsettiSTAT In the same manner, it is possible to determine the riveting force required for rivets of other diameters and of other materials.

The deformation work for heading the rivets can be determined from the formula

$$A_d = A_{di}\, n_k$$

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where n_k is the number of impacts of the hammer required for heading the rivet.

It follows, therefore, that in order to determine the energy of deformation required for heading the rivet, the energy of one impact of the hammer and the number of blows to form a clenched rivet head must be known.

As stated above, the energy of one hammer blow can be determined by the ball indentation method.

For determining the number of impacts necessary for riveting one rivet, use is made of the formula

$$n_k = \frac{nT}{60}$$

where n is the number of blows per minute;

T is the time of complete riveting in seconds.

The number of blows of the hammer per minute may be determined with a vibration-

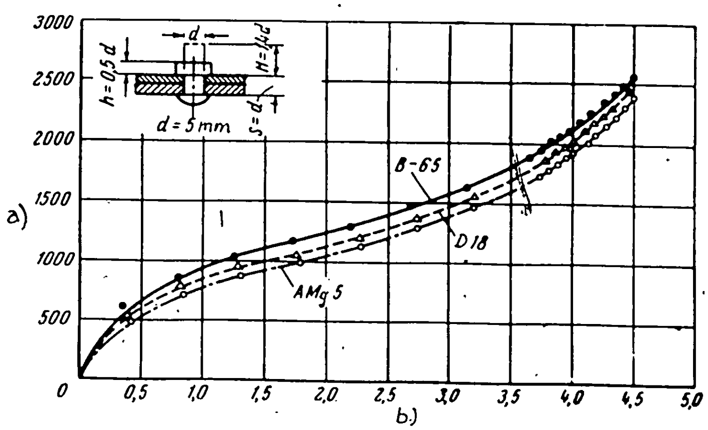

Fig.246 - Curves Showing the Relation Between the Power Developed by the Press and the Degree of Upsetting of Rivets of 5 mm Diameter of Various Materials

a) Force of press, in kg; b) Degree of upsetting, in mm

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type tachometer (see Fig.240) and the time of actual riveting, with a chronometer. Having thus determined all parameters entering the formula, the energy expended in

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the deformation of the rivet shank to form the clenched head is determined.

The deformation work directly done in the riveting operation is affected to a considerable extent by the length of the rivet shank allowed for forming the head. The graphs in Fig.247 show that, by reducing the allowable length of the rivet shank, the required deformation work as well as the time of riveting with multiple-blow hammers is reduced.

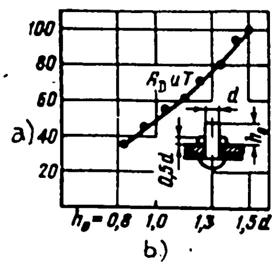

Fig.247 - Effect of Allowance for Formation of the Clenched Rivet Head on A_d and T

a) Value of A_d, T in %; b) Allowance for formation of the clenched head

4. Computation of Consumption Standards for Compressed Air

Equipment and tools intended for drilling, countersinking, and riveting structural parts from light alloys operate basically on the energy contained in air. For a clearer presentation of the utilization of the energy of compressed air for drilling and riveting operations, we will analyze the basic factors underlying the general requirement in the utilization of air according to the requirements of the work to be done, taking into consideration the allowable losses that occur during its practical application in the operation of equipment and tools.

The consumption of air in drilling and riveting operations is accounted for as follows:

a) Consumption of air in performing useful work with equipment, tools and auxiliary devices;

b) Loss of compressed air in the sectional air lines, hoses, fittings and in the equipment and tools themselves.

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To determine the consumption of air for drilling and riveting a component or a major unit, it is necessary to know the consumption of air for each type of equipment and tool individually, which is determined from their technical characteristics.

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10,0 | 0,0588 | 0,0714 | 0,0468 | 0,0570

Table 66

Average Values of Air Consumption for Drilling One Hole in Stacks of Various Thicknesses, in m^3

a)	b) 2,1	2,7	3,1	3,6	4,1	5,2	6,2	8,2	9,2	10,2
1	0,01510	0,01510	0,01510	0,01560	0,01750	0,02230	0,02750	0,04160	0,05460	0,06510
2	0,02416	0,02416	0,02265	0,02340	0,02450	0,03122	0,03575	0,05408	0,07098	0,07812
3	0,03473	0,03171	0,03171	0,03120	0,03307	0,04014	0,04675	0,06656	0,08190	0,09765
4	0,04379	0,04077	0,03926	0,03744	0,04025	0,04906	0,05500	0,07904	0,09828	0,11067
5	0,05285	0,04832	0,04681	0,04524	0,04900	0,06021	0,06600	0,08736	0,11466	0,13020
6	0,06191	0,05738	0,05436	0,05304	0,05775	0,06467	0,07425	0,09984	0,12558	0,14322
7	0,07248	0,06493	0,06342	0,06084	0,06475	0,07359	0,08525	0,11232	0,14196	0,16275
8	0,08154	0,07399	0,07097	0,06864	0,07350	0,08251	0,09350	0,12064	0,15834	0,17577
9	0,09060	0,08305	0,07852	0,07488	0,08225	0,09143	0,13312	0,10450	0,16926	0,19530
10	0,10117	0,09060	0,08758	0,08268	0,08925	0,10035	0,14976	0,11275	0,18564	0,20832

a) Thickness of stack, in mm; b) Hole diameter, in mm

In addition, it is necessary to know the operating time during which work is performed by the particular equipment or tool, which depends on the following basic factors:

a) In drilling operations, on the power rating of the hand drill, the number of revolutions, the diameter of the hole, the feed and cutting speed, and the depth of the cut.

b) In riveting with pneumatic hammers, on the number of blows, the energy of the impact blow, the type of prop, the diameter and the material of the rivet.

c) In press riveting, on the number of working strokes of the press, the force developed by the press, size and shape of the workpiece being riveted, and the extent of mechanization of the supporting and conveying equipment.

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Table 66 and 67 give data on the consumption of compressed air for drilling one hole and for riveting one rivet. The Tables are computed taking into consideration the principal factors that have an effect on the working time of drilling and

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Table 67

Air Consumption per Rivet of Equal Diameter for Riveting with Pneumatic Hammers, in m^3

a)	b)	c)	d) I				d) II				d) III		d) IV		d) V					
			UM-1		M-1; 2KM-P; UM-3; 2KM		5KM; 5KM-P		4KM; KB-5, MA-1; MA-1K		6KM; M-3 MA-3		7KM; PB-54; PB-58		8KM			10KM		
		e)	0,20		0,25		0,3		0,45		0,50		0,65		0,3			0,6		
		f)	2,0	3,0	2,0	3,0	3,5	4,0	3,5	4,0	5,0	6,0	7,0	8,0	9,0	9,5	10,0	9,0	9,5	10,0
		g)																		
h)	i)	D18	0,0014	0,0016	0,0017	0,0020	0,0022	0,0025	0,0036	0,0040	0,0063	0,0094	0,0192	0,0297	0,0222	0,0255	0,0294	0,0444	0,0510	0,0588
		B65	0,0018	0,0020	0,0022	0,0025	0,0027	0,0032	0,00[illegible]	0,0052	0,0081	0,0126	0,0247	0,0379	0,0282	0,0318	0,0357	0,0564	0,0636	0,0714
		Steel 15	0,0018	0,0020	0,0022	0,0025	0,0032	0,0037	0,0052	0,0060	0,0112	0,0198	0,0363	—	—	—	—	—	—	—
	j)	D18	0,0010	0,0012	0,0012	0,0015	0,0017	0,0020	0,0028	0,0032	0,0049	0,0085	0,0154	0,0286	0,0177	0,0144	0,0234	0,0354	0,0408	0,0468
		B65	0,0014	0,0016	0,0017	0,0020	0,0022	0,0025	0,0036	0,0040	0,0063	0,0108	0,0198	0,0302	0,0225	0,0285	—	0,0450	0,0510	0,0570
		Steel 15	0,0024	0,0016	0,0017	0,0020	0,0025	0,0030	0,0040	0,0048	0,0090	0,0175	0,0291	—	—	—	—	—	—	—
w)	k)	D18	0,0040	0,0048	0,0057	0,0060	0,0070	0,0080	0,0112	0,0128	0,0193	0,0256	—	—	—	—	—	—	—	—
		B65	0,0064	0,0068	0,0080	0,0085	0,0097	0,0110	0,0156	0,0176	0,0265	0,0351	—	—	—	—	—	—	—	—
		Steel 15	0,0064	0,0070	0,0080	0,0087	0,0100	0,0122	0,0160	0,0196	0,0382	0,0684	—	—	—	—	—	—	—	—
	j)	D18	0,0036	0,0038	0,0045	0,0047	0,0055	0,0062	0,0088	0,0100	0,0153	0,0202	—	—	—	—	—	—	—	—
		B65	0,0050	0,0054	0,0062	0,0067	0,0077	0,0087	0,0124	0,0140	0,0211	0,0279	—	—	—	—	—	—	—	—
		Steel 15	0,0050	0,0056	0,0062	0,0070	0,0080	0,0097	0,0128	0,0156	0,0306	0,0544	—	—	—	—	—	—	—	—

a) Shape of clenched head; b) Type of prop; c) Rivet material; d) Hammer group; e) Consumption of air in m^3/min; f) Diameter of rivets, in mm; g) Consumption of air for one rivet, in m^3; h) Flat; i) Elastic; j) Stiff; k) Flush;

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and riveting.

To determine the air consumption necessary for riveting a given component or a major unit with a riveting hammer, it is necessary to multiply the figure given in Table 67 for one rivet by the number of rivets in the workpiece, i.e.,

$$Q_{ym} = Q_e n$$

where Q_{ym} is the air consumption for riveting a major unit, in m^3;

Q_e is the air consumption for one rivet;

n is the number of rivets in the component or major unit.

For determining the consumption of compressed air in riveting a component on a riveting press, the figure given in Tables 48 and 50 on the air consumption for a double working stroke Q_x of the riveting press, must be multiplied by the number n in the component or major unit being riveted by the single riveting method, or by the number of working strokes of the press in the case of group riveting, i.e.,

$$Q_{yp} = Q_x n$$

For determining the air consumption in drilling a component or major unit, the mean value of the figure given for the consumption of compressed air for one hole of the required diameter in stacks of a given thickness, from Table 66, must be multiplied by the number of holes in the component or in the major units i.e.,

$$Q_{yc} = Q_c n$$

The combined consumption of air for drilling and for riveting of a component or a major unit is the sum of the consumption of compressed air for drilling, for hammer riveting and for press riveting, i.e.,

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$$Q_y' = Q_{ym} + Q_{yp} + Q_{yc}$$

Taking into consideration the loss of compressed air in the sectional air lines

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and flexible hose, and also losses due to inside roughness of pipe fittings and of the riveting equipment and tools themselves, the grand total of air consumption for all operations on the component or unit may be represented as follows:

$$Q_y \text{ total} = Q'_y$$

where η is the loss factor, which varies from 1.10 to 1.15 when the pressure in the main line of the system is equal to 5 atm.

Data on the computed air consumption standard for structural components and major units are entered on technological process charts. The air consumption of shops for one product is entered on sheets giving the overall air consumption based on each individual part or unit.

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CHAPTER XI

UTILIZATION OF RIVETING EQUIPMENT AND TOOLS AND THEIR MAINTENANCE

1. Importance of Servicing Equipment, Tools, and Auxiliary Devices

Every one who is working with equipment and tools and with auxiliary devices must realize that such means of carrying out specific technical operations involve precision mechanisms used for performing difficult work under heavy-duty conditions. For this reason, proper functioning of such equipment and tools depends not only on their operating condition but also on their correct preservation and maintenance during use.

The principal rules governing the servicing of equipment and tools (riveting presses, pneumatic and electric hand drills as well as pneumatic riveting hammers) are given below, covering servicing before starting the work, during work, and on completion of the work.

2. Rules for Preparation of Presses and Auxiliary Devices for Operation

Before work is started, the assistant examines the press and the auxiliary devices and prepares them for operation. The preparation of presses for operation is carried out in the following order:

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1. The mechanism of the press is lubricated through all the oiling devices that are on the body of the press. The automatic lubricator is filled with oil through the plug (Fig.248) to a level indicated by the oil gage (1). Turbine oil of grade L

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or spindle oil of grade Z is used for lubrication of the mechanism. When the oil is changed or replenished, an oil of the same grade must be used.

2. Foreign matter in the pneumatic system, separated by means of a filter, is

Fig.248 - Filter with an Automatic Lubricator

1 - Oil gage; 2 - Drain cock; 3 - Plug for dismantling the filter; 4 - Regulator for automatic oil feed; 5 - Sight glass; 6 - Manometer; 7 - Oil tank for the automatic lubricator; 8 - Hose for supply of compressed air to the press mechanism; 9 - Hose for supply of compressed air from the main line; 10 - Plug for replenishing oil

drained by opening the drain cock (2). It should be noted that cleaning of the filter should be done at intervals of not less than once every seven days in the following order:

a) Unscrew the plug (3), remove the filter, and wash it in gasoline;

b) Clean the hardened particles from the filter with a hair or fiber brush;

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c) Open the drain cock (2) and scavenge the oil reservoir with compressed air through the opening at the top;

d) Blow out the filter with compressed air and replace it, after which plug

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(3) and cock (2) are closed.

3. The feed of oil is controlled by means of the screw (4) so that two drops of oil will flow through the sight glass (5) at every power stroke of the press.

4. The press is then connected to the pneumatic and electric systems. Before any hose is connected to the press, it must be thoroughly scavenged with compressed air to remove dust and dirt, since any dirt that may find its way into the mechanism of the press will contribute to its rapid wear and interfere with its proper functioning.

5. The electric and pneumatic starting devices and the microswitches are inspected, and the safety features of their installation as well as their proper attachment are checked. During inspection of the electric equipment, the contact points are cleaned and the dust is removed.

6. After the press is lubricated and connected to the pneumatic and electric systems, the press is checked during idling operation. For this purpose, the inlet valve of the pneumatic system is opened and the manometer is watched, which must indicate a pressure of not less than 4 atm, and there must be no leakage of air at any of the connections. Then the main switch is closed, which connects the press to the electric system, and pressure is applied to the pedal of the press or the main manual control, located on the control panel, is turned. The operation of the press mechanism is then checked, including the supporting and conveying equipment.

The mechanism of the press and of the auxiliary equipment must operate smoothly without jerks or jamming.

7. The press is set for the thickness of the stack and the diameter of the rivet, where the number and diameter of simultaneously riveted rivets and the stack thickness must correspond to the number and diameter of the rivets in the pSTATbeing riveted.

8. Test riveting is performed, followed by checking all parameters (height and diameter of the clenched head) as well as the surface finish (as to possible inden-

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tations, scratches, cuts, and other defects).

After making certain that the press and auxiliary equipment are in good working order, and after checking the quality of test seam, it is in order to proceed with the riveting of the assigned job.

Supervision over the operation of the press and the auxiliary equipment is carried out as follows:

1. The air pressure in the main lines is read from the manometer, and work is stopped as soon as the pressure drops below 4 atm.

2. At the same time, all minor kinks in the operation of the press and the auxiliary equipment are noted and eliminated. If serious trouble develops in connection with the operation of the press mechanism, riveting of the workpiece is stopped, and either the foreman or the repairman is called in.

3. Off-center and one-sided loads on the tools of the press are not permitted, since this may cause breaking of the riveting tools or, in some cases, breakdown of the press mechanism leading to scrapping of the workpiece.

4. The number of simultaneously riveted rivets must be watched and must not exceed the number of rivets specified for the particular press according to its technical characteristics.

5. When working on semiautomatic presses of the type KP-503, KP-403, and KP-405, it is absolutely forbidden to repeat the same riveting operation in cases when the first riveting operation is not satisfactory.

After the work on the press is completed, the workman must close the main valve which admits air from the main compressed-air system, disconnect the electric switches, and allow the air from parts of the press to escape by opening the screw plug of the air filter to drain any condensate.

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When working with pneumatic tools, such as pneumatic hammers and hand drills, the following important rules must be observed:

1. The worker operating a pneumatic hammer must make sure that the shank length

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of the die corresponds to the particular type of hammer he is using, and that the flat end of the shank is perpendicular to the axis of the die. This is necessary primarily to have the hammer operate to its fullest rated capacity, and secondly to prevent damage to the end face of the piston.

2. Before inserting the shank of the die into the hammer, it must be wiped to remove any adhereing dirt.

3. Turbine oil of grade L is used for lubrication of the pneumatic tools, which proceeds in the following manner:

a) The hammer or hand drill is held with the nipple on top.

b) 12 to 15 drops of oil are poured into the nipple, while depressing the trigger to feed the oil to the tool.

4. The air hose is first blown out with compressed air and is then connected to the pneumatic tool, after which it is operated at idling for one minute to distribute the oil over the inside parts of the mechanism. Then the hammer is placed, with the smooth face of the die, on a wooden block to prevent the bushing from dropping out.

5. The hammer is tested by riveting several rivets and the hand drill is tested by drilling several holes of corresponding diameters.

After checking the pneumatic tools for proper operation, the drilling and the riveting operations are carried out.

6. The readings of the manometer are watched while the pneumatic tools are in operation. The air pressure in the main lines must not be lower than 4 - 5 atm. A drop in pressure results in lowering the power of the hammer or the hand drill, causing a decrease in production and resulting in unsatisfactory quality of the riveting work.

7. If jamming of any of the moving parts of pneumatic tools takes place STAT work and the tool stops, the tool must be sent to the maintenance department for repair, without attempting to make any adjustments while on the job.

After work with the pneumatic tools is completed, the inlet valve that supplies

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compressed air from the main line is closed, and the hose is disconnected from the main line and also from the pneumatic tool. Then the pneumatic tool and the inserted tool are wiped with a clean rag, placed in the tool box, and returned to the tool stockroom.

When working with electric hand drills, the specific rules applying to the par-

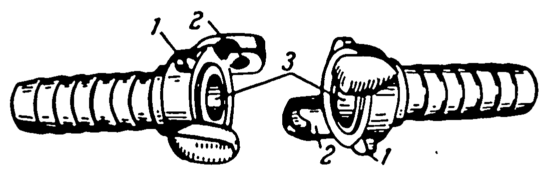

Fig.249 - Quick-Action Connector Sleeve

1 - Bosses; 2 - Cut-outs; 3 - Rubber gaskets

ticular tool must be followed, which consist of the following:

1. Before starting any work it should be checked whether the ground wire lead is connected to the grounding connection on the body of the hand drill. Breaking of

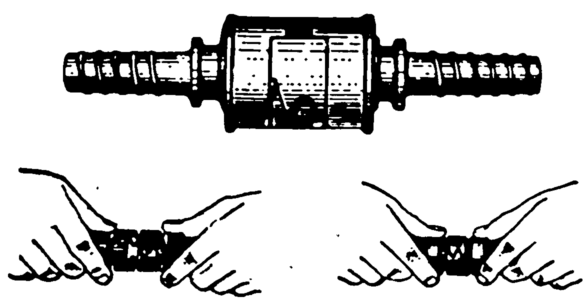

Fig.250 - Quick-Release Connector Sleeve

the ground-wire lead is dangerous, since current may pass from the metal of the electric hand drill through the body of the worker.

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2. The condition of the brushes and the commutator is checked. In normal work there should be slight sparking between the brushes and the commutator.

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3. Overheating of the hand drill must not be permitted while working with it. The temperature of the body of the hand drill must not exceed 60°C.

4. On detecting a strong smell of burning insulation, due to burning of the wire leads or parts of the hand drill, further drilling must be stopped and the hand drill turned over to the tool stockroom for repair.

3. Fittings and Rubber Hose

Parts, by means of which the connection is made between presses and impact and rotary tools to the main lines, are known as fittings for presses and for pneumatic tools.

The couplings for connecting rubber hose to presses and tools must be tight so that there will be no loss of compressed air, and they must be interchangeable so that any pneumatic press or tool can be quickly connected. For this reason, special attention must be given to the features of fittings and hoses, since any defects may considerably lower the output.

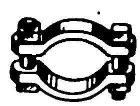

Fig.251 - Clip for Fastening a Hose to the Shank of a Quick-Release Coupling

The quickest and most convenient connection between hose sections and main lines is the quick-release coupling sleeve shown in Fig.249. This quick-release sleeve consists of two similar parts. One of these is fitted into the hose leading from the tool and is attached by clip or wire in extreme cases. The other part is connected to the main pipeline. In connecting the hose to the main pipeline, the bosses (1) on one part fit by snapping them into the cut-outs (2) of the other part of the sleeve. The parts are forced against each other by the rubber gaskets (3), resulting in a hermetic tight joint.

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Several other means exist for connecting hoses to the pneumatic tools. Figure 250 shows a quick-release sleeve of a somewhat superior design.

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Figure 251 shows a clip for fastening a hose to the shank of a quick-release coupling, to replace wire fastening.

Hoses must be inspected regularly and maintained in good order. After the hose is connected to the main system, the valve is opened and the hose is scavenged for several seconds to remove any accumulated dirt and dust. Then the valve is closed, and the free end of the hose is connected to the equipment or the tool.

Hoses should always be dry when in use, and for this reason must be frequently dried in winter or humid weather. It is forbidden to thaw out frozen hose with steam, since this may cause damage by disintegration of the rubber sheath. Drying of hose must be done in warm places. It is particularly necessary to guard against excessive tightening, abrupt twists, contact with sharp objects, etc.

4. Repair of Equipment and Tools

Proper inspection and maintenance of equipment and tools and their timely repairs, will prolong their useful life and improve the quality of the riveting work, as well as the rate of production. Repair work on tools and equipment consists of three types: current repairs, major repairs, and planned overhauls.

Current Repairs should be made in the tool stockroom, where hammers, hand drills and various fitted tools are stored. Current repairs are confined to elimination of minor defects not requiring much repair of the damaged parts, to washing, cleaning, and oiling of the tools and individual mechanisms, and to occasional replacement of broken parts.

The work mentioned should be done by a skilled expert mechanic who thoroughly understands the design, correct use, and manner of repair of a given type of equipment or tool.

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Major Repairs are made in a well-equipped workshop, with facilities for disassembling any equipment or tool, replacing worn parts with stockroom parts or newly manufactured parts.

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Planned Overhauls are made on the basis of routine inspection of the equipment, tools and auxiliary devices, and are carried out by a special administrative department in charge of the chief mechanical engineer of the plant.

The inspection program is previously worked out graphically for the planned overhaul of equipment, tools and auxiliary devices, and spare parts are provided beforehand on the basis of the defects detected during the inspection. The time when a certain machine is to be taken out of operation for repair is determined beforehand, and the repair work is done in a central repair shop.

Each time after any equipment or tool is disassembled and re-assembled after repair, it is tested before it is returned to production work. In the case of current repair work, it is sufficient to make sure that the equipment or tool operates smoothly without jerks, jamming, or interruptions.

After major repairs, the technical properties of equipment or tools are determined. For this purpose, the repair shop has an inspection and testing department, equipped with testing apparatus and devices, such as an aerometer for determining the consumption of compressed air, a manometer for indicating the air pressure, a vibration-type tachometer for determining the number of impacts per minute, a tachometer for measuring the rpm, a stop watch, a dynamometer for finding the impact energy of the hammer blow, a brake device for determining the torque, etc.

For each unit of equipment or tools, a report is prepared according to Form 3, and a record is kept of the repairs made according to Form 4.

During repair of equipment or tools, the necessary clearances and fits between the mating parts must be accurately maintained to ensure proper operation. In addition, replacement parts must be made up of the grade of metal and given the heat-treatment specified for each part.

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Repairs of the electric parts of equipment and tools are made by highly qualified electricians, who must familiarize themselves beforehand with the electric schematic diagrams of the particular equipment or tools.

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Form 3

Example of a Report on a Pneumatic Hammer

Plate No. of Pneumatic Hammer		Inventory No., Plant No.
Manufacturer's plant		Department No. where hammer is used
Type of hammer		Year released
Sketch of hammer		Year acquired

Principal data of hammer

Length without die		mm		Hammer is suitable for work on ....
Weight		kg		
Inside diameter of hose		mm		
Shank	Inside diameter	mm		
	Piston stroke	mm		
Shape and dimension of hole for die	Hole diameter	mm		
	Chamfered radius of bushing	mm		
Piston	Diameter	mm		
	Area	mm^2		
	Overall length	mm		
	Weight	kg		
Top speed		m/sec		
Calculated	Energy of impact	kg-m		
	Power rating	h.p.		

			Test data						
Test data	Characteristics								
	Air pressure in atm								
	Number of impacts per minute	According to characteristics							
		Actual							
	Air consumption in m^3/min	According to characteristics							
		Actual							
	Energy of impact in kg-m	According to characteristics							
		Actual							

Date	Reported by	Checked by	Section No. of chief experimental station
Signed			

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Form 4

Example of a Form for Recording the Repairs Made and the Test Data After Repair

a)		b)					c)					
d)	e)						f)	g)	h)	i)	j)	k)

a) Date; b) Name of repaired parts; c) Test data after repair; d) Sent to repair shop; e) Issued by repair shop; f) Air pressure in atm; g) Number of impacts per minute; h) Consumption as free air in m^3/min; i) Energy of impact in kg-m; j) Number and date when defect became known; k) Remarks

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CHAPTER XII

SPECIAL REQUIREMENTS FOR RIVETING SEAMS IN HERMETICALLY SEALED CABINS

1. Introduction

One of the most critical jobs in riveting aircraft assembly units is that represented by the hermetically sealed cabin. The volume of work on airtight units represents about 30% of the riveting labor of the entire fuselage, and in the case of a hermetically sealed passenger aircraft, it reaches up to 60%. When flying at high altitudes, the main requirement on airtight cabins is that of dependable insulation against the outer atmosphere, and for this reason the riveting of seams of cabins makes particularly high demands.

Riveting of airtight seams in aircraft structures is different from that of riveting ordinary seams. Airtight seams, in addition to accuracy of work, must be as hermetically sealed as possible. The airtightness of a hermetic seam must be effective under the following conditions:

a) Climb to a considerable altitude which means resistance to great pressure differences between inside and outside of the cabin (up to 0.5 atm);

b) Temperature fluctuations within the limits of +70° to -60°C;

c) Static, vibrational, and cyclic static stresses exerted on the seam. STAT

2. Types of Hermetic Seals

The types of adhesive packings used in aircraft production in connection with

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riveted seams are as follows:

a) Gaskets of sealing compounds;

b) Pastes, cements and glues;

c) Friction tape, impregnated with viscous or paste-like compounds of a sealing material.

The sealing of riveted seams with adhesive packing is done in the following manner (Fig.252):

a) By placing the packing between the parts to be riveted.

b) By applying the packing to the top of the part assembled last, usually on the side where the heading is done.

c) By a combination of packings, i.e., placing the packing between the parts to be riveted and then applying the packing on top of the part assembled last.

Application of the packing on top of the part assembled last is preferable since this simplifies the technical process of assembly and riveting, reduces the labor in completing the work on the assembled unit, and lowers the cost.

Pastes and cements are used as packings on the surfaces of the parts being riveted, in the holes, or on the shanks of the rivets, on the edges of the sheets, and, at the same time, for supplementing the sealing of structural and technical places with insufficient air-tightness.

The principal types of packings for rendering riveted joints airtight are the following: thiokol, film-type, and glue-type of packings.

Thiokol, in combination with another film-type sealing compound, is used in the form of tape, inserted between the parts to be riveted, and cement is then applied for additional airtightness of the seam.

Thiokol packing promotes corrosion in magnesium alloys, and its use in structures of this material is not recommended. For such alloys, use is made of a film-type packing in which the susceptibility to corrosion of duralumin and magnesium alloys is absent.

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Heat treatment is required when using glue-type sealing compounds, by heating the structure together with the packing compound to a temperature of 130 - 160°C, for polymerizing the packing. This complicates somewhat the technical process of making airtight cabins, and such a temperature may even be dangerous for some structural materials. For example, heating the D16 compound above 120°C develops a tendency toward intercrystalline corrosion. For this reason, clay-type packing has not found wide application in the construction of aircraft, but may be utilized in other structures, depending on the nature of the work and the kind of material used.

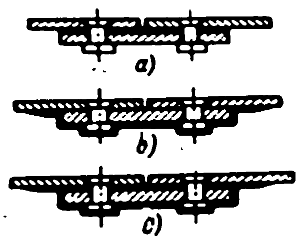

Fig.252 - Types of Packings in Riveted Seams

a)- Packing placed between the parts to be riveted; b - Packing applied to the top of the part assembled last; c - Combination packings

Following are the principal requirements for packings used in making cabins airtight:

a) Excellent adhesion;

b) Temperature stability within the limits from -60° to +70°C;

c) Resistance to changes in atmospheric conditions;

d) Considerable stability under vibration;

e) Resistance to the effects of moisture, oil, gasoline, and other substances;

f) Low specific gravity;

g) Absence of corrosive action;

h) Absence of chemical elements injurious to the health of the crew;

i) Facilitation of the riveting operation.

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Sealing compounds of the thiokol type U-20-A and others in use at present, do not fully satisfy these requirements, so that further research is required on developing new types of packings that would provide good hermetic seals and high ac-

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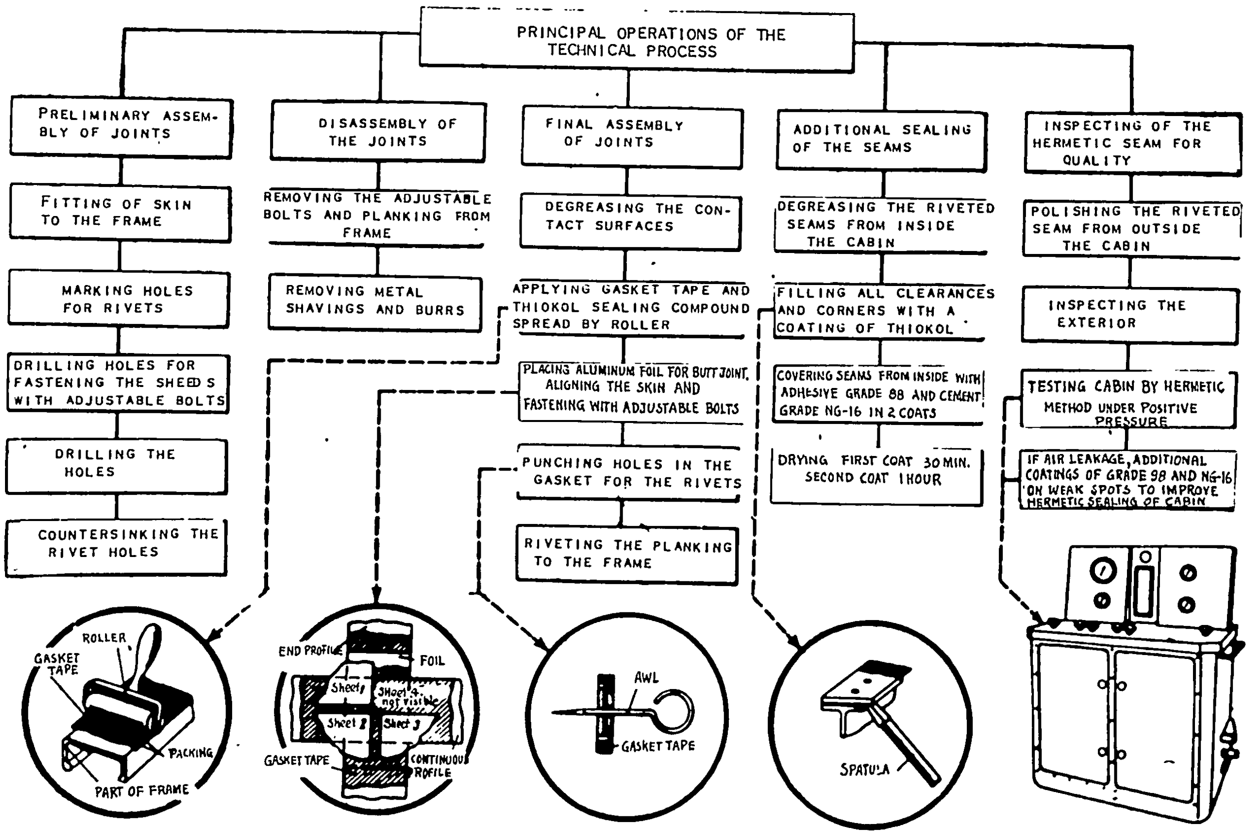

Fig.253 - Typical Process of Assembly and Riveting of an Airtight Seam Using Thiokol Sealing Compound

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curacy of the riveted joints.

3. Technical Peculiarities in Producing Airtight Riveted Seams

For cabins of modern high-altitude aircraft thiokol sealing compounds are primarily used. A typical example of the assembly and riveting of an airtight seam,

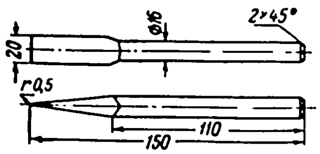

Fig.254 - Spatula for Removal of Burrs

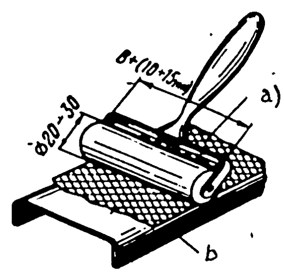

Fig.255 - Roller for Unrolling Tape

a) Thiokol tape; b) Frame

when using thiokol packings (Fig.253) consists of the following principal operations:

1) Preliminary assembly of parts;
2) Drilling of the holes;
3) Formation of the recesses by countersinking;
4) Disassembly of the joints;
5) Application of the packing;
6) Final assembly;
7) Riveting;
8) Test for airtightness;
9) Additional airtightness.

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Preliminary Assembly. The parts and the planking are delivered for assembly in a finished form, corresponding to the design drawings and the technical specifications. The parts should bear a mark indicating that they are accepted by the inspectors.

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The planking is placed on the frame of the major unit and attached to it tightly by means of flexible cord or special clamps that are available on assembly fixtures. With the parts squeezed together, they are fastened with adjustable bolts or clamps,

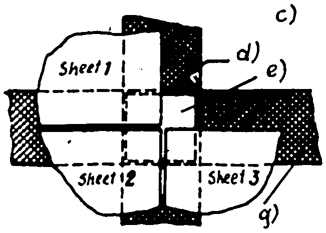

Fig.256 - Places Where Aluminum Foil is Installed

a) Sheet No.1; b) Sheet No.2; c) Sheet No.4 conventionally not shown; d) Butt joint of gasket; e) Foil; f) Sheet No.3; g) Gasket

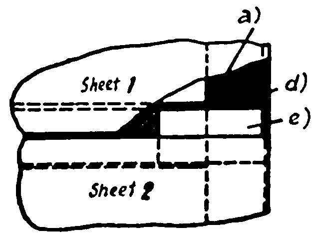

Fig.257 - Places of Aluminum Foil Installation

a) Butt joint of gasket; b) Sheet 1; c) Sheet 2; d) Gasket; e) Foil

spaced at a distance of 80 - 120 mm. The installation of the adjustable bolts and clamps is done either by the end or by the central method. The component, in assembled form, is submitted to the inspector who checks the correctness of the as-

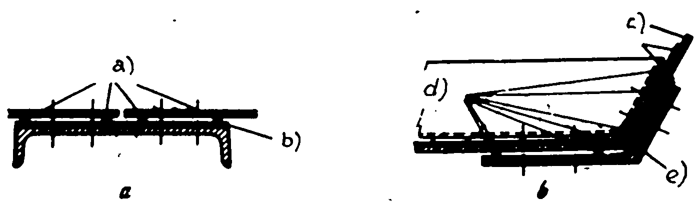

Fig.258 - Distribution of Thiokol Packing Sticks

a) Packing sticks of thiokol cement; b) Thiokol tape; c) Cabin partition; d) Packing sticks of thiokol cement; e) Thiokol cement

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sembly of the parts, the tightness of adjacent parts of the skin to the frame (observing that the clearance between adjoining parts must not exceed 0.2 mm over a

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length of 100 mm), the smoothness of the contours, and all other requirements pertaining to the quality of the component.

Drilling of Holes and Countersinking of Recesses. This is performed by the same means and methods as those used for making seams that are not airtight.

Disassembly of Joints. This operation is performed for the purpose of removing shavings and burrs that accumulate between the parts to be joined during the process of drilling and during countersinking of the recesses. The surface of the planking and of the airframe is carefully cleaned of shavings and dust with a hair brush or by blowing with compressed air. A spatula made of organic glass (Fig.254) is used for removing the burrs on the touching surfaces of the light-alloy sheets and the frame. Countersinking tools with a cutting angle of approximately 150° are used for removing burrs on steel parts; in so doing care should be taken not to remove any of the metal of the part itself.

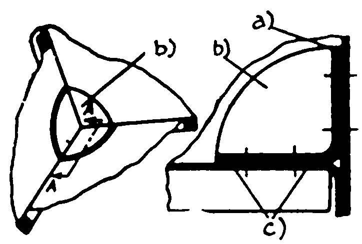

Fig.259 - Duralumin Angles in a Component

a) Thiokol tape; b) Angle; c) Thiokol packing sticks

Application of Sealing Compound. All touching surfaces are degreased before any sealing compound is applied. Gasoline B-70 is used for degreasing, applied to the contact surfaces with a clean rag.

The gasket tape is placed on the frame together with a protective strip by gradually unrolling the roll. The width of the tape must not be greater than 3 - 5 mm of the width of the frame part. The tape is smoothed with a steel roller (Fig.255) for eliminating wrinkles and for better adhesion to the metal.

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The protective strip is removed just prior to assembling the sheets and the parts. This is done by holding the gasket tape down with a plate made of plastic material, so that the thiokol gasket will not slip.

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Strips of thiokol tape are joined with a butt joint along their length without clearance between the abutting edges; the butt joint is located between the holes and is coated with thiokol sealing compound. On end bulkheads and in spots where

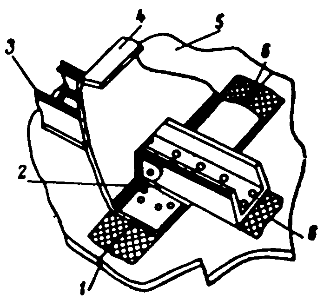

Fig.260 - Example of Making a Component Airtight

1 - Thiokol packing; 2,3,4,5 - Parts of the component; 6 - Thiokol tape

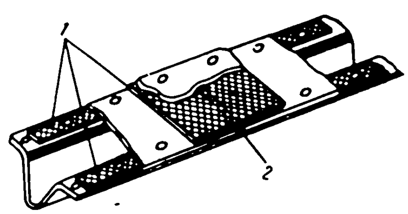

Fig.261 - Example of Making a Component Airtight

1 - Thiokol tape; 2 - Thiokol packing

longitudinal and transverse seams intersect (Figs.256 and 257), aluminum foil of a thickness of 0.15 - 0.20 mm is used as fillets.

Sticks of sealing compound made of thiokol cement, of a diameter of 1.5 - 2 mm, are placed over the thiokol tape along the butt and the end seams, by means of a spatula (Fig.258).

When there are trihedral angles in the cabin, supplementary stamped duralumin angles are placed over the thiokol packing sticks (Fig.259).

Figures 260 and 261 shows examples of making airtight individual comp[redacted] of hermetically sealed cabins.

Final Assembly. The planking is installed on the frame and is fastened with adjustable bolts and clamps. The installation of the adjustable bolts and clamps is done in the same manner as in the preliminary assembly, and it is essential that all fastened parts adjoin evenly and tightly.

Before the rivets are inserted, holes are punched in the thiokol tape with an

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awl (Fig.262).

The awl should have a diameter 0.2 mm less than the diameter of the corresponding rivet hole, should be well polished, and have a chromium-plated tip.

Riveting. The riveting of airtight seams is carried out by the same methods and by the same means that apply to ordinary riveting practice. However, in riveting

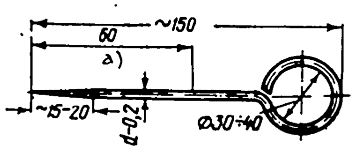

Fig.262 - Awl for Punching Holes in Thiokol Tape before Insertion of the Rivets

a) To be polished

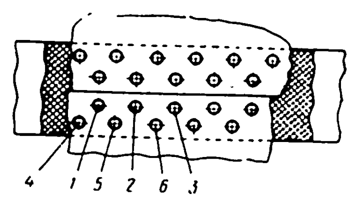

Fig.263 - Riveting Sequence for Double-Row Butt Seam with Pneumatic Hammer

1,2,3,4,5,6 - Rivets are inserted in the order shown by the numerals

hermetically sealed cabins, certain peculiarities of the work must be taken into consideration. The riveting of a double-row butt seam is carried out in the following manner: First 3 - 4 rivets are inserted in the inner row, followed by the same number of rivets in the outer row, after which rivets are again inserted in the inner row, and so forth.

To obtain better adhesion of the thiokol packing to the metal, the riveting of airtight seams is carried out at a temperature between 20 and 30°C of the parts being riveted. To maintain this temperature, warm air is blown over the parts in the assembly sections of the plant.

After the riveting is completed, the seams are cleaned. The partially squeezed out packing sticks and the surplus of thiokol tape are picked up at the edges of the seam and are smoothed out with the aid of a spatula.

The riveted part is submitted to the inspector, who passes on the quality of

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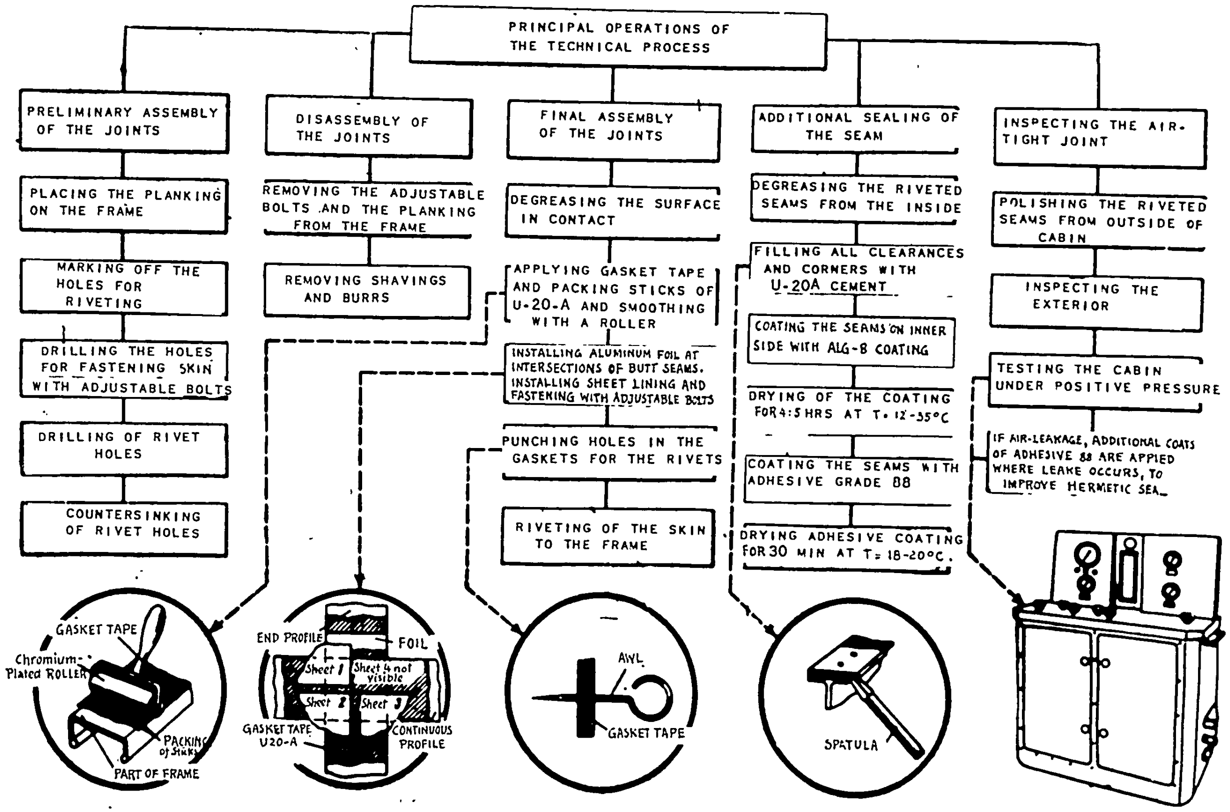

Fig.264 - Typical Technical Process of Assembly and Riveting of Airtight Cabins, Using a Film-type Sealing Compound

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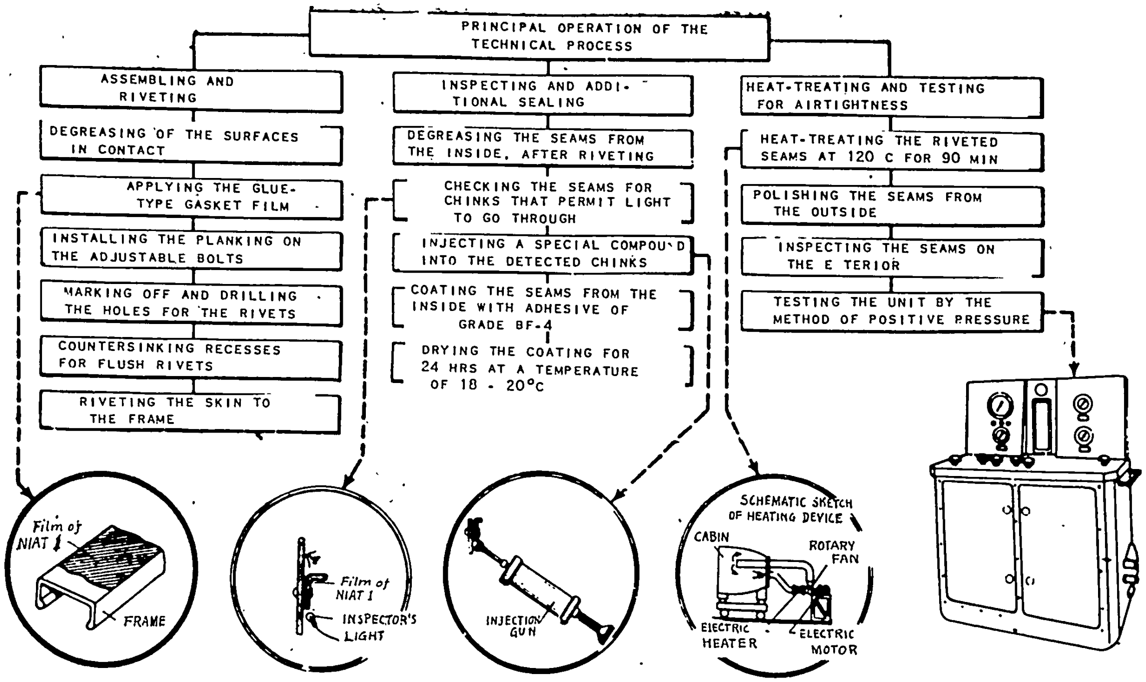

Fig.265 - Typical Technical Process of Assembly and Riveting of Cabins with Application of Glue-Type Sealing Compound

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the riveted joint and on the seam finish, by the methods given in Chapter XV.

This is followed by installation of the glass parts, control cables and rods, pipe conduits, electrical wiring, canopy, and port-holes. The cabin is then subjected to teste for airtightness, and if necessary, additional sealing is performed.

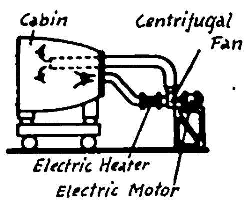

Fig.266 - Schematic Sketch of a Heating Device

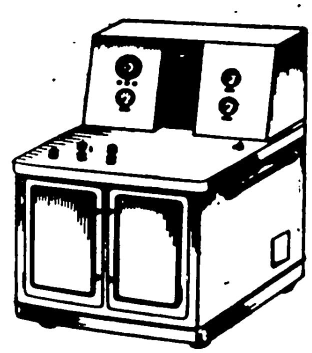

Fig.267 - Setup for Testing Airtight Cabins by the Pressure Method

Outlines of the technical processes of assembly and riveting of airtight cabins with application of film and glue types of sealing compounds are shown in Figs.264 and 265.

As stated above, the use of glue-type sealing compounds requires that heat-treatment by preheating the structure with the sealing compound to a temperature of 130 - 160°C for 30 min. The preheating of this temperature may be carried out in special heating chambers or by means of special devices that supply heated air of the required temperature inside the cabin. A schematic sketch of one of such de STAT is shown in Fig.266.

4. Inspection of the Quality of Airtight Seams

The test for airtightness is performed by the vacuum method with removal of air or by the pressure method with supply of air. The vacuum method is used for inspection of the riveted seam during assembly of the unit and fabrication of components and panels. The pressure method is used for testing the cabin after the components have

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been assembled up to the stage of installing the heat insulation, together with the equipment, and also after final assembly and installation of related equipment and heat insulation.

The rating of airtightness by the pressure method is performed on the basis of

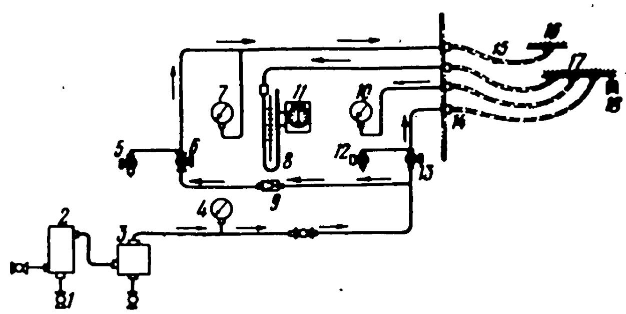

Fig.268 - Principal Schematic of the Instruments for Testing Airtight Cabins by the Pressure Method

1 - Intake valve; 2 - Settling tank; 3 - Filter; 4 - Manometer; 5 - Outlet valve for exhausting compressed air from the pressurized hose of the canopy; 6 - Intake valve for admitting air in the pressurizing hose of the canopy; 7 - Manometer indicating the pressure in the pressurizing hose of the canopy; 8 - Manometer indicating the pressure in the cabin; 9 - Reducing valve; 10 - Manometer indicating the pressure in the cabin; 11 - Stopwatch; 12 - Outlet valve for exhausting the air from the cabin; 13 - Valve for admitting air into the cabin; 14 - Nipples; 15 - Hoses; 16 - Nipples for the pressurizing hose of the canopy; 17 - Pipe connections to the cabin; 18 - Safety valve

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the pressure drop from p_2 to p_1 during a definite time after stopping the supply of air into the cabin.

A special apparatus (Figs.267 and 268) is used for testing the airtightness of cabins by the pressure method, tapping the compressed air from the sectional pneumatic system. The supply of compressed air during the test is regulated by valves

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located on the control panel (see Fig.267).

The amount of excess air pressure in the cabin during the pressure drop is checked with the aid of instruments and devices mounted on the control panel.

Before any testing is done, the interior of the cabin is cleaned of dust and shavings. On the outside, all riveted seams and bolt joints are wiped with clean rags, lightly soaked in gasoline, so as to remove all traces of packing. All holes intended for the installation of parts or components in the final assembly, are

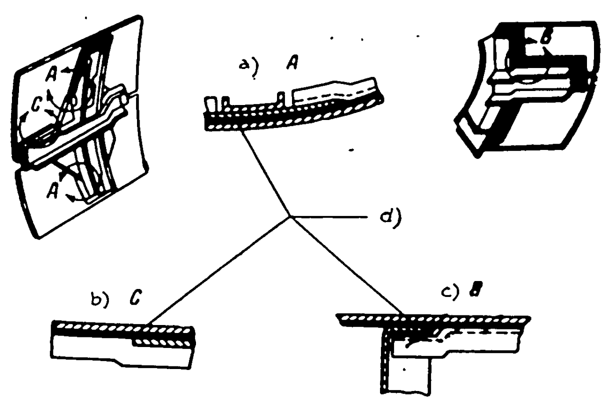

Fig.269 - Places Requiring Additional Sealing

a) Component A; b) Component C; c) Component B; d) Places requiring additional sealing

closed by plugs with rubber gaskets, the port-holes and canopy are closed and locked, and all outlets to the exterior connections are closed.

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The next step is to install a safety valve in the cabin which is set to the maximum pressure Δp_{max} ; the hoses through which air is supplied are connected to the corresponding nipples of the cabin, and the airtightness of all hose joints are checked with soap water.

The pressurizing of the cabin is then performed in the following order: The intake valve is opened for admission of air into the cabin, and the pressure is

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slowly raised to the maximum value of Δp_{max}, which is specified in Technical Orders for testing the cabin, and this pressure is maintained in the cabin during the time specified by the Technical Orders. Pressurizing of the cabin takes place at that time. The rise in pressure in the cabin is checked on a mercury manometer.

After completing the pressurizing of the cabin at the pressure Δp_{max}, the air intake valve is closed, and an evaluation of the airtightness of the cabin is made on the basis of the time it takes for the operating pressure to drop from Δp_{cp} to the lower limit equivalent to 0.1 atm (73.5 mm Hg). After measuring the time required for the pressure drop, the valve is opened and the air is released from the cabin.

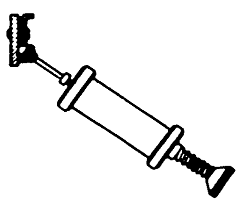

Fig.270 - Injection Gun for Additional Sealing of Joints

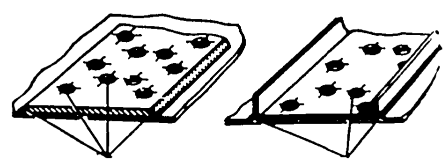

Fig.271 - Places where Additional Sealing for Airtightness is Done with B-10 Adhesive

The checkup on the finish of the cabin is done in the following manner: The inlet valve is opened and air is admitted slowly into the cabin until the pressure reaches 0.1 - 0.15 atm less than Δp_{cp}. This pressure is maintained while all air leakage spots are being detected, for which purpose all riveted seams are swabbed with soap water. If the pressure inside the cabin is greater than outside, bubbles will form at all places of the joints that are not airtight, while no bubbles will form where the joints are airtight.

Lack of airtightness is eliminated by tightening the joints; if that is not possible, then the rivets are replaced with others of larger diameter, and the additional sealing for airtightness is accomplished as follows:

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1. All clearances caused by cut-outs where the profiles intersect, etc., (Fig.269), are filled with thiokol sealing compound by means of the injection gun shown in Fig.270, and smoothed with a spatula. The places to which thiokol packing is applied are degreased first by wiping with rags slightly soaked in B-70 gasoline.

2. All butt and all through joints (Fig.271) are coated with B-10 adhesive in the following manner:

a) The surfaces to which the adhesive is applied are degreased with gasoline.

b) A first coat of B-10 adhesive is applied and allowed to dry for 30 min at a temperature of 18 - 20°C.

c) A second coat of B-10 adhesive is applied and allowed to dry for 30 min at the same temperature.

At the termination of the additional sealing treatment, the cabin is again checked for airtightness.

The hermetic seal of the cabin is considered as having passed the tests and can

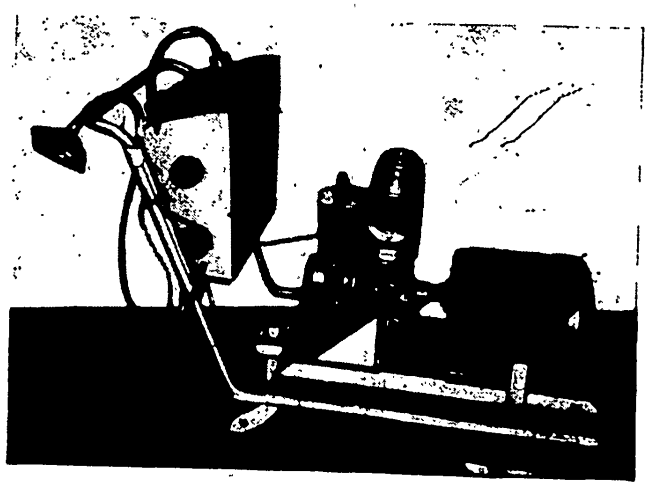

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Fig.272 - Portable Device for Testing Airtightness of Seams by the Vacuum Method

be worked further, provided the leakage of air does not exceed the tolerances specified by the technical conditions.

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On completion of testing the cabin for airtightness, all plugs inserted during the test are removed; the seams are wiped with clean rags moistened with gasoline to remove all traces of packing material and of soap water.

As stated above, the vacuum method is used for the preliminary inspection of

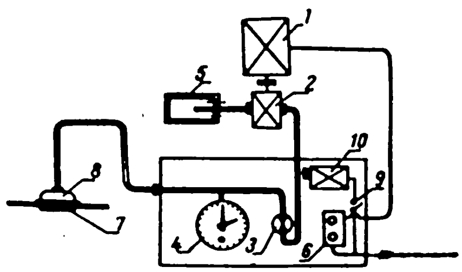

Fig.273 - Schematic Sketch of Operation of a Portable Device for Testing the Airtightness of Seams by the Vacuum Method

1 - Motor; 2 - Vacuum pump; 3 - Shut-off valve; 4 - Altimeter; 5 - Air separator; 6 - Pushbutton switch; 7 - Portion of seam under test; 8 - Suction cup; 9 - Switch; 10 - Vibration motor

portions of the riveted or bolted seams during the assembly process of the unit. The portable device shown in Fig.272 is used for airtightness tests by the vacuum method, and an outline of the arrangement of its component parts is shown in Fig.273. The vacuum device is provided with suction cups by means of which the test foSTAT-tightness is performed at any location of the seam.

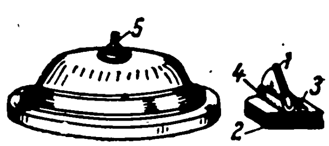

Fig.274 - Construction of a Vacuum Cup

1 - Wall of cup; 2 - Flexible rubber; 3 - Strip of packing type rubber; 4 - Strip of percale; 5 - Nipple

The vacuum cups are made of plexiglass of a thickness of 3 - 4 mm. Their shape and dimensions depend on the characteristics of the seam and on the accessibility to the place being tested. Readily access-

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ible seams are tested with suction cups having a length of 200 - 300 mm, as shown Fig.274.

Figure 275 illustrates vacuum cups for use in the inspection of seams at various parts of the cabin. The cups are stamped out of plexiglass, and are filed smooth and polished along the edges. To the edges of the cup (1) (see Fig.274) strips (4) of percale or linen rubberized on one side are glued. The flexible rubber strip (2), of a thickness of 8 - 10 mm, is cemented to the cloth with rubber cement. The rubber

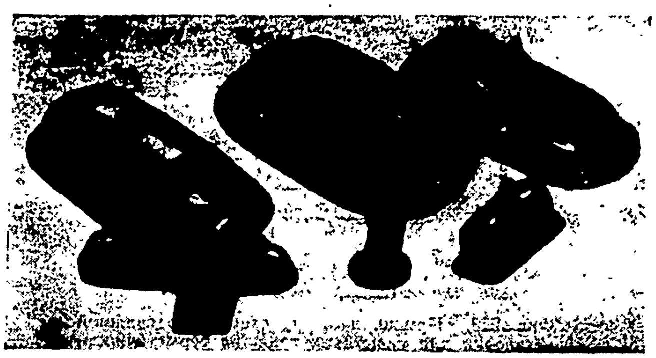

Fig.275 - Vacuum Cups Used for Inspection of Seams at Various Parts of the Cabin

strip (2) is cut to the dimension of the roughly finished cup, with a small allowance. For reinforcement of the flexible rubber, a strip (3) of rubber sealing compound of a thickness of 0.8 - 1.0 mm is cemented on. The nipple (5) is fitted into the predrilled hole for connecting the cup to the hoses.

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The evacuation under the cups is determined by a mercury manometer of an aircraft-type altimeter. When using an altimeter, the degree of vacuum is calculated in accordance with the graph shown in Fig.276.

In testing for vacuum, the degree of rarefaction must correspond to the working pressure as established by the technical specification for the job, multiplied by a factor of safety equivalent to 1.5.

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The riveted seam is inspected for airtightness by the following procedure.

The seams are first wiped with gasoline, after which the portion of the seam being inspected is coated with soap water, using neutral soap, applied with an ordinary brush. The vacuum cups are connected to the vacuum testing device through rubber canvas hoses and are placed on the portion of the seam that is being inspected. When the vacuum testing device is put in operation, exhaustion of air in the cups takes place, which is recorded by an instrument. On reaching the required degree of vacuum, the valve of the testing device is closed, and the condition of the soap-water film is inspected. If the seam is not airtight, the places where leakage of air takes place will show by the formation of soap bubbles. The detected leakage spots are marked with an ordinary pencil after the suction cups are removed. The disclosed defects are eliminated after completion of testing the entire component.

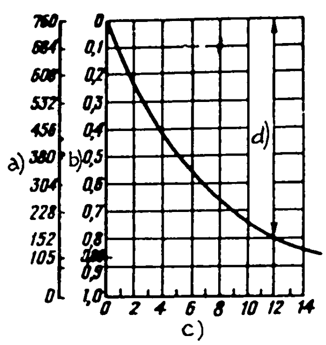

Fig.276 - Graph for Calculating the Degree of Exhaustion when Using an Aircraft-Type Altimeter

a) Absolute pressure in mm Hg; b) Pressure drop, in atm; c) Altitude, in km; d) Degree of exhaustion

The means for eliminating the defects are different in each case. The principal means consist in tightening or in replacing the rivets, filling up with sealing compound cement from the inner side of the seam, etc. After the defects are eliminated, the joint is subjected to a repeated test in the manner as outlined ab[ove].

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After the testing of the seams is completed, they are wiped dry with rags slightly moistened with gasoline for removal of any soap water remaining on the seams.

5. Performance of the Seam under the Effect of Loading

Leakage of air through airtight seams depends on the positive pressure; by in-

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creasing the positive pressure, the time during which leakage takes place through the seam, at a given value of positive pressure, is decreased (Fig.277).

It was established by investigations that there is a loss of airtightness during the riveting process of a seam. The extent of such loss depends on the type of

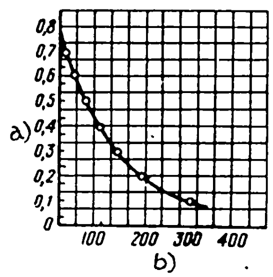

Fig.277 - Effect of Positive Pressure on Leakage of Air

a) Positive pressure Δ_p, in kg/cm^2; b) Leakage time, in sec

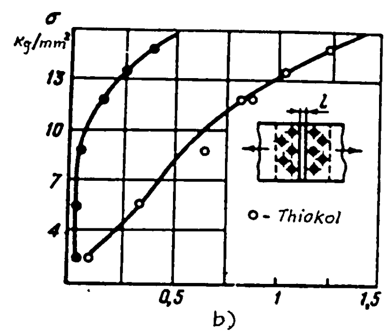

Fig.278 - Deformation of Joints as Related to Type of Packing

a) Thiokol; b) Separation of the joint in mm

packing, on the manner and on the magnitude of the applied static, vibrational, or cyclic static loads.

Airtight seams deform on application of loads, resulting in an increase of the clearance in places where there are butt joints of the sheets, which leads to an increase of air leakage through the joints. Greater deformation, as evidenced by the separation of the sheets, in airtight seams when subjected to loading, is STATved when the packing is of the thiokol type. Seams with cement-type packing (upper curve) show less deformation, due to the cementing properties of the packing layer (Fig.278).

Deformation of the hermetic seal is distributed unevenly over the cross section of the seam. In the center of slipping (cross section 0-0, Fig.279a), the amount of slip Δ_z is approximately one-half of the slip Δ_l at the edges of the sheets (cross

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section x-x, Fig.279b). At a thickness of 0.3 mm of the hermetic seal, the greatest absolute value of the slip in the areas of elastic deformation in the cross section 0-0 and in the cross section a-a (Fig.280), is as high as 0.04 mm, while the slip in the cross section x-x is equivalent to 0.8 mm.

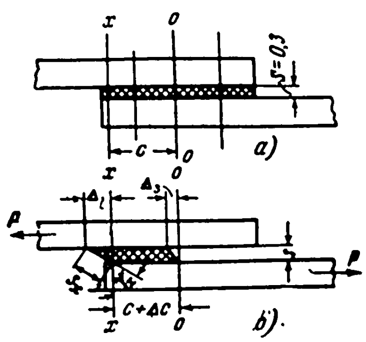

Fig.279 - Deformation of Packing in a Riveted Joint

a - Seam in its original free condition; b - Seam under loaded condition

A corresponding slip of the material of the hermetic seal in the cross section x-x (see Fig.279b), is expressed by the angle γ_x, which is determined in the following manner:

$$\tan \gamma_x = \frac{\Delta l}{S} = \frac{0.08}{0.03} = 0.2666;$$

$$\gamma_x = 14^\circ 55'.$$

The corresponding elongation of the fibers of the packing in the cross section x-x is equivalent to

$$\varepsilon = \frac{S_x - S}{S} = \frac{\Delta S}{S}; \quad \frac{\Delta p}{S_x} = \sin \gamma_x;$$

$$\varepsilon = \frac{0.307 - 0.3}{0.3} = 0.025.$$

or $\varepsilon \approx 2.5\%$.

In the center of the slip there will be considerably less elongation of the fibers.

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6. Effect of Some Technical Factors on the Airtightness of Joints

One of the technical factors which produces a considerable effect on the airtightness of a joint is the manner in which the riveting work was done. As stated above, in riveting structures of light alloys, use is made of press riveting as well

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as of impact riveting by the direct and by the reverse method.

A uniformly steady procedure in press riveting results in uniformly good airtight seams. Impact riveting by the direct method, especially without tightening,

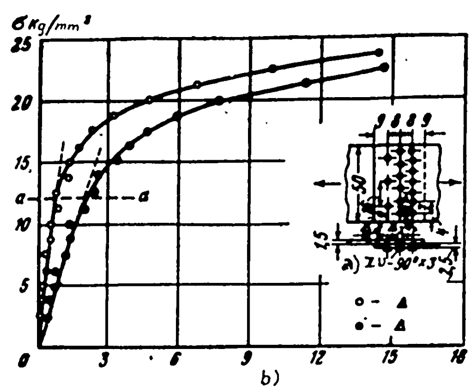

Fig.280 - Relation Between the Slips of Rivets and of Sheets in Joints and the Magnitude of the Applied Stress

a) Rivet ZU-90° × 3; b) Slip Δ in % of d_z

gives seams that are of lower quality and of nonuniform hermetic sealing (Fig.281).

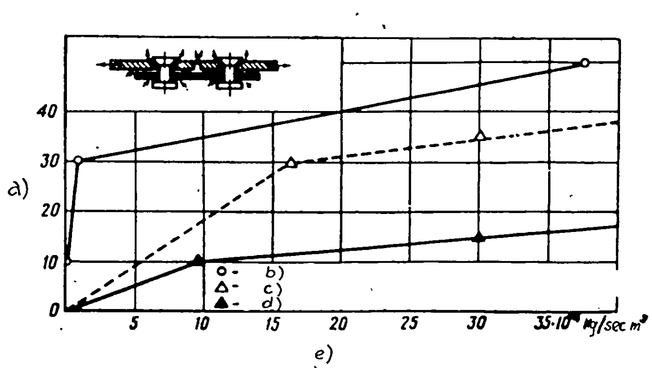

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Fig.281 - Effect of the Riveting Means and Methods on the Airtightness of Seams

a) Load in % of P_{ult}; b) Single riveting on presses; c) Pneumatic hammer riveting by the reverse method with direct tightening; d) Pneumatic hammer riveting by the direct method (without tightening); e) Air leakage G/V

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The airtightness of a riveted joint depends to a considerable degree also on the force of squeezing the sheets together, since the condition of the packing between the sheets is affected thereby. When the applied squeezing pressure on the sheets is excessively high while riveting, the packing is squeezed out from the seam, which

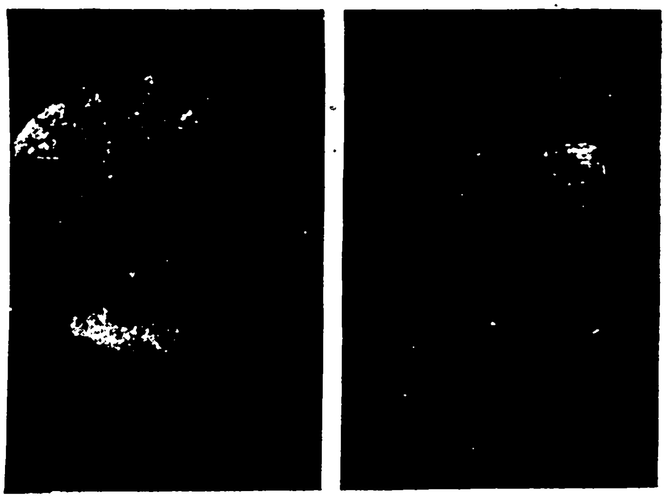

Fig.282 - Appearance of Filled Holes as Related to the Thickness of the Packing Applied between the Contacting Surfaces

a - Thickness of packing 0.5 mm; b - Thickness of packing 1.0 mm

destroys its texture and affects its sealing properties. A much better seam, as regards airtightness and smoothness of the outer surface, is obtained by squeezing the sheets together at a unit pressure of 20 kg/cm^2.

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The depth of countersinking also is a principal factor affecting the quality of airtightness of a joint. If the recesses are overcountersunk, the sealing of the seam is impaired, resulting in the development of clearances between the conical surfaces of the original rivet heads and the recesses. Protrusion of the heads of flush rivets above the surface of the sheet lining by 0.05 - 0.15 mm contributes to tightening of the pack during riveting, which, in turn, improves the hermetic seal

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of the seam.

The thickness of the packing also affects the airtightness of the seam. At a thickness of the packing up to 0.5 mm, the filled hole in an airtight joint has the same appearance as in a joint that is not airtight. When the thickness of the packing is increased, the nature of the filling of the hole is greatly changed. Figure 282 shows cross sectional views of joints with packings applied in one and in two layers. The photo micrographs (Fig.282b) show that, in the case of the thicker packing, the rivet between the sheets was deformed, resulting in the formation of clearances between the sheets and impairing the hermetic seal of the riveted seam. For this reason, the application of packings of a thickness greater than 0.5 mm is not recommended.

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PART IV

ORGANIZATION OF RIVETING PROCESS, INSPECTION AND MEANS OF INCREASING PLANT OPERATING EFFICIENCY

CHAPTER XIII

CONTINUOUS ASSEMBLY IN THE COMPONENT ASSEMBLY SECTIONS, ORGANIZATION OF WORK, AND ARRANGEMENT OF WORK STATIONS

1. General Considerations

The organization of assembly work by riveting consists of the following steps:

1. The work stations are arranged in an orderly sequence for carrying out the technical processes.

2. A definite task is assigned to each worker or group of workers, consisting of one or several similar operations.

3. The execution of each task at all working places is accomplished during a definite time interval that is equal to or a multiple of the time assigned for fabrication of the workpiece.

4. All production operations are on a continuous basis, i.e., the transfer of the part on which work is done from one operation to another is uniformly timed, without forced interruptions.

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The adoption of the continuous production system results in an increase in output of each worker and consequently in an increased production output of the plant, in a reduction of the number of workers per unit output, in a lowering of manufacturing costs, and in an improvement in quality.

Work by the continuous method is carried out as follows:

a) On an assembly line with the workpiece in motion.

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b) On an assembly line with the workpiece stationary.

Work on the assembly line, with the workpiece in motion is characterized by the fact that the workers remain at their usual work stations while the workpiece is moved consecutively from one location, where work on it is performed, to another, in an orderly manner for the performance of the technical process of assembly and riveting. This form of assembly-line work is adopted primarily where the assembly of components and units is done without the aid of jigs.

Work on the assembly line with the workpiece stationary is characterized by the fact that throughout the entire cycle of the assembly process the workpiece remains at one place, while the workers move from one place to another to perform the assigned work to be done during a definite time interval, in accordance with the time assigned for the completion of the entire job. This form of assembly-line work is usually adopted when the assembly is done in jigs or with the aid of special assembly equipment. However, there are also examples of assembly-line work on units with the jigs in motion.

In developing an assembly-line technical process for riveting assembly jobs, the process must be divided by the number of operations involved, depending on the structure of the workpiece and the time assigned for its completion. It is recommended that the division of the technical process be such that the length of time of the operation will approach as far as possible, the time assigned for its completion in accordance with the production program laid out for the plant. In that case it is easier to allocate the work to the various groups of workers at the several STAT where the assigned assembly work is done. Too much time for the execution of an operation cannot be allowed as in that case the combination of the various operations of the assigned task is particularly difficult.

The following principal requirements are presented in the construction of aircraft units by assembly-line methods:

1) Feasibility of subdividing a major unit into components and panels, which

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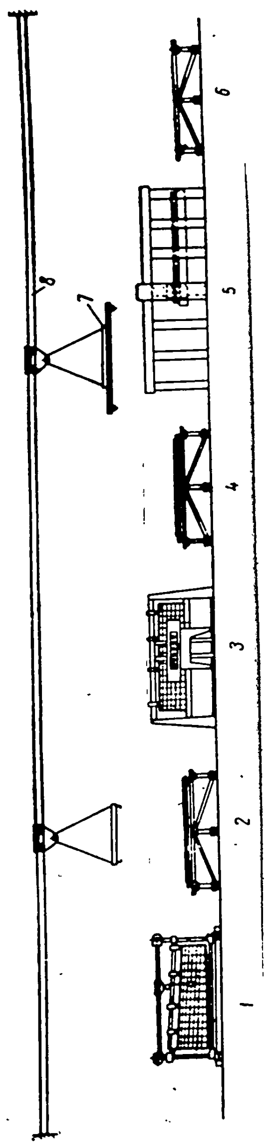

Fig.283 - Assembly of a Wing Panel by the Continuous Production Method

1 - Fixture for assembling and riveting; 2 - Stand for placing the panel on a carriage; 3 - Drilling and countersinking press; 4 - Stand for intermediate inspection; 5 - Press for group riveting; 7 - Carriage; 8 - Monorail

constitute fully finished elements of the manufactured product.

2) Interchangeability of components and panels, thus eliminating work to make the parts fit during their assembly.

3) Simplification of assembly, to familiarize the workers more quickly with their work.

Figures 1 and 2 showed a wing, a fuselage, and a tail group disassembled into individual components, panels, and sections. The feasibility of subdividing a major unit into components and panels contributes to the adoption of highly mechanized equipment for drilling and riveting, thus reducing the labor involved, increasing the output, improving the quality, and lowering the manufacturing costs.

2. Riveting Operations by Organizing Production on an Assembly Line

As an example, we will analyze the assembly of a wing panel by the STATbly-line method. Figure 283 shows a schematic sketch of the principle of continuous processes in the assembly and riveting of a wing, as one of the possible variations of riveting assembly work utilizing highly mechanized production equipment.

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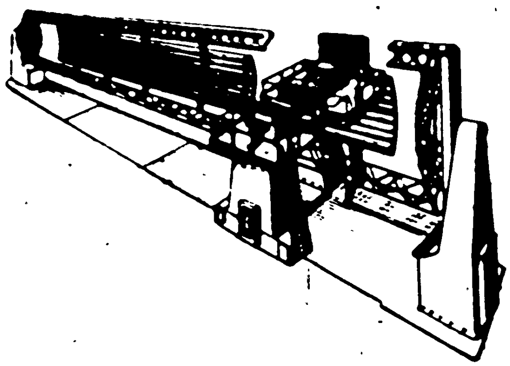
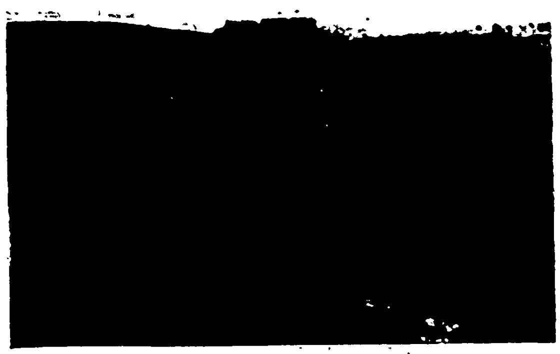


Sketch 1



Sketch 2

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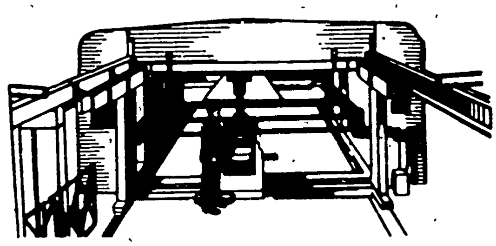

Sketch 3

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Table 68

Schematic Outline of the Continuous Technical Process of Assembling and Drilling a Wing Panel

Number in sequence	Type of operation	Sketch - see preceding page	Equipment, tools, and devices
1	Assembling according to the assembly holes of the air-frame and skin parts, drilling holes for control rivets, and riveting	-	Assembler's bench or assembly fixture, hand drill, portable press or pneumatic hammer
2	Drilling and countersinking holes over the entire panel	Sketch 1	Drilling and countersinking press for group drilling and countersinking
3	Inspection of work at every step	-	Indicating device with a calibrated rivet, limit gage for control holes
4	Removal of shavings from the surface of the panel and inserting rivets along the entire length of the seam	Sketch 2	Hair brushes
5	Riveting the rivets along the length of the seam over the entire panel	Sketch 3	Press for group riveting
6	Inspection of the quality of riveting	-	Indicating device; template for inspection of clenched heads

The parts are kept in the warehouse where they are classified in grou STAT ord-ing to the assigned tasks, and are delivered to the assembly fixture (1) where the parts are assembled, holes are drilled for control rivets, and these are riveted. The panel thus assembled goes to the stand (2), where it is placed on a carriage laid out to correspond with the configurations and dimensions of the panel. Then the carriage with the panel is moved over to the drilling and countersinking press (3) and is placed on its table. In this press, the group drilling of the holes and the countersinking of the recesses for the rivets are performed. The use of aligning

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devices assures that the surface of the parts is perpendicular to the axes of the rivet holes and that the axes of the recesses coincides with the axes of the holes. The press automatically feeds the spindles into the holes while drilling and countersinking, withdraws the tool from the holes and shifts the panel for the successive group operation. The drilled panel then goes to the stand (4) for intermediate inspection, where the quality of drilling and countersinking is inspected. Here the surface is cleaned of shavings and, if previously specified in the technical process, a rust-preventive coating is applied to the surfaces of the holes and the recesses, and the rivets are inserted over the entire panel. Then the panel, with the rivets installed, is conveyed to the group riveting press (5) by the carriage, where it is installed on the frame of the conveying and aligning equipment. Here the panel is riveted. On the stand (6) the panel is removed from the carriage, inspection is

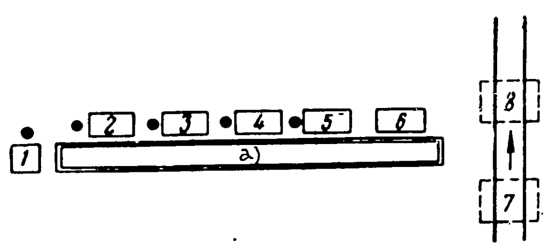

Fig.284 - Schematic Outline of Assembly-Line Production of a Wing Rib

1 - Table for arranging the parts; 2 - Equipment for assembly and drilling; 3 - Work station for riveting; 4 - Work station for inspecting the quality of assembly and riveting work; 5 - Work station for putting on finishSTAT touches; 6 - Rack for the finished ribs

a) Belt conveyer

made of the quality of riveting, and, when necessary, supplementary finishing work is done, after which the finished panel is placed on a rack. The entire cycle of the technical process of assembly and riveting of the panel is outlined in Table 68.

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The use of powerful group riveting presses during the assembly of relatively small components is not always convenient. In such cases use is made of drill presses and riveting presses for single riveting, or of low-power presses for group riveting, for the simultaneous riveting of a small group of rivets. As an example, we will analyze the schematic sketch of the assembly of a wing rib (Fig.284) by the assembly-line method, together with the operation of the equipment used in this continuous production line.

Working Stations along the Conveyer. For carrying out the operations of the technical process, the workers remove the parts from the conveyer, assemble them, and then return them to the conveyer for further assembly and riveting. In the given case, the streamlining is intermittent with deliberate interruptions of the motion,

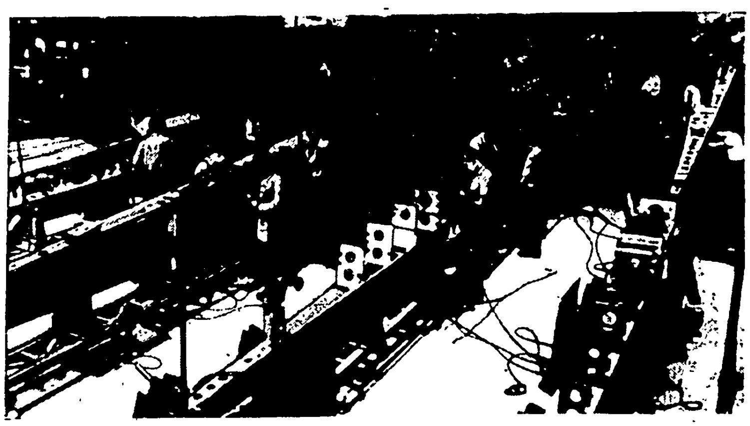

Fig.285 - Assembly Department for Wing Sections

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whereby the wing rib remains stationary at the place where the work is being done during the necessary time of assembly, until all work is finished at that particular place of work, after which it is conveyed to the next place for further assembly.

The work station (1) consists of an ordinary table for arranging the parts obtained from the stockroom of the stamping section. The arranger inspects the surface finish of the parts, for defects in the form of scratches, dents, nicks; checks the

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inspection marks that indicate the acceptability of the parts, and places the components forming part of the rib on the conveyer which conveys them to the work station (2) where the assembling and drilling is performed.

The worker, charged with operation of the stand (2), performs the assembly operation, i.e., he installs the parts in the jig or assembles them according to the assembly guide holes, he drills holes for the rivets and fixes all holding clamps in accordance with the instructions on his technological cards.

The work station (3) for riveting is equipped with a press and all necessary tools, such as dies and props. The press operator removes the clamps, inserts the rivets, and performs the riveting operation. Then the wing rib is conveyed to the work station (4), where the inspection of the quality of the assembly and riveting is done, together with an inspection of the exterior contour of the rib, after which the rib goes to work station (5) for final touch-up work. Here the drilling of holes and riveting is done in places of difficult access; if necessary, defective rivets are replaced, the alignment of the rib after riveting is corrected, etc. In the finishing and correcting work, use is made of hand drills, pneumatic hammers, and hand presses with their various accessory tools. The finished rib goes to the rack (6), which is the final point of assembly of the rib by the assembly-line method. At right angles to the rib assembly line is the wing assembly line, where the finished ribs go for further processing.

The same principle of streamlined assembly work is applied to other components, such as bulkheads, longerons, etc.

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Figure 285 shows the department where the work of assembly-line production of wing sections is done. The assembled sections are delivered to the jigs where they are assembled into units. The assembled wings are removed from the jigs and placed in corresponding pairs on carriages (Fig.286); after they are conveyed further, final work is done on them without the aid of fixtures.

In some cases the length of time for performing particular operations does not

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agree with the time allocated for the job according to the calculated work program, and in such cases parallel work stations are added to the program (Fig.287).

Inspection is a mandatory requirement in the technical process of assembly and riveting work that cannot be eliminated, since it determines the quality of the work done, especially in connection with assembly-line work. When a program of assembly-line work is laid out, it is necessary to take into consideration the time, the place, and the means used for inspection, to prevent interruptions in the continuity of the work along the entire assembly line. For this reason, an analysis of the inspection steps in assembly-line work is of great importance.

The principal problems connected with the technical inspection of riveted assembly work are the following:

1) Precautionary measures to prevent the possibility of rejects.

2) Quality checks of assembly and riveting of components and major units for compliance with the design drawings and the technical specifications.

The inspector in charge of a group of workers on specific assignments, must be qualified to perform the following duties:

1) To become thoroughly familiar with the design drawings of the components and units which are being assembled in his department, with the technical process of assembly, and also with the technical specifications of a given job, as well as with the control and instruction charts.

2) To supervise the progress of assigned assembly work and to notify the foremen whenever an inaccuracy occurs in the technical process of assembly. When defects in the work are observed, he must make sure that they are corrected.

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The inspector must ascertain the reasons for any defects in the work and must take precautionary measures to prevent their occurrence.

3. Order of Equipping Assembly-Line Work Stations and Organization of Their Arrangement

The equipment and servicing of the work stations on an assembly line, together

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with the arrangement of the stations, has a considerable effect on the increase of the output of labor. The servicing of continuous production lines includes the following: supplying the work stations with tools, auxiliary equipment, parts, components, and materials; repair of assembly equipment, drilling and riveting presses; repair of drilling and riveting tools and other equipment.

The tool room is charged with the issuing of tools. Depending on the type of

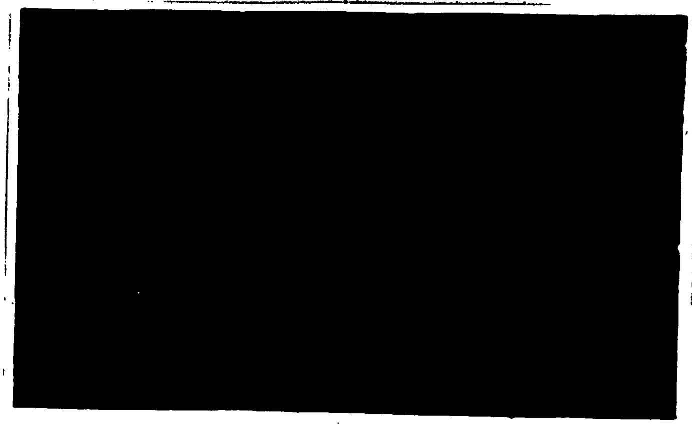

Fig.286 - Assembly of Wings on Movable Carriages

work to be done, the tools are placed in tool boxes which are charged out to the workers assigned to specific jobs and responsible for the tools.

Each tool box carries the following markings: the number of the assigned job, for which the tools in the box are to be used, the inventory number of the box, and the record number of the worker. The tool box must be of compact size and suitable for moving it from place to place while working. There should be a separate place in the box for each tool. An example of a good design of a riveter's tool-box is shown in Fig.288. The box is shown open and ready for work. When the tool box is

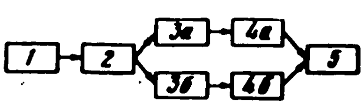

Fig.287 - Parallel Work Stations in Assembly-Line Work

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closed it can be carried from one place to another like a satchel. When the covers are closed, all trays in which the tools are kept are in a horizontal position.

The tool boxes are given out, before the shift is changed, to the worker or the supply assistant, who delivers them to the work stations before work is started. To

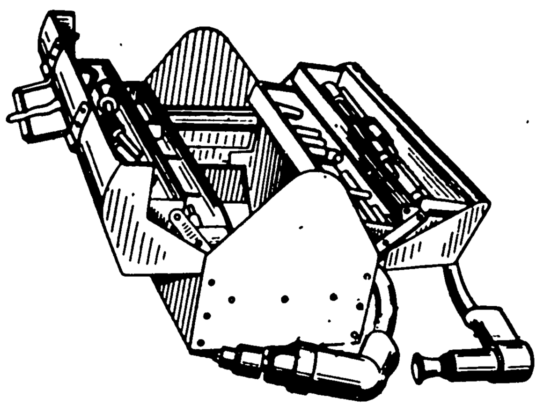

Fig.288 - Riveter's Tool Box

prevent interruption of work due to breakage of any of the accessory tools, such as drills, dies, etc., any tool subject to frequent breakage is supplied in duplicate in the tool box.

Parts, components and materials specified in the design drawings are arranged in sets for each assigned job. The sets of parts, standard sections, and components are stored on racks and are charged out to the particular crew of workers assigned to the job. Identification tags are attached to the boxes or to the parts of the rack on which it is indicated for what job the parts, components, material, etc. are held.

In assembly-line production, the upkeep of the fixtures and equipment of the production line during the entire time of work is of great importance. This is accomplished as follows:

a) Daily servicing and inspection of the jigs and equipment during their use.

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b) Timely repair of the jigs and equipment, with particular attention to adherance to charts listing all preventive repairs.

Timely repairs, according to the planned preventive maintenance schedule, markedly increase the useful life of the jigs and equipment, and eliminates idle time and interruption of continuous production due to breakage in service.

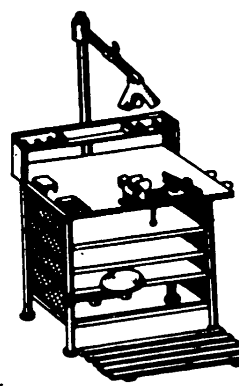

Fig.289 - Work Bench for Assembly and Riveting of Small Components

The rate of labor production depends largely on the orderliness with which the work station has been arranged, degree of its suitability for the work to be laid out, convenience of access to the component or unit being assembled, etc. A poorly organized work station results in superfluous motion, fatigue of the workers, and consequently in lowered production.

Depending on the structure and the size of the components or major units being assembled, the work may be carried out directly in assembly jigs or on workbenches.

For the assembly, drilling, and riveting of large units in fixtures, the work station is provided with removable platforms and ladders, which permit working on the higher portions of the structures(see Fig.228). All necessary tools, such as hand drills, pneumatic hammers, dies, props, and rivets, are arranged handily in convenient places. When riveting with portable presses, as described above, the assembly jigs are provided with balancing devices, so that the press can be moved over the entire area of the unit being assembled (See Fig.189).

In cases where the work is done without auxiliary fixtures, the work station consists of a bench on which all necessary tools and equipment are suitably arranged. Figure 289 shows a workbench for the assembly and riveting of small components. The

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lower part of the bench has partitions on which separate parts of the components are kept. All tools necessary for doing the work are arranged on the top of the bench in a convenient location.

The arrangement of the work station in connection with stationary presses for single and group riveting, as well as with pneumatic hammers, was described in the appropriate parts of this book.

The problem facing the technical personnel in sections of the plant where large units are assembled, is to educate and instruct systematically the leading workers on the application of progressive methods of work and to inculcate these principles in the minds of the other workers in order to reduce these principles to practice. Whenever new equipment and tools of a more highly mechanized type becomes available, the technicians should re-arrange the work stations so as to make full use of the possibilities of the new equipment.

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CHAPTER XIV

SPECIAL TYPES OF RIVETS

1. Riveting from One Side

While carrying out riveting work in structures, there will be spots where access to the rivet heads is difficult or impossible. Rivets of special design are used in such places for heading the rivets without the aid of props.

Of the available various types of rivets for unilateral riveting, the types in widest use are rivets with a mandrel, rivets of specification TsIT (threaded shell type), and explosive rivets.

A rivet with a mandrel consists of two parts: a shell and a core. The shell part is in the shape of a stem with a hole in the center. Inside the shell is the core, which is in the shape of a stepped stem, ending in a gripping and a locking head. At the side of the locking head, the stem is thicker, while toward the gripping head the stem is necked so that the core breaks off here at the instant the riveting is finished. The shell part is manufactured with half-round and with flush heads, and their use depends on the particular location in the structure. Rivets with flush heads are used for riveting parts exposed to the air stream. Such rivets have a head with a taper angle of 120° for providing a larger thrust surface for the riveting tool.

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Rivets with mandrels are manufactured from light aluminum alloys: the shell part, of alloy D18P and the core, of alloy grade D16P. Such rivets are standardized

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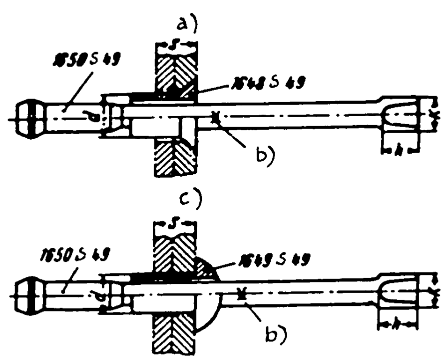
and have a code designation pertaining to the type of rivet, its diameter, and the thickness of the parts that may be riveted with them (Table 69).

For riveting rivets with a core, use is made of a manually operated pneumatic

Table 69

Data for the Selection of Rivets According to Their Length and Diameter Depending on the Thickness of the Stack being Riveted (According to Standards 1646S49 and 1647S49)



d)	e)	f)	g)	f)	h)	i)	j)	k)
1	1648S49-0	1,5—3	1649S49-1	to 3	1650S49-1	3,5	2,5	2,8
2	1648S49-1	3—5	1649S49-2	3—5				
3	1648S49-2	5—6,5	1649S49-3	5—6,5				
4	1648S49-3	3—5	1649S49-4	3—5	1650S49-2	5	3,5	4
5	1648S49-4	5—6,5	1649S49-5	5—6,5				
6	1648S49-5	6,5—9,5	1649S49-6	6,5—9,5				

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a) Rivet with a flush head; b) Necking; c) Rivet with a half-round head; d) Rivet number; e) Shell with flush head; f) Thickness of stack S, in mm; g) Shell with half-round head; h) Core; i) Shell diameter, in mm; j) h ≈ in mm; k) K (tolerance) B_7, in mm

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lever-type press of the type KP-111 (Fig.290), or of lever pliers in special cases. Lever pliers are also used for repairs under field conditions when compressed air is not available where the repair work is performed. The use of the manually operated lever-type pneumatic press KP-111 greatly increases the productivity of labor, improves the quality of riveting and lightens the work of the riveter.

Characteristics of Press KP-111

1. Greatest diameter of the rivet with mandrel	5	mm
2. Maximum force on the press plunger at an air pressure of 5 atm	800	kg
3. Air consumption for one work cycle	0.0014	m^3
4. Number of working strokes per minute	10	
5. Travel of plunger	20	mm
6. Overall dimensions		
Length	340	mm
Width	68	mm
Height	180	mm
7. Weight	2.7	kg

The press (Fig.291) consists of two main components: the power unit with a cylinder and starting devices, and the head which is the working element. The power component consists of a unit that may be used in combination with different heads.

The cast aluminum cylinder (1) is connected to the cast body (2) by screws. The body and the handle are in one piece. The starting device is contained in the handle, and consists of a distributing bushing (3), a valve (4) sliding in the distributing bushing by means of the trigger (5) on the shaft pin (6), and the adapter bushing (7) with a screen (8). The bushing (7) presses the cap (9) against the distributing bushing (3). The cylinder is located in the upper part of the body and is closed by the cover (10). The piston (11) with the glands (12) moves inside the

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cylinder. The piston is connected to the shaft (14) with the nut (13) and is guided by the bushing (15).

The working chamber of the cylinder, in combination with the spindle (14) and the bushing (15) is filled by the gland (16), held in place by the ring (17) and the nut (18) in the left part of the cylinder body.

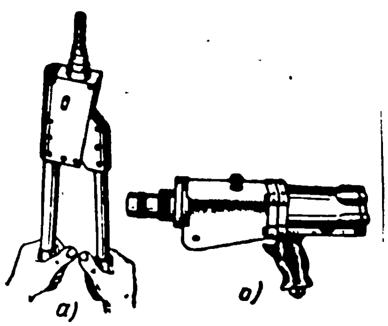

Fig.290 - Tools for Riveting Rivets with Mandrels

a - Lever pliers; b - Hand-operated lever-type pneumatic press, type KP-111

The yoke (19) carries the rollers (20) which move along the plate (21), fastened to the body (2) with the screws (22), and also along the lever (23) on the shaft (24). The lever (23), rotating about its axis, pulls through the lug (25) the plunger (26), in which the shaft (27) carries the projecting lugs (28), under compression of the springs (29).

The plunger with the lugs moves in the ring band (30) fastened by the nut (31) to the flange (32); the other threaded end of the ring band is fitted with the interchangeable end piece (33).

Compressed air from the main lines is supplied through the hose and the adapter bushing (7) into the air-distribution mechanism. At that time, the valve (4) is forced against the trigger (5), and air is admitted to the rear chamber of the cylinder along the channels in the valve and through its ports as well as through the slots in the distributing bushing. When pressure is applied to the trigger, the air that enters the inner space of the rear chamber, is discharged through the groove in the valve (4) to the duct connected to the atmosphere.

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After the valve (4) is shifted, the air from the main lines is admitted to the front chamber of the cylinder (1), causing the piston (11) with the spindle (14) and

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the yoke (19) that carries the rollers (20), to move to the right side. To the extent that the rollers are shifted, the lever (23), rotating about its axis, entrains the plunger (26), on which the protruding lugs (28) are located. As the lugs (28)

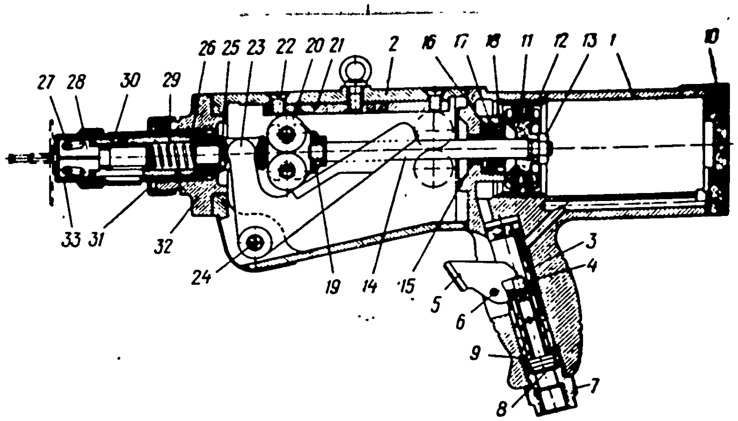

Fig.291 - Design of Hand-Operated Lever-Type Pneumatic Press KP-111

1 - Cylinder; 2 - Body; 3 - Distributing bushing; 4 - Valve; 5 - Trigger; 6,24,27 - Shafts; 7,15 - Bushings; 8 - Screen; 9,10 - Covers; 11 - Piston; 12,16 - Glands; 13,18,31 - Nuts; 14 - Spindle; 17 - Ring; 19 - Yoke; 20 - Rollers; 21 - Plate; 22 - Screws; 23 - Lever; 25 - Lug; 26 - Plunger; 28 - Projecting lugs; 29 - Spring; 30 - Ring band; 32 - Flange; 33 - End piece

are in motion, they pull the shank of the rivet through the rivet piston, thus performing the riveting operation.

When the riveting is completed, the trigger is released and the plunger returns to its initial position. The compressed air in the front chamber of the cylinder becomes connected to the atmosphere, while the rear chamber becomes filled with compressed air which acts on the piston and returns it, together with the entire mechanical system, to the initial position.

Schematically, the technical process of riveting rivets with mandrels (Fig.292) consists of the following operations:

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1. According to the guide holes in one of the parts, holes are drilled in the second part. In this case, the diameter of the hole for the rivet must be 0.1 mm larger than the diameter of the rivet.

2. Recesses are countersunk for the flush rivets.

3. The gripping head of the mandrel is fitted in the lugs of the press and the rivet is inserted in the hole of the stack.

4. Pressure is applied on the trigger, causing the mandrel to be pulled through the rivet shell, whereby the thicker portion of the mandrel deforms the shell and forces it against the walls of the hole. On further pulling, the locking head of the mandrel enters the shell and expands it. At this moment the mandrel breaks off at the notch. The breaking of the mandrel usually takes place at the following loads:

For rivets Nos.1,2,3....165 kg $\pm$ 25 kg

For rivets Nos.4,5,6....375 kg $\pm$ 25 kg

The remainder of the mandrel is nipped off with cutting pliers (Fig.293), and is smoothed with a file.

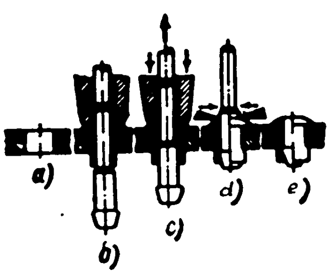

Fig.292 - Outline of the Technical Riveting Process of Rivets with Mandrels

a - Formation of the hole; b - Insertion of the rivets into the holes of the stack; c - Pulling the mandrel through the piston; d - Removal of the remainder of the shank; e - Finished rivet

When there is considerable vibration of the assembled unit while it is in use, the mandrel might drop out. To prevent this, the shank is "rolled out" while it is cleaned so that it will be locked in place.

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A well riveted job, using rivets with mandrels is characterized by the fact that the shell closely fits the walls of the hole, and that the locking head of the rivets is tight against the surface of the riveted stack. Defective riveting may be

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due to the following causes:

a) Incorrect adherence to the required dimensions of the rivet holes: If the rivet hole in the stack is too large, it will not be completely filled by the rivet, with the result that the entire seam will be loose, which in turn, leads to weakening of the joint. Conversely, if the hole is too small, it is impossible to perform the riveting operation.

b) Incorrect length of the rivet for a given thickness of the stack being riveted: If the stack is too thick, the wedging action will not be sufficient for riveting, and if it is too thin the clenched head will not be formed to the proper shape.

The correct position of the tool during the process of riveting has a considerable influence on the quality of the clenched rivet head during its formation. The tools used in the riveting must be held in a strictly perpendicular position with respect to the surfaces of the parts being riveted.

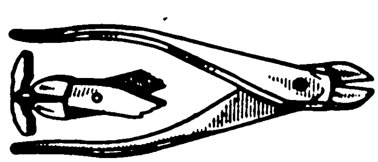

Fig.293 - Cutting Off the Protruding Portion of the Mandrel with Cutting Pliers

Threaded shell-type rivets (rivets TsIT) consist essentially of a small bushing with an original rivet head. The bushing is threaded internally approximately over one half of its length. The remaining portion toward the original head is drilled out to a larger diame STAT so that the wall thickness of this portion is less than the wall thickness of the threaded portion of the rivet. Rivets of this type are manufactured with flush and with flat heads.

A second integral part of the rivet is a screw, used for increasing the resistance of the rivet in shearing. The screw may also be used for attaching any other part. The material used in the manufacture of the shell part of the rivet is wire

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of grade D18P and in the manufacture of the screws, wire of grade D16P.

Riveting of threaded shell-type rivets may be done by means of pneumatic tools or hand pliers. The use of hand pliers does not ensure the required quality of ri-

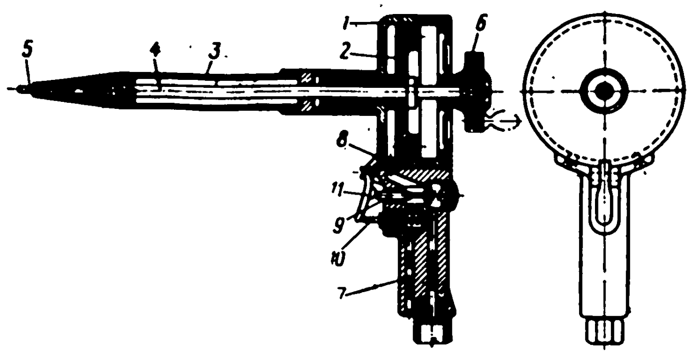

Fig.294 - Pneumatic Tool for Riveting Threaded Shell-Type Rivets (Rivets TsIT)

1 - Cylinder; 2 - Piston; 3 - Adapter; 4 - Coupling rod; 5 - Tip; 6 - Knob; 7 - Handle; 8 - Bushing; 9 - Starter; 10 - Valve; 11 - Trigger

veting work nor a high rate of production, since the labor involved requires the expenditure of much force during the heading of the rivet, which results in excessive

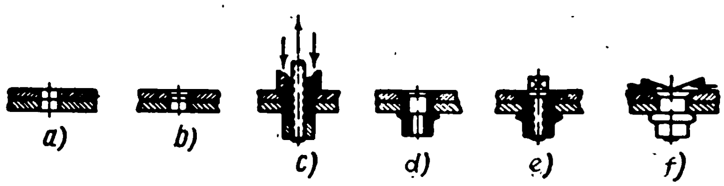

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Fig.295 - Outline of Riveting Threaded Shell-Type Rivets

a - Drilling holes; b - Countersinking recesses; c - Screwing the tip of the tool into the rivet at the beginning of the heading process; d - Rivet is riveted; the tip of the tool is unscrewed from the rivet; e - Screwing the screw into the rivet; f - Cutting off the head of the screw

fatigue of the workers, especially when such tools are used for a long time. In ad-

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dition, hand pliers do not give clenched heads of uniform dimensions, since the force exerted is variable, depending on the experience and the skill of the worker. The adoption of pneumatic tools eliminates the disadvantages mentioned.

A pneumatic tool for riveting threaded shell-type rivets is shown in Fig.294. The tool weighs 1.7 kg and develops a force within the limits of 300 - 360 kg, which is sufficient for the riveting of rivets up to 5 mm in diameter.

The pneumatic tool for riveting threaded shell-type rivets consists of the steel cylinder (1) with the piston (2). To the cylinder is screwed on adapter (3), whose length varies from 100 - 1000 mm, depending on the place where the riveting work is done. One end of the coupling rod carries a screwed-on tip (5) and the other end of the rod the knob (6), by means of which the tip (5) is unscrewed after heading the rivet. The cylinder is connected with the handle (7) by means of screws.

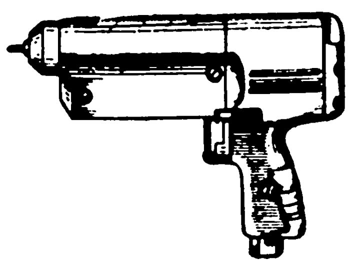

Fig.296 - Press KO-3 for Riveting Threaded Shell-Type Rivets

The chambers of the cylinders communicate with the channels in the handle over the conical bushing (8). Inside the handle are located the starter (9) and the valve (10) for exhausting the air to the atmosphere.

Operation of the tool is carried out in the following manner: The threaded shell-type rivet is screwed on the tip (5) and is inserted into the previously drilled hole. By pressing on the trigger (11) air is admitted to the cylinder. Under the action of compressed air, the piston (2), and together with it the coupling rod (4) and the end piece (5) shift to the right, thus performing the riveting operation on the rivet.

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After heading the rivet, the tip (5) is unscrewed from the rivet by means of the knob (6) (see Fig.294), and by manually pressing on the trigger, the entire op-

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erating mechanism of the tool is returned to its original position. The adoption of this tool at one of the production plants has resulted in a reduction of labor by approximately one and a half as compared with riveting with hand pliers.

A schematic outline of the technical process of riveting threaded shell-type rivets is presented in Fig.295.

A tool giving greater output of production, while riveting threaded shell-type rivets, is the hand press KO-3 shown in Fig.296, equipped with a device for indicating completion of the riveting process.

The principal components of the press are: a pneumatic motor with a reducing gear; a pneumatic cylinder and plunger with lugs and rollers; a signal device containing electric contacts, battery, wire leads, and a light; a control mechanism consisting of a valve, latches, and air conduits. The end piece is interchangeable, depending on the diameter and length of the rivet being used.

The body (1) (Fig.297) of press KO-3 is integral with the handle and consists of a casting with several communicating channels through which compressed air from the main line is admitted to the mechanism of the tool. The casting also contains a space which serves as an oil reservoir (2). From the communicating channels and through the distributing valve (3) and the air conduits, compressed air is admitted to the reversible pneumatic motor (4) and to the pneumatic cylinder (5). The chambers of the motor and the cylinder are closed by the cast cover (6), in which the signal lamp (7) is located. Two rollers (8) are mounted to the connecting rod (9) of the piston of the pneumatic cylinder, and move between a supporting pla STAT d the lever (10). The lever has a definite curvature, calculated for developing the necessary pressure on the plunger of the tool.

Regulation of the travel of the plunger (11) is accomplished by the micrometer bushing (12), located at the front part of the tool. The set screw (13) is used for locking the tool in the required position. The end piece (14) protects the micrometer bushing against damage during occasional change in its adjustment for position.

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The press operates in the following manner: Compressed air from the main line enters the chamber (15) of the handle, from where it flows through the rotary valve along its channels and ports into the motor, which then starts and rotates the tip (16), thus screwing it into the shank of the rivet (Fig.298a). Then the valve is

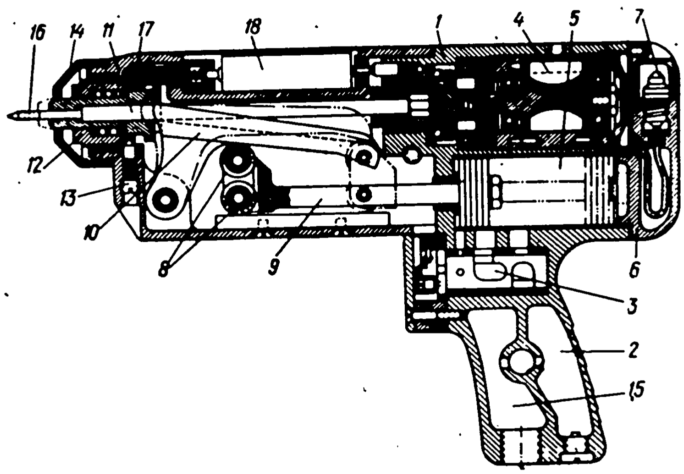

Fig.297 - Design of the Press KO-3 for Riveting Threaded Shell-Type Rivets

1 - Body; 2 - Oil reservoir; 3 - Distributing valve; 4 - Reversible pneumatic motor; 5 - Cylinder; 6 - Cover; 7 - Signal lamp; 8 - Rollers; 9 - Connecting rod; 10 - Lever; 11 - Plunger; 12 - Micrometer bushing; 13 - Set screw; 14,16 - Tip; 15 - Air chamber; 17 - Contacts; 18 - Battery

turned through 90°; admission of air to the motor is stopped and filling STAT working cylinder with air takes place, causing the piston in the cylinder to move to the right; by means of the rollers, this causes a displacement of the lug, which, in turn, presses on the plunger, thus performing the second riveting step (Fig.298b). At this moment, the original rivet head is tightly pressed to the surface of the part being riveted.

The movement of the plunger stops at the instant at which its flange strikes the inner recess of the micrometer bushing. On reaching its extreme left position,

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the plunger closes the contacts (17) (see Fig.297), causing an electric current to flow from the battery and thus lighting the lamp (7). After the head is formed, the valve is again rotated, starting the pneumatic motor and unscrewing the tip from the

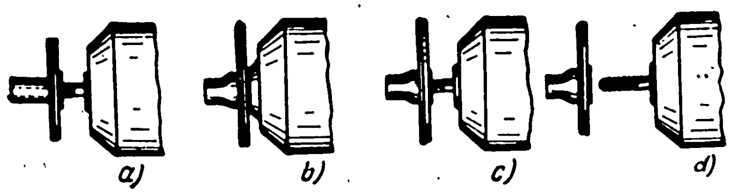

Fig.298 - Sequence of Operations in Riveting Threaded Shell Rivets with the KO-3 Press

a - Tip is screwed into the rivet; b - Formation of the clenched head; c - Unscrewing the tip from the rivet; d - Riveted rivet

rivet (Fig.298c). This concludes the operating cycle of the press.

Lubrication of the pneumatic motor and the working cylinders takes place at every cycle of operation by atomized oil from the oil reservoir.

Among the hand pliers for riveting threaded shell-type rivets, the pliers shown in Fig.299 are of greatest use in production and are the most convenient for handling. The upper handle (1) has an eccentric connected by the link (2) with the rod (3). The end piece (4) with its threaded end, fits on the rod. The rivet is screwed to the tip and is inserted in the hole of the stack. By pressing on the handle (1), the rivet is upset. The handle (1) is returned to its initial position, and by turning it, the tip is unscrewed from the rivet.

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During the upsetting of the rivet, the bushing (6) provides the pressure for forcing the original rivet head against the surface of the part being riveted.

The following conclusions were obtained by investigations carried out on joints riveted with solid-shank rivets, rivets with mandrels, and rivets of the threaded shell type, by subjecting them to static and to vibrational loads (Fig.300).

1. The static strength in shear of rivets with mandrels is 19% lower than the

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strength of ordinary shank rivets made of material D18. The tests were made on the specimens shown in Fig.300.

2. The static strength in shear of threaded shell-type rivets is 30% lower than the strength of ordinary shank rivets.

3. The fatigue strength of joints riveted with mandrel-type rivets is 25% lower than similar joints riveted with ordinary shank rivets. The fatigue strength of joints made with threaded shell-type rivets is 35% lower than the strength of similar joints riveted with ordinary shank rivets.

The data given refer to the particular types of joints shown in Fig.300. On changing the thickness of the sheets or the diameter and type of rivets (whether flush or protruding), the strength data may become different. However, in all cases the strength of joints made with rivets with mandrels or with threaded shells, is lower than the strength of joints riveted with ordinary shank rivets.

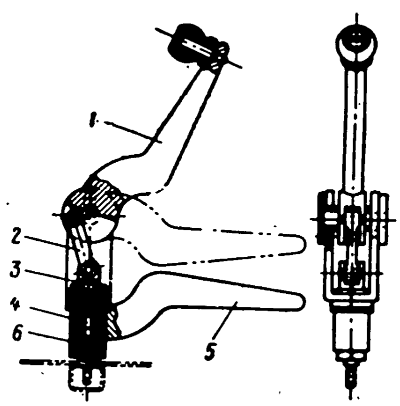

Fig.299 - Hand Pliers for Riveting Threaded Shell Rivets

1,5 - Handles; 2 - Link; 3 - Connecting rod; 4 - Tip; 6 - Clamp bushing

Explosive rivets consist of a cylindrical shank with an original head at one end and a hollow enclosure containing an explosive charge at the other end. For protection of the explosive char STAT om moisture, the enclosure is coated with a lacquer.

Explosive rivets are manufactured from wire of light aluminum alloy D18 or V65 and of grade 15A (select) or 30KhMA steel. Explosive rivets are produced in various diameters (from 2.6 to 6 mm) and in different types, with half-round heads and flush heads having taper angles of 90° and 120°, on conventional automatic upsetting ma-

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chines, with special plungers and dies. The dimensions of explosive rivets and their tolerances are the same as the dimensions and tolerances for ordinary rivets, with the exception of the tolerance for the diameter of the shank, which is more rigid

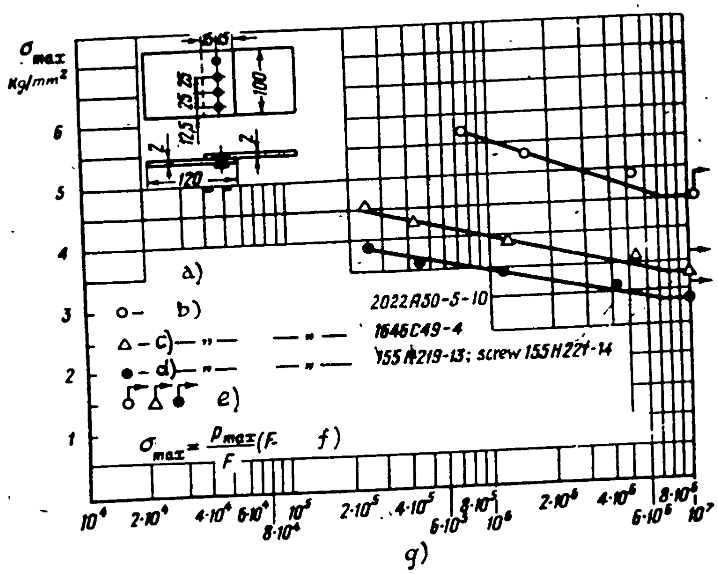

Fig.300 - Effect of the Type of Rivets Used on the Fatigue Strength of the Joint (Sheets D16T)

a) Legend; b) Joints with 2022 A 50-5-10 rivets; c) Joints with 1646 S 49-4 rivets; d) Joints with 155 N 219-13 rivet ; screw 155 N 221-14; e) Without rupture; f) $\sigma_{max} = \frac{P_{max}}{F}$ (F is the area of the sheet along its weakened cross section); g) Number of cycles

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than for ordinary rivets.

The technical process of installing explosive rivets in structures consists of the following principal steps (Fig.301):

1. Drilling the holes with a drill whose diameter is 0.3 - 0.5 mm less than the diameter of the rivet.

2. Finishing the holes with a reamer of the corresponding diameter.

3. Insertion of the rivets into the holes.

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4. Formation of the head. The tip of the heater, which has been preheated to the working temperature for 30 - 40 min, is placed on the original rivet head. After the tip of the heater is placed on the original rivet head, the heat is transmitted through the rivet head and the shank to the explosive charge which, on exploding, generates gases that act on the shank portion protruding from the stack, causing it to spread and form a barrel-shaped clenched head.

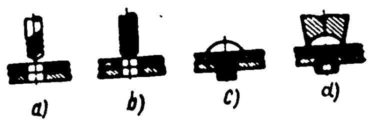

Fig.301 - Schematic Diagram of Installation of Explosive Rivets
a - Drilling the hole with a drill of a diameter 0.3 - 0.5 mm less than the rivet diameter; b - Finishing the hole with a reamer; c - Insertion of the rivet; d - Formation of the head with the aid of an electric heating device

A correctly riveted rivet should have a clenched head of a diameter 15 - 30% larger than the diameter of the rivet.

In view of the fact that after the rivet is headed, the shank of such rivets does not increase in diameter, and therefore does not fill the clearance between the shank and the walls of the hole, the final diameter of the rivet hole must be 0.01 - 0.02 less than or equal to the diameter of the shank. But since the diameter of rivets varies within the specified limits, a series of reamers must be kept on hand (Table 70).

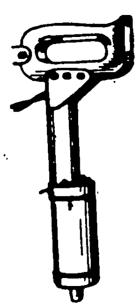

Fig.302 - Electric Heating Device for Riveting Explosive Rivets

Squeezing of the parts of the stack does not take place in riveting with explosive rivets. To assure a tighter contact between the parts, spring clamps must be used at every 2 - 3 holes in the row.

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Comparing the calculated data for selection of explosive rivets of D18 alloy with the data for solid-shank rivets of the same material but installed by the reverse method of impact riveting, the following facts were established:

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1. The shear strength of explosive rivets is lower than the shear strength of ordinary shank rivets installed by the reverse method of impact riveting. The decrease is 26.2% for rivets with diameters of 2.6, 3.0, and 3.5 mm and 13.2% for rivets with diameters of 4, 5, and 6 mm.

2. The resistance of the heads of explosive rivets to shear is 36 - 58% less

Table 70

Diameters of Reamers for Reaming the Holes for Explosive Rivets

a)	$2,6_{-0,06}$	$3,0_{-0,06}$	$3,5_{-0,06}$	$4,0_{-0,06}$	$5,0_{-0,10}$	$6,0_{-0,10}$
b)	2,54	2,94	3,42	3,92	4,90	5,90
	2,56	2,96	3,44	3,94	4,92	5,92
	2,58	2,98	3,46	3,96	4,94	5,94
	2,60	3,00	3,48	3,98	4,96	5,96
			3,50	4,00	4,98	5,98
					5,00	6,00

Remarks. The data shown in this Table are for manually operated cylindrical reamers of Class II accuracy

a) Rivet diameter in mm; b) Diameters of reamers in mm

than the resistance to shear of the heads of ordinary shank rivets installed by the reverse method of impact riveting.

The technical process of riveting with explosive rivets of the type shown in Fig.301 (i.e., rivets in which the enclosure containing the explosive charge is deformed only in that portion which forms the clenched head and does not extend to the portion of the shank itself) presents particular difficulties, requiring supplementary operations, such as reaming the holes and sorting the rivets according to their diameters. Since the rivets, when installed in the structure, inadequately fill the holes in the stack, it is observed that even when the seam is not heavily loaded, there is a noticeable slipping of the sheets (separation of the seam). This draw-

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back of explosive rivets with a hollow head is eliminated by using special improved explosive rivets.

The special type of explosive rivets consists of a cylindrical shank with an original head at one end and two coaxial chambers at the face of the other end. One chamber of smaller diameter extends over the entire length of the shank up to the original rivet head, while the other chamber, coaxially in line with the first at the lower part of the shank, serves the purpose of forming the clenched head. Both coaxial chambers are filled with an explosive and are coated with a layer of lacquer.

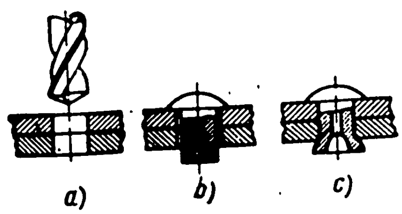

Fig.303 - Outline of the Installation of Special Explosive Rivets

a - Riveting the hole; b - Insertion of the rivet; c - Formation of the clenched head with the aid of an electrically heated device

An outline of the installation of special explosive rivets is presented in Fig.303.

A special feature of the technical process of riveting with such rivets is an elimination of the step of reaming the rivet holes, since in this case, the explosion of the charge in the upper chamber causes the shank of the rivet to increase in diameter, thus filling the holes tightly. This permits drilling the holes for the rivets without supplementary reaming. Simultaneously, the explosion of the charge in the lower chamber results in a barrel-shaped clenched head similar to that of ordinary explosive rivets.

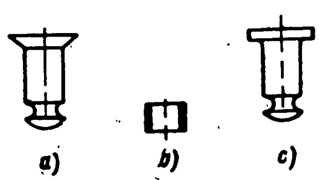

Fig.304 - Rivets of High Shear Strength

a - Flush; b - Ring for the rivet; c - Rivet with a flat head

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Table 71

Data on the Selection of High Shear Strength Rivets, Depending on the Thickness of the Stack being Riveted

(For Rivets of Standards 2032A50 - 2034A50)

a)	4	5	6	8	10
b)	c)				
10	5,6-6,2	4,5-5,1			
10,5	6,1–6,7	5,0–5,6			
11	6,6–7,2	5,5–6,1			
11,5	7,1–7,7	6,0 6,6			
12	7,6–8,2	6,5–7,1			
12,5	8,1–8,7	7,0-7,6			
13	8,6–9,2	7,5–8,1	6,6–7,2		
13,5	9,1–9,7	8,0–8,6	7,1–7,7		
14	9,6-10,2	8,5–9,1	7,6–8,2		
14,5	10,1–10,7	9,0–9,6	8,1–8,7		
15	10,6–11,2	9,5–10,1	8,6–9,2		
15,5	11,1–11,7	10,0-10,6	9,1–9,7		
16	11,6–12,2	10,5–11,1	9,6-10,2		
16,5	12,1–12,7	11,0–11,6	10,1–10,7		
17	12,6-13,2	11,5–12,1	10,6–11,2	9.0–9,6	
17,5	13,1–13,7	12,0–12,6	11,1–11,7	9,5–10,1	
18	13,6–14,2	12,5–13,1	11,6 - 12,2	10,0–10,6	
18,5	14,1-14,7	13,0–13,6	12,1–12,7	10,5-11,1	
19	14,6–15,2	13,5–14,1	12,6–13,2	11,0–11,6	
19,5	15,1–15,7	14,0–14,6	13,1–13,7	11,5-12,1	
20	15,6–16,2	14,5–15,1	13,6–14,2	12,0–12,6	10,4–11,0
20,5	16,1–16,7	15,0–15,6	14,1–14,7	12,5–13,1	10,9–11,5
21	16,6–17,2	15,5–16,1	14,6–15,2	13,0-13,6	11,4–12,0
21,5	17,1–17,7	16,0 - 16,6	15,1–15,7	13,5–14,1	11,9-12,5
22	17,6–18,2	16,5–17,1	15,6–16,2	14,0–14,6	12,4–13,0
22,5	18,1–18,7	17,0–17,6	16,1–16,7	14,5–15,1	12,9–13,5
23	18,6–19,2	17,5–18,1	16,6–17,2	15,0–15,6	13,4-14,0
23,5	19,1–19,7	18,0–18,6	17,1–17,7	15,5–16,1	13,9-14,5
24	19,6–20,2	18,5-19,1	17,6-18,2	16,0–16,6	14,4–15,0
24,5		19,0–19,6	18,1–18,7	16,5–17,1	14,9–15,5
25		19,5–20,1	18,6 19,2	17,0–17,6	15,4–16,0
25,5		20,0–20,6	19,1–19,7	17,5-18,1	15,9–16,5
26		20,5–21,1	19,5–20,2	18,0–18,6	16,4–17,0
26,5				18,5–19,1	16,9–17,5
27				19,0–19,6	17,4–18,0
27,5				19,5–20,1	17,9–18,5
28				20,0–20,6	18,4–19,0
28,5					18,9–19,5
29					19,4–20,0
29,5					19,9–20,5
30					20,4-21,0

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a) Rivet diameter, in mm; b) Rivet length, in mm; c) Thickness of the stack being riveted, in mm

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2. Riveting of Rivets with High Shear Strength

Rivets with a high shear strength (Fig.304) are used in joints subjected to high shearing forces. Rivets of this type replace bolts, in comparison with which

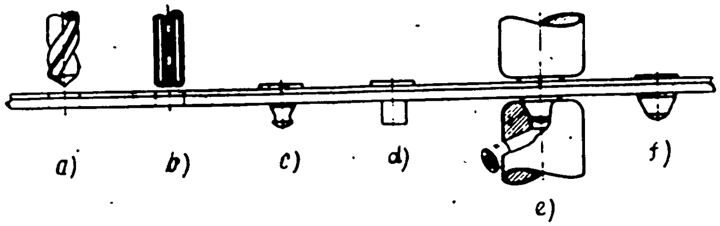

Fig.305 - Outline of Riveting High Shear Strength Rivets

a - Drilling the hole; b - Reaming the hole; c - Inserting the rivet in the hole; d - Attaching the ring; e - Upsetting the ring; f - Riveted rivet

they are lighter in weight, cost less, and are simpler to manufacture. The rivet consists of two parts: namely, a stem usually made of steel of specification 30KhGSA, and a ring of aluminum alloy D16.

On one end, the rivet has a previously upset original head, and on the other a special groove. The groove is made on special automatic machines. After manufacture, the shank is subjected to heat-treating: quenching and tempering or isothermal quenching ($\sigma_b = 125 \pm 25$ kg/mm^2).

The duralumin rings are made from cold-drawn extruded tubes and are STATed in the structure in a freshly tempered condition.

High shear strength rivets are manufactured with flush and with flat heads in various diameters, from 4 to 10 mm, and in different lengths, from 10 to 30 mm.

Table 71 gives data on the selection of the rivet lengths depending on the thickness of the stack being riveted.

An outline of riveting high shear strength rivets is shown in Fig.305. The

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process consists of the following operations:

1) Drilling holes for the rivets;

2) Reaming the holes;

3) Inserting the rivets into the holes;

4) Attaching the ring;

5) Upsetting the ring.

Table 72 gives original data for the selection of drills and reamers, depending on the diameter of high shear strength rivets.

Drilling, reaming and countersinking of the holes is performed on drill presses

Table 72

Hole Diameters After Riveting and Reaming, Depending on the Diameter of High Shear Strength Rivets

Rivet diameter, in mm	Preliminary diameter of the hole after drilling, in mm	Final diameter of the hole after reaming, A_4, in mm
4	3.8	4
5	4.8	5
6	5.8	6
8	7.8	8
10	9.8	10

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or with pneumatic hand drills. When drilling holes with pneumatic hand drills, attachments are used to make sure that the axis of the holes is perpendicular to the surface of the workpiece.

For formation of the clenched heads, use is made of presses or pneumatic hammers with a set of fitting tools consisting of a prop and a special die. The riveting operation with pneumatic hammers may be done, as in the case of ordinary ri-

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veting, either by the direct or the reverse methods of riveting (Fig.306).

In the direct method of riveting (Fig.306a), the prop is placed on the original rivet head; the impact of the hammer equipped with a special die, forces the material

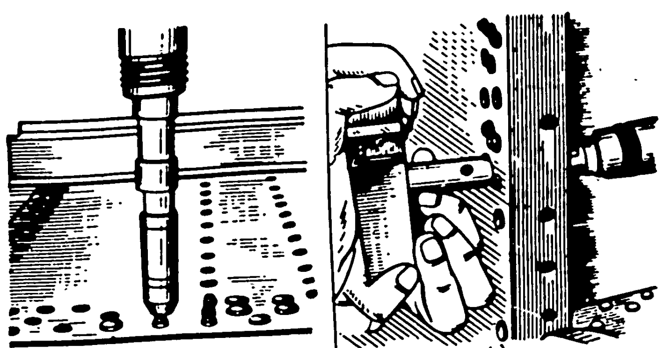

Fig.306 - Riveting with High Shear Strength Rivets

a - Direct method of impact riveting; b - Reverse method of impact riveting

of the ring into the groove of the shank; this cuts off the superfluous portion of the material which is ejected through the hole in the die.

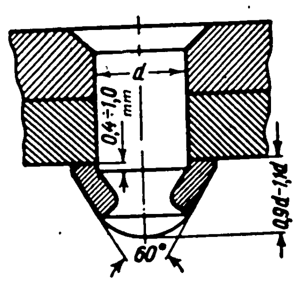

Fig.307 - Dimensions of the Clenched Head of High Shear Strength Rivets

In the reverse method of riveting (Fig.306b), the blows are directed on the original rivet head by the pneumatic hammer equipped with an ordinary die, while the head is formed on a special prop, whose working part design and dimensio STAT similar to those of the special die.

Riveting of high shear strength rivets by the direct method results in proper heading of the rivets and, therefore, in a better quality of the riveted seam as compared with riveting by the reverse method. However, in all cases where it is possible to employ press riveting, the

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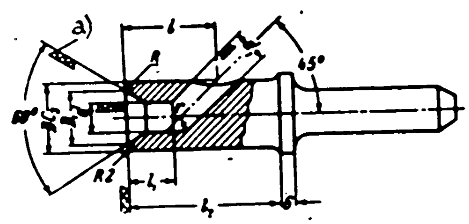
use of impact tools should be avoided, since in addition to the higher rate of production with press riveting, a better quality of seam is obtained.

Table 73

Dimensions of the Working Portion of the Die for Riveting High Shear Strength Rivets



b)	c)								
	d	d_1	D C_3	D_1	R	l	l_2	l_1	r
5	$5^{-0.04}_{-0.08}$	6,1	17	8,2	0,8	19,0	44	10,5	3,05
6	$6^{-0.04}_{-0.08}$	7,2	18	10,2	1,0	20,0	44	11,0	3,60
8	$8^{-0.05}_{-0.1}$	9,3	20	13,2	1,3	22,5	49	12,5	4,65
10	$10^{-0.05}_{-0.1}$	11,7	22	16,9	1,5	25,6	54	14,6	5,85

a) Mirror-finish polishing; b) Diameter of rivet used; c) Dimensions, in mm

The dimensions of the clenched head must correspond to the data given in Fig.307.

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Particular attention should be given to the following: After the rivets are inserted into the holes of the stack, a check should be made on the extent to which the cylindrical part of the stem protrudes from the stack, which protrusion must not exceed 0.4 - 1.0 mm (see Fig.307). The shape and dimensions of the working parts of the special dies and props for riveting high shear strength rivets, as related to the diameter of the rivets used, are given in Table 73.

The dimensions of the shank of the dies depends on the type of press or pneu-

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matic hammer used and must correspond to them.

The static strength of joints made with high shear strength rivets is considerably higher than the strength of similar joints made with ordinary shank rivets. The shear strength σ_{shear} of such rivets is $0.6\,\sigma_b$ and is equal to 72 kg/mm^2.

The fatigue limit of joints made with high shear strength rivets is the same as

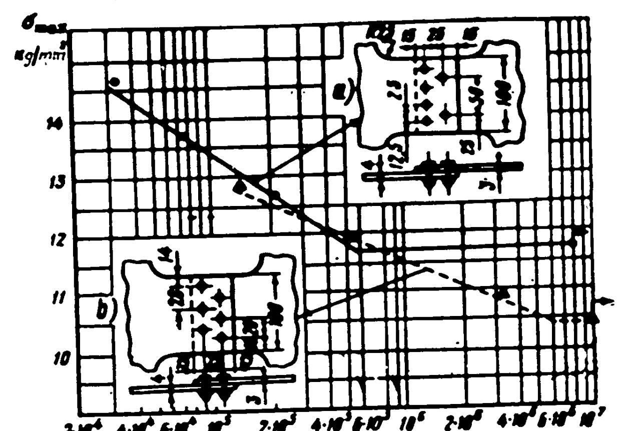

Fig.308 - Fatigue Limit of Joints Made with High Shear Strength Rivets

(Sheets D16T, Rivet Diameter 6 mm)

a) Number of cycles

for shank rivets, and for the seams shown in Fig.308, it is as follows:

for seams of type (a),

$$\sigma_{\omega\ sh} = 11.6\ \text{kg/mm}^2$$

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for seams of type (b),

$$\sigma_{\omega\ sh} = 10.3\ \text{kg/mm}^2$$

That the fatigue limit of joints made with high shear strength rivets and of joints made with ordinary shank rivets are the same is explained by the fact that, in breaking tests, rupture of the sheet takes place along the first row of rivets.

High shear strength rivets are expensive to manufacture, do not permit proper

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compression of the parts, and provide only resistance to shear. The shortcomings of high shear strength rivets as mentioned, are eliminated by using rivets with different degrees of strength. In external appearance and in their dimensions such rivets do not differ from ordinary shank rivets.

Rivets of variable strength are manufactured from grade 30KhGSA steel; after suitable heat-treatment they possess the same strength as high shear strength rivets. For the riveting of such rivets the portion of the shank intended for formation of the head must be as hard as the remaining portion in the hole of the stack. This is obtained by annealing a portion of the shank with high-frequency current.

The same equipment and tools are used for riveting variable strength rivets as for ordinary shank rivets.

Joints made with such rivets, from the standpoint of strength, are just as good as those made with high shear strength rivets, and when subjected to tension they are considerably stronger than the latter.

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CHAPTER XV

QUALITY REQUIREMENTS IN PERFORMING THE STEPS OF THE TECHNICAL PROCESS OF RIVETING AND INSPECTION OF THE QUALITY OF RIVETED UNITS

1. Quality Requirements in Performing the Steps of the Technical Process of Riveting

The basic function of riveted joints is the transmission of forces from one element of the structure to another. Riveted joints must provide the following:

a) Necessary strength.

b) Surface smoothness of the joined parts.

c) Resistance to corrosion.

d) Hermetic seams.

Meeting the requirements listed depends on the structural factors of the seam, i.e., on the geometry of its dimensions, and also on the technical factors with respect to the kind of equipment used in making the seam.

The technology involved in drilling the holes, countersinking the recesses, and riveting, must be so laid out as to give the following results:

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1) Perpendicularity of the axis of the holes with respect to the surface of the parts at the particular point;

2) Absence of fluting, torn edges, cracks and burrs in the holes;

3) Perpendicularity of the axis of the recesses with respect to the surface of the lining at the particular point and coincidence of the axes of the holes with those of the recesses;

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4) Absence of fluting and scratches on the surface of the recesses;

5) Absence of cracks and torn edges in punched holes and in dimpled recesses;

6) Absence of dents, cracks, cuts, and other damage to the surface of the original rivet head;

7) Absence of cracks, cuts, stratification, and roughness of the surface of the clenched rivet head;

8) Coaxiality of the original and the clenched rivet heads.

Allowances for deviation from the requirements listed are given in the technical specifications of riveting and are established in each practical case.

Below are given some of the quality requirements for performing the process steps, together with allowances for deviation from the listed requirements, which may be used in preparing the technical riveting specifications for various types of machines:

1. In replacing defective rivets with other rivets of the same diameter, the diameter of the hole is allowed to be larger by the following values: 0.2 mm for rivets of diameters up to 5 mm, and 0.3 mm for rivets of diameters above 5 mm.

2. The countersunk recess should be made to such an accuracy that the protrusion of the special calibrated rivet above the surface of the part, when placed in the recess, is within the limits of 0.01 mm - +0.10 mm.

3. Out-of-round of countersunk recesses is allowed within the limits to 0.2 mm and, as an exception, to 0.3 mm, but in not more than 15% of the recesses in a given seam.

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4. Dimpled recesses, after drilling the holes, must have no cracks or torn edges.

5. As an exception, dimpled and countersunk recesses can show faint nicks and cuts on the surface of the part made by the face of the attachment on the countersinking tool, that limits the depth of the dimpled recess; insignificant mechanical damage in the form of scratches to a depth less than the thickness of the plated

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layer of the material, is also allowed, but in not more than 5% of the recesses in the seam.

6. In multiple-row seams of small pitch (up to 20 mm) and on surfaces of small curvature (up to 400 mm in radius) localized protrusions and depressions up to 0.2 mm are allowed around dimpled recesses.

7. After riveting, the original rivet heads must be in close contact with the surface of the joined parts. Incomplete osculation of the original rivet heads with the surface on one side is allowed up to 0.05 mm, but in not more than 10% of the rivets in a row, and such rivets must not be in succession.

8. The extent to which the original heads of flush rivets protrude with respect to the surface of the lining, is established in each concrete case by the chief designer of the product manufactured. Depression of the original head of flush rivets with respect to the surface of the lining is not permitted.

9. The allowable size of "rims" around the original heads of flush rivets after they are riveted, is established in the technical specifications of the chief designer.

10. Mechanical damage to the surface of the riveted seam around the rivet heads due to the riveting tool, in the form of scratches, cuts, and other flaws is allowed, provided their depth is less than that of the plated layer, but not more than in 5% of the rivets in the seam.

11. Localized clearances in the parts between the rivets are allowed to the following extent:

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a) Not more than 0.5 mm for plankings of a thickness up to 1.5 mm.

b) Not more than 0.3 mm for plankings of a thickness from 1.6 to 2 mm.

c) Not more than 0.2 mm for plankings of a thickness over 2 mm, if not contrary to the requirements of the chief designer.

12. Depressions in the planking along the riveted seam are allowed up to 0.2 mm and, as an exception, to 0.3 mm in multiple row seams of small pitch, with the mea-

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surement taken on the basis of a double pitch of the given seam.

13. The arrangement of the rivets in the seam, the lead of the pitch, and the rectilinearity of the seams must correspond to the specifications in the design drawings.

The technical specifications are to be used as a guide in preparing the exterior outlines of the assembled unit, which determine the requirements as to shape and quality of the outer surface of the unit. The general requirements as to form and quality of the exterior surface of aircraft are as follows:

1. Butt joints and others of the skin of aircraft units should have smooth fairings, corresponding to the theory of their contours. Deviation from the allowed limits of the outline from the theoretical contour, in the form of convexity, concavity, waviness, hollowness, terracing, clearances and slits, is determined by the technical specifications for the particular job.

2. The surface of the metal skin of assembly units must correspond to the technical specifications governing the supply of the sheets from which a given skin is made.

3. All parts must correspond to the design drawings and have an inspection stamp certifying their acceptability.

4. Parts and components of major units should be given a rust-preventive coating corresponding to the technical specifications.

Resistance to corrosion of riveted joints is obtained by the following conditions:

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a) Absence of the surface of the riveted joints of dents, cuts, scratches, abrasions, and other mechanical damage that destroy the plated layer.

b) Absence of substances that induce or promote corrosion of rivets and structural elements, which may be due to a poor job in cleaning up the rivets after heat treating, such as leaving traces of saltpeter, and other causes.

Airtight joints, besides strength and smoothness, must have excellent hermetic

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sealing properties under the conditions under which an aircraft is used. The seal of the riveted joint must not be destroyed by vibrational forces, differential pressure, or rarefication, and must correspond to the technical specifications for a particular aircraft, as well as withstand a drop in pressure and excessive humidity.

2. Types of Inspection Operations

Defects in riveting depend on the quality of assembly and finishing work on the separate parts, the accuracy of marking the spots for drilling, and the correctness of drilling and countersinking, as well as on the kind of tools, fixtures, and equipment employed.

Fig.309 - Limit Gage for Inspecting the Diameter and Out-of-Round of Rivet Holes

Inspection of the work in progress is to eliminate rejects during the process of assembly by riveting and to evaluate the quality of finished riveting work on the assembled unit as a whole.

Inspection consists of two types: inspection of individual operations and inspection of finished work. Individual operations are inspected during the various technical processes of assembly and riveting, while final inspection consists in an evaluation of the quality of finished joints and the manner in which the exterior contours of the components are matched.

Inspection of the individual operations covers the following points:

1) Correctness of mounting the parts in the jigs, proper fit of the skin to the airframe, and clearances in butt joints of the sheets;

2) Arrangement and location of the holes in accordance with design drawings or with templates;

3) Diameter, shape, and surface finish of the rivet holes at the inlet and outlet holes of the drill;

4) Form and surface finish of the recesses as well as depth of the recesses.

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Final inspection consists in checking the following points:

1) Extent to which the original heads of flush rivets protrude from the surface of the parts;

2) Tightness of contact between the original rivet heads and surface of the recesses in the case of flush rivets, or surface of the parts in the case of ordinary riveting with the original heads protruding;

3) Shape and dimensions of the clenched heads of the rivets;

4) General surface condition of the clenched and original rivet heads with respect to possible cracks, cuts made by the riveting tool, and other defects;

5) Type and material of the installed rivets;

6) Size and extent of clearance between the riveted parts;

7) General surface conditions of the parts, particularly of the planking, including cuts, dents, nicks, scratches, and other mechanical flaws;

8) Buckling and dents on the surface of the parts along the riveted seams and between the seams;

9) General contour and dimensions of the assembled unit.

3. Methods and Means of Inspection

Checking correctness of the arrangement of parts in assembly fixtures is done in compliance with the design drawings or the standards set up for a particular component or unit, and a cursory check is made on the quality of the materials supplied, such as the sheets, sections, and semifinished materials.

Correctness of location of the rivet holes is inspected with standardized and special measuring instruments, such as slide gages, calibrated rulers, sliding calipers, and others.

For checking the diameter and out-of-round of holes (which must be done in at least 10% of the total number in the seam) special gages of the type shown in Fig.309 are employed. At the same time, the quality of the surface is inspected

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visually as to presence of fluting and burrs.

For checking the depth of the countersunk recesses (which must be done in not less than 15% of the total number in the seam) use is made of a calibrated rivet in

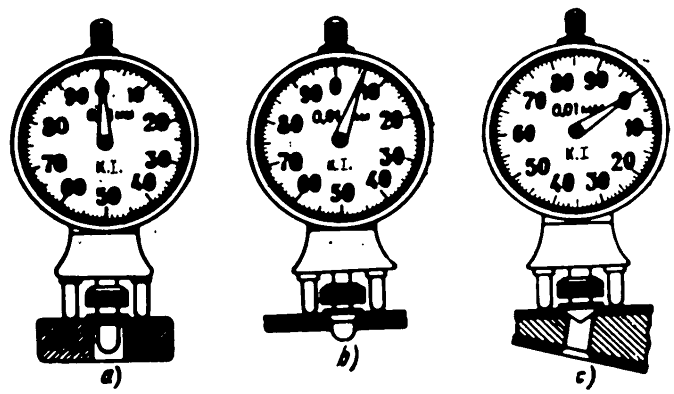

Fig.310 - Measuring the Depth of a Countersunk Recess by Means of a Calibrated Rivet and an Indicating Instrument

a - Setting the device "on zero" with respect to a calibrated recess; b - Measuring the protrusion of the calibrated rivet from the recess placed in a normal stack of parts; c - Measuring the protrusion of the calibrated rivet from the recess, placed in a wedge-shaped pack of parts

combination with indicating devices (Fig.310b). For this purpose, the indicator is preset to zero by the calibrated rivet (Fig.310a). The deflection of the pointer from zero on the dial indicates the correctness of the depth of the countersunk recess. The surface finish of the recess, as to fluting, adhering metal particles, and cuts, is evaluated by a spot-check examination. The extent of out-of-round of the recess is of necessity checked by optical means, such as a magnifying glass with a scale or a microscope.

Inspection of the extent to which the heads of flush rivets protrude with respect to the surface of the lining is also done by means of an indicating instrument

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(Fig.311). Not less than 10% of the rivets in the seam are subjected to the test. Before protrusion of the heads is checked, the instrument is set to the zero division of the dial scale by placing the instrument on the smooth surface of the planking.

Feeler gages are used for checking the tightness of contact of the original rivet heads with the surface of the recesses or of the parts, and also the clearances between them. Inspection of the diameter and height of the clenched rivet heads is done with limit templates (Fig.312), and not less than 10% of the total number of rivets in the seam are thus inspected.

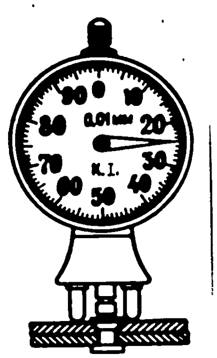

Fig.311 - Measuring the Extent of Protrusion of the Heads of Flush Rivets

The superficial examination of the original and the clenched rivet heads is done with the naked eye, and in doubtful cases magnifying glasses are used for the detection of cracks.

For checking the clenched heads from inside the structures, as for example in tubular or rectangular profiles and other places, use is made of optical instruments such as telescopic tubes with auxiliary lighting (Fig.313). The device consists of the extensible tube (3), a reflecting mirror (2), a small light (1) and an eyepiece (4). The small light illuminates the spot being examined, which in this particular place is the clenched rivet head, that the inspector sees clearly in the eyepiece. The extensible tube is marked with scale divisions, which makes it possible to define accurately the location of the rivet in the seam under examination. This optical instrument is provided with a set of interchangeable tubes, for installation to correspond with the dimensions of the part being inspected.

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Inspection of the surface condition on the side of the original rivet head, in

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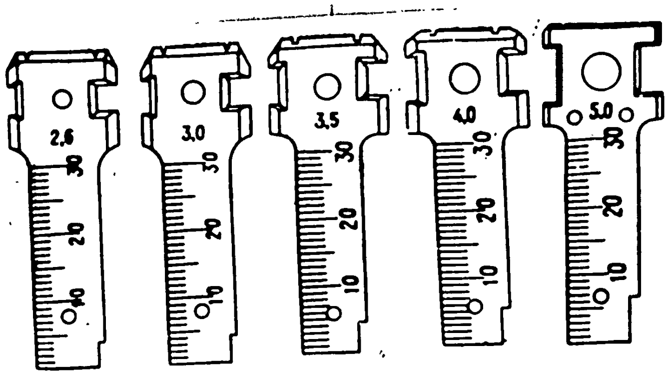

Fig.312 - Templates for Inspecting the Dimensions of Clenched Rivet Heads

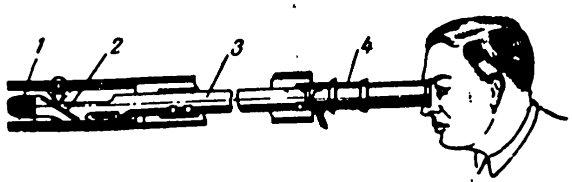

Fig.313 - Optical Instrument for Inspecting the Quality of Riveting in Concealed Places of Structures

1 - Light; 2 - Mirror; 3 - Tubes; 4 - Eyepiece

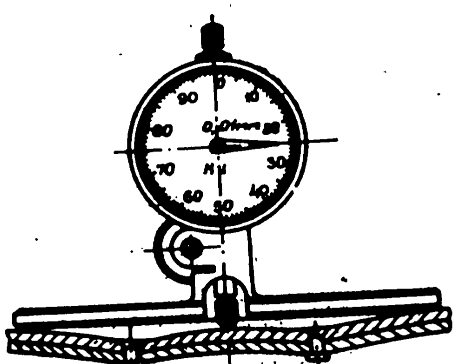

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Fig.314 - Measurement of the Extent of Gaps and Depressions in Plankings

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the case of flush and also in the case of ordinary riveting, consists in an examination of the surface. This is to check for marks made by the die, such as scratches, dents, cuts, ridges, and other defects. Gaps, as well as bulging of the skin, caused by riveting, are measured with an indicating device (Fig.314).

In a similar manner, measurements are made of line marks and scratches (Fig.315). The surface of a flush-riveted seam at separate sections and over its entire formation, is inspected by means of a feeler gage and a ruler. The ruler is placed on the seam and the clearance is determined with the feeler gage between the ruler and the surface of the seam.

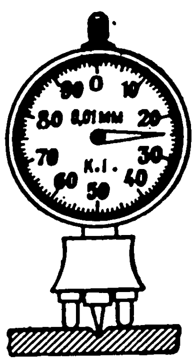

Fig.315 - Measurement of the Depth of Scratches and Line Marks

Measurement of the contour of a wing over its profile is done with the aid of templates or along the bracing parts of the assembly fixture, employing feeler gages or special indicating devices (Fig.316).

During the inspection of airtight seams, along with the checking of the quality of assembly and riveting, particular attention is given to the checking of the hermetic sealing of the seam, for which special methods and means were described in Chapter XII.

4. Types of Rejects and Means of Their Elimination

The principal types of rejects encountered in flush and in ordinary riveting, together with the means of their elimination, are presented in Table 74.

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The principal types of rejects, which affect the strength of riveted joints, include cracks and cuts on the original and on the clenched rivet heads, cuts on the sheets, cold-hardening due to riveting with a low-power hammer, skewed rivets, incompletely formed clenched heads, overcountersinking of the recesses, and a number of other defects.

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The principal types of rejects which affect the aerodynamic characteristics of the riveted unit include: original heads of flush rivets protruding from the exterior surface, dents near the riveting area, depressions of the seam, buckling of the material, and others.

For the prevention of rejects, it becomes necessary in many cases to replace

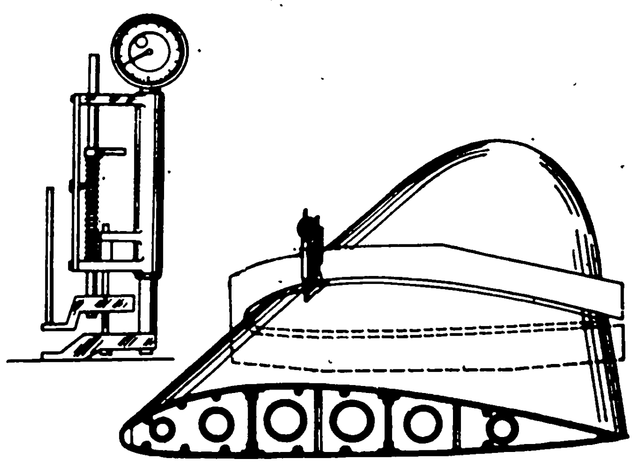

Fig.316 - Measurement of the Contour Profile of a Wing

the defective rivets and to carry out additional technical operations. In the case of rejects that cannot be corrected, it becomes necessary not only to replace the sheets, but also the individual parts, in most cases the entire skin.

Figure 317 shows an unsatisfactory surface of a flush-riveted seam. The surface of the lining shows many marks of the tool, resulting in destruction of the plated layer and cuts in the planking. In such cases the rivets must be drilled out and the sheet changed.

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In some cases, elimination of the defects requires additional work on correcting the sheets, which is done after the rivets have been drilled out. It is not recommended to do any work on the sheets without removing the rivets, since this would change the shape of the rivet heads and lead to hidden cracks, which may be-

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come the cause of premature rupture of the seam.

When shavings and dirt are detected between the riveted joints, the rivets should be taken out and the space between the joints cleaned of all foreign particles and dirt.

Removal of the rivets is usually done by means of drilling them out from the

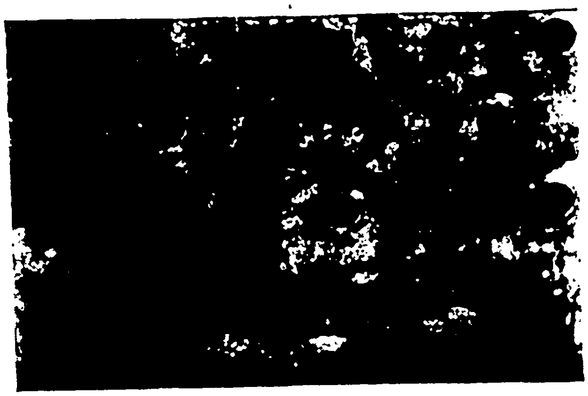

Fig.317 - Effect of Riveting Tool After Flush Riveting

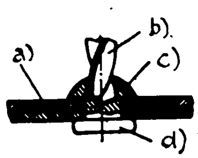

Fig.318 - Drilling Out Rivets

a) Parts; b) Drill; c) Original head; d) Clenched head

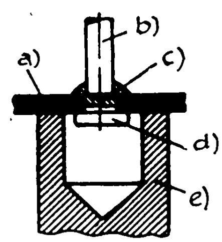

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Fig.319 - Knocking Out Rivets with a Bar

a) Parts; b) Knockout bar; c) Original head; d) Clenched head; e) Support

end of the original head and to hammer out the rivets with a special knockout bar.

Before the rivets are drilled out a central punch mark must be made on the rivet head with a center punch and a hole drilled on the original head with a drill

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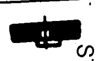
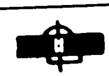
Table 74

Defects in Flush and in Ordinary Riveting; Means for Preventing and Eliminating the Defects

Type of Defect	Sketch of Defect		Cause of Defect	Preventive Measures to be Taken	Means of Elimination
	With flush Riveting	With Ordinary Riveting			
Original and clenched heads are not coaxial			Hole is drilled crooked	1. Hold the drill at right angles to the surface of the part 2. In drilling, use a hand drill	Replace the rivet
Cut in the material of the sheet from the end of the original head			1. Die and hammer not located at right angles 2. Socket recess in the die too large	1. Hold the die in rivet riveting, at right angles to the surface of the part 2. Socket recess in the die must correspond to the original rivet head	Replace the rivet and in case of a large number of such defects also replace the part
Clenched head is slanted			1. Working surface of the prop is not held parallel to the surface of the part, in the case of impact riveting 2. Working surface of the tool is tilted in the case of press riveting	1. Working surface of the prop must be held parallel to the surface of the part during riveting 2. Check the condition of the tools before riveting	Replace the rivet where the defect is in one rivet only, can be left without correcting it
Clenched head is displaced			Shank of the rivet is excessively long	Install rivets of the correct dimensions	Replace the rivet

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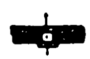
Type of Defect	Sketch of Defect		Cause of Defect	Preventive Measures	Means of Elimination
	With Flush Riveting	With Ordinary Riveting			
Shank of the rivet is upset and spread between the sheets			1. Poor preparation of the parts 2. Sheets not stretched on 3. Sheets too tightly packed, due to poor spring action in tightening	1. Check the finish of the parts before riveting 2. Stretch on the sheets before riveting 3. Check the condition of the tools before riveting	Replace the rivet and correct the condition of the sheet
Shank of the rivet bent in the hole, and insufficient material in the shank for formation of a full clenched head			Rivet does not correspond to the diameter of the hole	Install rivets of the correct dimensions	Replace the rivet
Height of the clenched head is less than specified			1. Shank of the rivet is short 2. Rivet is over-riveted	1. Install rivets of the correct dimensions 2. Make control riveting tests during adjustment of the press operation	Replace the rivet
Cracks in the original and in the clenched rivet heads			Insufficient plasticity of the rivet material	Check the riveting properties on rivet specimens	Replace the rivet

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Clenched head is low and of large diameter with cracks present			The rivet is over-riveted	1. Check in riveting on the formation of the clenched head 2. Adjust the press for proper height of the clenched head	Replace the rivet
Clenched head not sufficiently riveted			1. Time interval during riveting too short 2. Press not adjusted for proper height of the clenched clenched head	1. Check in riveting, the height of the clenched head 2. Adjust the press for height of the clenched head	Do additional riveting on the rivet
Clenched head of incorrect shape			1. Riveting hammer of too low a power 2. Insufficient weight of the prop	1. Use hammers of proper power 2. Use props of correct weight	Replace the rivet
Original rivet head too deep relative to the surface of the skin			1. Recess was countersunk to an excessively large diameter 2. Height of the original rivet head is less than the allowed dimensions	1. Countersink the recesses with a countersinking tool that has a depth limiting attachment, after first adjusting it to the required depth of countersinking 2. Check the height og the original head with calipers	Replace the rivet
Original head protrudes above the skin more than allowed	 STAT		1. Recess is countersunk to smaller dimensions 2. Height of the original rivet head is greater than the allowed dimensions	1. Countersink the recesses with a countersinker with limiter, after first adjusting it to the required depth 2. Check the height of the original rivet head with calipers	Replace the rivet

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Rivet shank upset under original head; not enough material to form full clenched head	–		Riveter's helper had forced the prop too tightly against the rivet face	Exert moderate force in pushing prop against rivet	Replace the rivet
Gap between original rivet head and recess			Taper angle of original rivet head differs from that of recess	Install rivets of proper dimensions	Replace the rivet
One side of original rivet head protrudes from the skin		–	Recess is eccentric	Countersink recess with a countersinker with limiter for countersinking depth	Replace the rivet
Original head not tight against recess surface		–	Depth of the recess excessive	Check the adjustment of the depth limiter on the countersinker for required depth before countersinking the recesses	Replace the rivet

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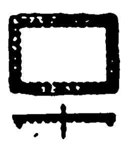
Depression of the skin around the rivets		–	1. Presence of gaps between skin and air-grame 2. Recesses were stamped with faulty tools 3. Lack of coordination of warning signals between riveter and his helper 4. Insufficient weight of the prop	1. Check contact of adjoining parts for tightness before riveting 2. Check condition of tools before stamping the recesses 3. Agree on a conventional system of signals 4. Use a prop suitable for the rivets used	Minor correction leading to tightening of the rivets
Cavities in the skin along the riveted seams		–	1. Excessive power of the riveting hammer 2. Lack of coordination between the riveter and helper 3. Riveting was done by reverse method	1. Use a hammer corresponding to the power group for the given diameter of the rivet 2. Agree on a conventional system of signals 3. Perform the riveting by the direct method if possible	Minor correction leading to tightening of the rivets
Roughness of the skin			1. Nonobservance of the order in which the rivets are installed 2. Faulty preparation of the joining parts	1. Use the "central" or the "end" method of riveting 2. Before riveting, check the quality of the work in preparing the parts	Install additional bracings and, if necessary, replace the sheets and rivets

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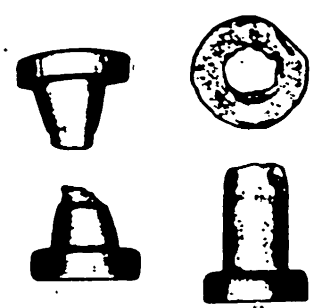
having a diameter less than the rivet diameter. The depth of the hole is determined by the height of the original rivet head (Fig.318). If the drill is properly positioned, the original rivet head usually "comes off" on the drill after the required depth of the drilled hole is reached. In case the original head does not "come off" on the drill, a knockout bar is placed in the drilled hole and the remaining portion of the rivet is knocked out by tapping lightly.

A special supporting prop is used for knocking out the remaining portion of the rivet, to prevent buckling of the sheets (Fig.319). The diameter of the tip of the knockout bar should be 0.5 mm less than the diameter of the rivet being removed.

5. Effect of Defective Riveting on Mechanical Strength

Of the total number of defects in riveting, the most common one is a deviation in the geometric dimensions of the clenched rivet heads. The deviation may be in diameter D, the height h, or shape of the head. Rivets with clenched heads deviating from the specified dimensions have a lower strength as compared with rivets that have correct dimensions, in accordance with the established standards. The dimensions of rivets with protruding heads are so specified in the standards that the rivets, when subjected to tension, will maintain their strength at all types of rupture.



a) b)

Fig.320 - Characteristic Rupture of Rivets when Subjected to Tension
a - Rupture of the shank; b - Ring-like shear of the head

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In a correctly designed joint, using rivets with protruding original heads, in the case when it is subjected to tension, the rivets should fail by rupture of the shank when subjected to tension (Fig.320a), which preserves the maximum strength of the joint. When there is a deviation in dimensions of the heads from the specified

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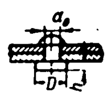
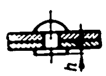
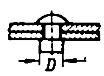
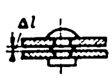
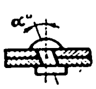
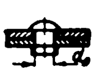
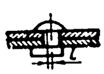
Table 75

Effect of Riveting Defects on the Strength of Joints

e)	a) d_0 mm	h mm	D mm	Δl mm	l mm	l_0 mm	$\alpha°$	b) c) f)	c) g)	d) f)	d) g)
	3,1	1,5	4,9					100	h)	100	j)
		0,8						90		67	k)
			4,2					80		70	l)
				0,5 1				87 85	i)	75 70	k)
							20°			80	m)
	3,4									82	l)
					1,2			98	h)	85	n)
						0,8				96	j)

a) Values of the factors under investigation; b) Results of the experiment; c) In shear; d) In tension; e) Sketch; f) Strength in %; g) Nature of failure; h) Shearing of the rivets; i) Bending and shearing of the rivet shanks; j) Tearing of the sheets; k) Ring-like shearing of the clenched head; l) Tearing the sheet on the side of the clenched head; m) Tearing of the original or the clenched head; n) Tearing of the clenched head

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standards, failure of the rivet takes place in the form of a ring-like shearing of the head (Fig.320b), or by the pulling out of the head through the hole in the part, whereby the strength of the joints is lowered. By maintaining the dimensions of the clenched heads of rivets with flush heads, the characteristic manner of failure, on subjecting the joint to tension, is the ring-like shearing of the original head.

In case the joint is subjected to stresses with the rivets in shear, the riveting defects produced by incorrect dimensions of the heads, have a less noticeable effect on the strength. For example, in the case of insufficient diameter ($D = 1.3d$) and excessive height h, the decrease of the strength in shear is about 10%. However, increasing the diameter D and correspondingly reducing the height h results in a somewhat higher strength in shear, due to the increase of the shank diameter and the hardening of the material.

Table 75 gives data on the effect of some riveting defects, related to the geometry of the clenched heads, on the static strength of joints. The Table is based on the results of tests with specimens using D16T sheets with D18 rivets. Tests of joints with deviations in the dimensions of the clenched heads, with alternating loads subjecting the seam to shear, have shown that the fatigue point changes little, since, under alternating loads, failure of the joint takes place in the sheet along the first row of rivets.

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CHAPTER XVI

SAFETY TECHNIQUE MEASURES

1. General Considerations

Safety technique is inseparably correlated with technology and is founded on a study of the production processes, methods of production, and procedure of work. Safety rules are established and means are developed for avoiding unfortunate accidents during the processes of production.

Promotion of safety involves education in safety technique during production, elimination of dangerous or harmful technical operations, and a number of other questions. Safety technique is correlated with the hygiene of labor, whose problem consists in studying the effect of working conditions on the health of the workers, and the development of sanitary and prophylactic measures necessary to make such conditions healthier in order to increase the productivity of labor.

The importance of safety in the sections of the plant where assembly work by riveting is done, obligates the commercial and technical engineering personnel to take all necessary measures for strict observance of the safety rules, for the prevention of industrial accidents. The reduction of accidents depends on the following:

1. Proper instruction of the workers and the engineering personnel in safety methods and extensive posting of the rules.

2. Systematic supervision on observance of the rules and measures to be taken

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for the prevention of accidents by all workers.

3. Systematic briefing on special safety rules of all workers and checking on familiarity with these rules.

The principal causes of accidents in the operation of drilling and riveting presses, as well as in the operation of manually operated riveting tools, are the following: improper and indifferent attention in handling the tools proper and the replaceable parts in the tools, such as in hand drills, hammers, drills, counter-sinks, dies, etc.; insufficient attention given to fastening of the parts on which work is done; nonobservance of the rules for handling of the chips, etc.

For this reason, every worker, foreman and technician in the department must know and observe all safety rules and permit no negligence in that respect.

The safety rules must be worked out on the basis of the working conditions for the plant, departments, and individual sections. For example, noise in the riveting assembly sections of the plant has a bad effect on the ear, being as high in some cases as 90 - 110 phons, which is bad for the hearing and interferes with the prod-uction output. The harmful effect of noise gradually dulls the hearing of the work-er, and at times leads to total deafness. The noise irritates the central nervous system, with the result that the attention of the worker to his work is lowered, leading to a decrease in work output and to unfortunate accidents.

A useful means of combating noise is to section off large working aisles with multiple-layer partitions, apply porous materials to the wall surfaces, mount wooden paneling with cushioning materials to the jigs, etc. If the elimination or reduc-tion of noise in individual sections of the plant is impossible, individual noise combating should be adopted. For example, the use of special internal or external ear plugs considerably reduces the effect of noise on the worker.

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Internal plugs are inserted in the outer ear duct. These are usually made of rubber, plastics, or wax-impregnated cotton wadding. It is helpful to make use also of outer ear muffs and caps which completely cover the ear helix.

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A very effective way of combating the noise in riveting assembly departments is to replace the equipment and tools operated on the impact principle (such as pneumatic hammers) with equipment operated on the press principle.

Aside from riveting hammers, considerable noise in riveting assembly departments is caused by pneumatic hand drills. For this reason, if at all possible, work in drilling and countersinking should be done on drill presses.

Working with hammers with a high performance rating, or using a prop of insufficient weight causes certain vascular system disorders in the workers, up to atrophy of the wrist muscles of the hands.

For this reason, props of the greatest possible weight should be used, suspending them from balancing devices. The body of the prop, with the exception of the working portion, should be protected by a suitable covering. This precaution, in addition to protecting the surface of the parts from damage by accidental hits, contributes to the damping of vibrations which may be harmful to the worker.

The workers in the riveting assembly sections of the plant have to deal with equipment and tools operating on the principle of rotation, impact, and press action. Below are given the principal safety rules when working with various types of equipment.

2. Some Safety Rules

a. Safety Technique for Work with Hand Drills and Drill Presses

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Accidents in working on drill presses and with hand drills are caused by the fact that the part being drilled is poorly fastened or is held by hand. When the part is not properly fastened, the drill might break, become jammed in the part, tear the part from the hands of the worker and injure him. In addition, a poorly fastened part usually leads to breakage of the drill and spoilage of the part itself. For this reason, while drilling, all parts must be correctly placed and tightly fastened in the assembly jig or on the table of the drill press, making use

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of special fastening devices.

In drilling through sheet material in parts of given thickness, hands or other parts of the body of the helper must not be near the drill tip.

When working on drill presses, the worker must sometimes hold his head near the revolving spindle. Lack of attention to the revolving spindle may be the cause of an accident. A spindle with a key groove is particularly dangerous, since it may grip part of the clothing or hair, resulting in serious injury. For preventing this, the danger spot on the spindle should be covered with smooth collapsible tubes. The clamping chuck must also be smooth. The protruding parts, such as lugs, clamping bolts, etc,, must be covered with cylindrical jackets, which can be displaced upward along the chuck while the cutting tool is inserted.

When working with a drill having tapered shanks, the surface condition of the drill taper must be checked constantly. Wear of the taper of the shank causes the drill to drop out of its fitting and injure the worker.

Of considerable danger to the worker while drilling, is a long chip revolving with the drill at high speed, which may strike the worker in the face or hands and cause injury. To prevent excessively long chips, periodic stopping of the manual feed or use of a special drill tip in the case of automatic feed should be used. For protecting the eyes of the worker from flying chips, while working on drill stands, safety goggles must be worn.

The driller must know how to handle electric equipment and know the safety rules while working with them. STAT

According to the safety rules, perfect grounding is necessary for the body of electric hand drills, motors, transformers, electric equipment, metal frames carrying electric devices and electric equipment, covers, fittings, electric cables, metal conduits for wires, and all wire leads and open metal parts that carry current must be thoroughly insulated. These rules apply not only to equipment and tools for drilling and countersinking work, but also to press equipment with electric parts.

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b. Safety Rules in Operation of Riveting Presses

The working conditions with presses are less hazardous than with pneumatic riveting hammers. However, in operating the presses the safety rules must be observed since lack of skillful attention or negligence may lead to serious injury.

Working alone on presses is authorized for specially trained operators and helpers only after checking on their skill.

During operation of the press, the worker must watch the position of his hands during the process of riveting. The hands of the worker must not be in the working area of the press between the dies. Accidents during operation of the press may be produced by insecure tightening of the interchangeable dies in their chucks, causing the dies to drop out during operation of the press and thus injure the worker.

Lack of attention when using interchangeable dies may also be the cause of an accident. Particularly dangerous is the replacement of dies in two-stroke presses. Adjustment of the press by two workers is not permitted, since even a minor lack of coordination of the work may lead to an accident or to the spoilage of the part being riveted. In presses with foot-operated pedals, accidental starting of the press can be prevented by enclosing the pedal in a guard covering.

During replacement of the die or prop tools, accidental starting of the press may occur. To prevent this, the press must be disconnected from the power source during change of tools. Disconnecting the press from the main power line is done just before starting work.

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When working with suspended presses, before any work is started, the worker must make sure of accuracy of the balancing device and of the entire suspended mechanism, paying particular attention to proper performance of the springs of the balancing device and to fastening of the press to the cable.

Accidents, when working on presses, occur due to the cluttering of the working area near the press and the auxiliary equipment with extraneous objects or with riveted parts. While working on the press and auxiliary equipment, these objects may

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fall and injure the worker. Therefore, before starting work on the press, all unessential objects must be removed and the working place cleaned up; all tools necessary for the work must be arranged in an orderly manner, most convenient for their utilization.

c. Safety Technique when Working with Pneumatic Hammers

Pneumatic hammers used in riveting must be in good order, as in the case of presses, drill stands, hand drills, and all other equipment, since poor operating conditions may lead to injury. Operation of pneumatic hammers requires attentiveness, correct manipulation, and proper maintenance.

Operation of a pneumatic hammer without a safety catch for preventing drop-out of the die is not permitted. A hurled-off die may injure the operator or bystanders. The simplest device to prevent the die from dropping out is a spring, whose one end is fastened to the body of the hand drill, and the other to the die. The spring does not interfere with operation of the hammer, and prevents the die from dropping from the hammer.

During the process of work, the number of impacts of the hammer is at times readjusted during which time the die should not be held by the hand while the hammer is being tested. The energy of a hammer blow is so great, that it is difficult to keep the die in place, not to mention the possibility of injuring the wrists or pinching the fingers in the spring.

Since riveting with pneumatic hammers is done by two workers (the rivet STAT lding the riveting hammer and his helper who directs the prop), they will have to agree on a system of signaling. This is particularly necessary, when one of the workers cannot see what the other is doing, as in the riveting of a fuselage, canopy, nacelle, and other large units.

During work stoppage or when changing over from one work station to another, the working tool - the die - should be removed from the hammer to avoid accidental

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starting of the hammer. Precautions must be taken to prevent piling of hose sections in the work station, twisting or undue stretching, kinking, or dropping on sharp objects.

d. Safety Technique when Working with Magnesium Alloys

The manufacture of parts from magnesium alloys differs markedly from the manufacture of parts from other materials. Due to its high chemical reactivity, magnesium presents greater fire hazards than other currently used structural metals.

The flame point of magnesium shavings and dust is 425 – 450°C.

Under the effect of blows and other causes of localized heating or under the effect of a spark, shavings, filings, and dust of magnesium alloys become flammable. At a high concentration of dust, such as 20 – 25 gm/m^3 of air, the causes mentioned might result in an explosion.

In view of the low flame point and the explosive hazard of magnesium alloys, special precautionary measures should be taken when working with them, the chief ones being as follows:

1. Shavings and filings of magnesium alloys must be collected in dry iron boxes with tightly fitting covers. Accumulation of shavings and filings at the work stations is not permitted.

2. The box with the shavings must be sent from the work area of the section to the central warehouse not less than twice during each shift.

3. During installation of work for stamping recesses that require prehe[redacted]g of the area to be stamped, the worker must make use of asbestos gloves and aprons to prevent burns, and must strictly obey the temperatures specified for preheating.

While working with magnesium alloys, thorough observation of all special safety rules in the plant is required.

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CHAPTER XVII

FURTHER MEANS OF IMPROVING THE QUALITY OF ASSEMBLY WORK BY RIVETING AND TO INCREASE THE OPERATING EFFICIENCY OF THE PLANT

A large volume of riveting assembly work in the manufacture of light-alloy structures, particularly in the production of aircraft, requires the adoption of measures to lighten labor difficulties, to improve the quality of the product, and to reduce the manufacturing costs. Such measures include primarily the training and raising of the qualifications of technicians, foremen, maintenance men, and assembly and riveting workers; the utilization of high production equipment, tools, auxiliary equipment and devices, and the adoption of perfected technical processes of assembly and riveting, as well as a good program of utilization of labor.

The plant technicians must thoroughly indoctrinate the production crew leaders with the basic work methods, teach them to improve scientifically their experience, and to brief them extensively on the most productive methods and means of work. Considering the large volume of work involved in the assembly and riveting, eveiSTATinor improvement and perfection of the technical process has a marked effect on the economical aspects of production.

Following are the principal factors which may serve as a guide in setting up and developing measures for improving the quality of the product and increasing the plant efficiency in connection with assembly and riveting work:

1. Finding more perfected methods and means for the formation of holes and recesses for the rivets.

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2. Development of a manual combination drilling and counters. for drilling holes of a large diameter with mechanical feed of the drill a lesser reaction of the torque transmitted to the hands of the riveter.

3. Invention of mechanized means for group riveting and countersinking as as mechanization of the process of inserting the rivets in the holes.

4. Finding more perfected methods of riveting whereby a riveted seam of high quality may be produced with a minimum expenditure of time and means; particularly a complete change-over from the impact method to press riveting.

5. Mechanization of riveting in jigs by installation of power units.

6. Developing light and maneuverable presses for riveting of aircraft gliders.

7. Invention of automatic stands for drilling, countersinking, and riveting.

8. Invention of specialized assembled machines with automatic action, for the assembly and riveting of components and major units, containing in itself, assembly fixtures and a set of combination drilling, countersinking, and riveting mechanisms.

9. Development of more perfected methods and means for the inspection of riveted seams.

10. Invention of a new type of gasket packing for airtight cabins, that will provide high output of labor, greater accuracy, and hermetic sealing of the seam.

11. Development of more perfect methods and means for riveting from one side.

12. Development of a machine of highly technical design of its separate components and units, that would permit a more extensive application to existing as well as to newly developed means for the mechanization of assembly and riveting work STAT, especially, that would make it possible to increase drastically the volume of group press riveting as related to the volume of impact riveting.

The effectiveness of press riveting may be considerably increased by providing the presses with standardized supporting, aligning, and conveying devices. With the availability of highly mechanized means of producing holes and recesses for rivets and with riveting presses, it is possible to change the technical process of assem-

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bly and riveting work, and to build up an extensively mechanized conveyer system for the assembly of aircraft units. With this arrangement, the parts and components will be automatically conveyed through the drilling and countersinking stands and the presses.

It is possible to raise the percentage of press riveting (by the single as well as by the group method) to 80 - 90%. This may be accomplished under the condition that the design of the machinery will satisfy the following requirements:

1. In designing the machine, attention should be paid to subdividing the major units into components and panels in a more efficient technical manner, that would permit group drilling, countersinking, and group press riveting.

2. The panels of major units should be designed, as far as possible, to have the same curvature and have only longitudinal stiffeners.

3. As far as possible, the profiles of components should be of the open type; this would provide free access for drilling and riveting tools during their assembly into complete structures.

4. More extended use of standardized seams as to pitch, diameter, and rivet material should be adopted in the design of the completed product.

Aircraft designers were highly successful in improving the technical features of their machines; in particular, they have made it possible to subdivide major units into panels. The problem facing the technicians is to utilize more fully these possibilities, by developing more efficient technical processes for the fabrication of major riveted units at all stages, including preliminary assembly, drilling, countersinking, insertion of the rivets, riveting, and final assembly of panels with butt joints into major units, as well as assembly of these units.

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The technical process should be carried out with all work highly mechanized, resulting in a good quality of the product and in high efficiency of the plant. It must be remembered that the fabricating of separate panels requires supervision not only of the processes of drilling and riveting, but also of the subsequent processes

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in the assembly of separate panels into major units.

Cases have been observed in the prevailing practice of plants where the mechanization of the riveting work on panels did not give useful results, due to the inefficiency of the technique of general assembly of major units, involving a considerable amount of hand work, that does not result in excellent quality of production nor in high plant efficiency.

Of no less importance with respect to the quality of riveted units, particularly with respect to the strength of the seam, is the automation of the drilling and riveting processes. The principle of automized work, with automatic stoppage of a given operation after obtaining the specified dimensions, ensures uniformity of the manufactured product. For this reason, it is necessary to plan and to introduce tools with automatic action for countersinking recesses, riveting with pneumatic hammers, installation of the rivets in press riveting, and so forth.

The principal measure to be taken for attaining the required quality of products and for increasing plant efficiency is the mechanization and automation of all riveting processes.

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PART IV

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