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ECONOMIC INTELLIGENCE REPORT

THE ELECTRON TUBE INDUSTRY IN THE SOVIET BLOC

CIA/RR 7

29 August 1952

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CENTRAL INTELLIGENCE AGENCY

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Correction

To Holders of CIA/RR 7, 29 August 1952:

The NOTE following the CONTENTS should read as follows:

This report contains information available
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Appendixes

NOTE

This report contains information available to CIA as of 1 January 1951.

CIA/RR 7
(ORR Project 46-51)

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THE ELECTRON TUBE INDUSTRY IN THE SOVIET BLOC

Summary

Production of electron tubes in the Soviet Bloc is the limiting factor which determines the magnitude and breadth of the Soviet military electronics program. Although shortages of tubes are evident in some sectors of the Bloc economy, the present output is believed to be adequate to meet the current, rather austere civilian and military electronics requirements. The distribution-of-output pattern was heavily weighted toward military applications in 1950 and 1951, indicating an acceleration in the build-up of Soviet military electronics capabilities.

A serious vulnerability of the electron tube industry in the Soviet Bloc results from its continuing dependence upon Western sources for specialized production materials. Manufacturing techniques for electron tubes vary somewhat between the USSR and the Satellite industries. The USSR tends to follow US practices, whereas the Satellite countries follow Western European methods. Labor productivity in the Bloc industry is appreciably lower than in the US, although much improvement is indicated for the USSR since 1947.

The value of the Soviet Bloc output of electron tubes in 1951 is estimated at $52 million, including $24 million of transmitting and special tubes. Most of the capacity of the Bloc electron tube industry is concentrated in nine major plants, five of which are in the USSR. Of the total Bloc production, the USSR supplied about 75 percent in 1951. A significant increase in output is anticipated through the use of planned facility expansions and through improved skill of the labor force, and the capacity of the industry is estimated to reach $71 million by 1953. The value of the Bloc output of electric lamps, which are related to electron tubes in the frequent use of common materials and facilities, is estimated at $22 million in 1951.

A marked improvement in the technology of the electron tube industry of the Soviet Bloc is evident, especially for the USSR, between 1947 and 1950. Primarily, this improvement has been due to more efficient tooling, more new factory equipment in use, and greater competence in the technical staff. Of the several tube industries in the Bloc, that of Hungary is the most efficient, and those of East Germany and Czechoslovakia are the least efficient. For the output of tubes and lamps, average productivity during 1951 is measured at $1,800 per employee per year in Hungary, $1,450 in the USSR and $750 in East Germany.

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Throughout the Soviet Bloc, electron tubes allocated to the consumer market have remained at a low level. Civilian consumption is estimated at 16 percent of the total, whereas 64 percent is devoted to the production of military electronic equipment and its maintenance. The balance of the Bloc output is used for essential services and for export to Soviet-controlled areas. There are indications that over half of the entire military share of the Bloc output of tubes is for radar systems, including the quantity production of newer, improved types of radars. Although supply is adequate for current needs, continuing expansion will be necessary if the heavier tube requirements of a general war are to be met, particularly if a large-scale use of expendable devices is intended.

Except for parts of the East German and Czechoslovak electron tube industries, there is no evidence of a shortage of technical and factory personnel or of basic plant machinery in the Soviet Bloc. The weak point at present, as well as the future, is the dependence of the Bloc industry upon Western sources of critical materials, especially tungsten and molybdenum metal products, diamond dies, and, to a lesser extent, mica. If it were feasible, a complete and effective embargo against the shipment to the East of such items would reduce the Bloc capabilities by as much as 50 percent, with a corresponding effect upon Soviet military electronics programs. The concentration of the production of electron tubes in a few major plants creates a serious military vulnerability, although no single facility can be considered as an exclusive key objective.

I. Introduction. 1/*

The industrial development of the electron tube industry in the Soviet Bloc has been closely related to that of the electric lamp industry. In many cases, both products are made in the same plant. Some of the critical production materials are similar in the two industries. Therefore, although this report is devoted primarily to an analysis of the manufacture of electron tubes, data are included on the lamp industry, particularly as related to tube operations.

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A. Nature and Uses.

The electron tube is a device which provides the means for the conduction of electricity through gases or in vacuum and which is intended for use in the detection, amplification, generation, or control of electrical signals. Electron tubes comprise a wide variety of types* and are required in large quantities for the operation of all electronic equipment. (For a catalogue of electron tubes produced in the Soviet Bloc, see the Annex to this report, issued separately.) In the US, for example, net prices range from 35 cents to $2,500 for each tube. Although electron tubes usually are described as a single product group, there are three broad categories in which the facilities and methods are not interchangeable: receiving tubes and allied types, produced in large numbers with automatic equipment; transmitting and special tubes, produced in smaller numbers, generally with less complex plant equipment; and cathode-ray (CR) tubes, requiring special facilities and methods. In order to measure output and input exactly and to evaluate the consumption pattern, a further breakdown of categories is necessary (as indicated in Table 18, Appendix A).

The principal applications of electron tubes are as follows:

1. Production of radio and television receivers.
2. Replacements in existing services and receivers.

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* Various types of electron tubes and related technical terms, as referred to in this report, may be defined as follows:

Tube shrinkage, expressed in percent, is a measure of rejected tubes. It is the ratio of tubes rejected at test and in processing to the total number of internal structure assemblies (tube mounts) started.

Magnetrons, klystrons, TR boxes, and mixer (silicon) crystals are special tubes employed in microwave (centimeter-wave) circuits, primarily radar. These special tubes were developed for use during World War II. The magnetron is a self-excited magnetic-field oscillator, employed as the transmitting output tube and circuit, especially in radars. The klystron is a special form of velocity-modulated ultrahigh-frequency tube. It may be either an oscillator or an amplifier, and a principal use is as the low-power local oscillator in radar receivers. The TR box is a gas-filled diode, used as an antenna switch, for duplexing in radars. The mixer (silicon) cyrstal, not strictly a vacuum tube, is a semiconductor diode, employed as a detector at ultrahigh frequencies and as first detectors in radar receivers.

Miniature tubes define a structural shape for a line of receiving tube, usually 5/8 inch in diameter. Subminiature tubes define another product category of special receiving tubes, shorter than miniatures, 3/8 inch in diameter or less.

3. Production of military communications equipment.
4. Production of military radar and countermeasure equipment.
5. Special military devices such as missile controls and VT (variable-time) fuses.
6. Professional broadcast, communications, and sound equipment.
7. Industrial electronic equipment.
8. Military depot stocks and strategic stockpiling.

In an industrially advanced economy, electron tube requirements usually occur largely in the radio and television market, including replacements. However, the consumption pattern of the Soviet Bloc is devoted principally to military, industrial, and public-service end uses, with a relatively small proportion of production available to the civilian consumer.

B. Importance of the Industry.

Since 1935 the electronics industry has become an important factor in the economies of industrial countries. For example, the 1951 output of the US electronics industry is estimated at $3.3 billion, divided as follows: military electronics, $1 billion; civilian radio and television, $1.3 billion; civilian and commercial telephone and telegraph equipment, $1 billion. The predictions for the output of the US electronics industry in 1952 are $2.4 billion for military electronics, $1 billion for civilian radio and television, $0.8 billion for civilian and commercial telephone and telegraph equipment, or a total for the US electronics industry of $4.2 billion.

Of all component industries which comprise the electronics industry, the manufacture of electron tubes represents the largest economic effort, both in manpower and in plant facilities. In addition, a complete electronics program, either civilian or military, results in heavy requirements for special classes of tubes such as magnetrons and klystrons for radar, CR tubes for indicators and television receivers, and subminiature tubes for fuses. The pattern of electronics in the Soviet Bloc clearly indicates lesser quantities and simpler devices than are considered to be necessary in Western planning. The electron tube industry, however, represents a major industrial effort for the Soviet economy.

Rigid security measures, high-priority attention given to tube facilities, and the heavy postwar effort in the USSR to acquire plant and technical assistance from occupied areas confirm the importance of the electron tube industry to the USSR as well as to the Satellite countries. The electron tube industry of the Soviet Bloc deserves primary consideration as an intelligence objective, since this is the most important factor in determining Soviet industrial capabilities for electronics, as well as the best indicator, in both magnitude and kind, for the evaluation of the military electronics program.

C. History of the Industry. 2/

As in the US and in Western Europe, the manufacture of electron tubes in the Soviet Bloc areas has developed close affiliation with the manufacture of electric lamps. The emergence of this latter industry in Central and Eastern Europe occurred after World War I, largely through the commercial effort of the AEG (Allgemeine Elektrische Gesellschaft AG) and Siemens-Halske AG, with their Telefunken and Osram subsidiaries, of Germany; the N.V. Philips Company, of the Netherlands; and the United Incandescent Lamp Company -- Tungsram, commonly known as UILCO "Tungsram," of Hungary. The highly specialized industry for the manufacture of tubes, lamps, and parts was concentrated geographically in Berlin and Budapest, with lesser facilities in Vienna, Prague, and Bratislava.

1. USSR.

In the USSR, German electrical combines had established facilities in Leningrad, Riga, and Moscow before the Russian revolution. The present Soviet tube and lamp industry was established on a small scale by 1923. The foundation for the present Soviet electron tube industry as an effective manufacturing program was established in 1935 under the direction of a section of the Ministry of Electrical Industry dealing with communications equipment. This program was implemented by technical assistance, manufacturing equipment, and production supplies furnished under a contract with the US Radio Corporation of America (RCA). By 1938, US-made facilities provided production capacity for receiving tubes, transmitting tubes, and a limited number of CR tubes. This expansion program provided for a theoretical capacity of 30 million tubes a year, divided between the Svetlana Plant [redacted] in Leningrad 50X1
and the Shchelkovo Plant near Moscow, but this output was never realized from the 14 production units supplied. By 1940 the maximum annual production rate attained was 8 million tubes. At that time, Soviet manufacture of lamps was concentrated at the Svetlana Plant [redacted] in Leningrad and 50X1
the Electric Lamp Works [redacted] in Moscow. 50X1

Early in World War II it became necessary to evacuate farther east a major portion of the tube facilities of the Leningrad and Moscow area, principally to Novosibirsk and Tashkent, and much of the effective tube-making capacity was lost. Most World War II requirements of the USSR for vacuum tubes and for the production of tube materials were supplied by the US. Some shipments of tube machinery, especially grid lathes and stem machines, were made. Following World War II, tube facilities were reestablished at Leningrad and Moscow. In addition, manufacturing operations were maintained at the major evacuation plants at Novosibirsk and Tashkent. Large amounts of manufacturing machinery were removed from electron tube industries in Germany, Czechoslovakia, and Hungary. To supplement this added plant equipment, a group of several hundred German specialists was employed in the USSR from October 1946 through the end of 1950. Major changes in the effective ness of the Soviet electron tube industry were seen between 1948 and 1951, and by the end of 1950 the industry was operating at a scale larger than anything previously planned. It is apparent that manufacturing techniques and plant operations have improved to a point where the Soviet tube industry currently can be considered both competent and large according to European standards. (For further discussion of the electronics industry in the USSR, see Appendix B.)

2. Hungary.

The tube and lamp industry in Hungary was not disrupted during World War II. Although up to 90 percent of the manufacturing machinery was removed early in the Soviet occupation, no key personnel moved to the USSR. The industry was quickly reequiped and reorganized, partly with new machinery and partly with machinery retained from the Soviet dismantling. The Budapest industry is efficient and relatively large. Before World War II, UILCO "Tungsram" was the third largest European company in its field, exceeded only by Philips of the Netherlands and Osram of Germany. The Hungarian tube and lamp industry must be considered currently as one of the major contributors to the Soviet Bloc electronics industry.

3. East Germany.

In East Germany the present tube and lamp industry operates in former facilities of the AEG, Telefunken, and Osram companies. Before World War II the German electrotechnical industry was heavily concentrated around Berlin, where it still is the largest manufacturing industry. During World War II, however, some operations were dispersed, especially to eastern sections of Germany and to Czechoslovakia. With the Soviet occupation, the East German electron tube industry became a primary target for removal to the USSR, and most tube manufacturing equipment and a large number of specialists were moved to the USSR, first in 1946 and again in 1948. As a result of this enforced displacement of men and materials and of the separation from parent organizations in West Germany, the East German tube industry was somewhat disorganized from 1945 to 1949. In particular, the industry suffered from a lack of skilled employees, specialized materials, and technical plant equipment. Considerable improvement has been indicated since 1949, although the East German tube industry remains smaller and relatively less competent than its West German counterpart.

4. Czechoslovakia.

The Czechoslovak tube and lamp industry before World War II comprised branch plants of Philips and of UILCO "Tungsram" located in Prague, Bratislava, and Vrchlabi. In the postwar period the manufacture of tubes was continued at relatively low levels, and considerable difficulty has been reported in obtaining production materials and in maintaining adequate plant efficiency. Starting in 1950, the tube manufacturing operations were consolidated and scheduled for removal to the town of Roznov pod Radhostem. A sizable manufacturing establishment was planned as a result of this move, utilizing equipment and trained manpower from other Czechoslovak areas as well as new equipment to be imported from the Netherlands and the UK. Recently, this move was reported as being complete, and in the future a significant contribution can be expected from the Czechoslovak electron tube industry.

5. Other Satellites.

In other Satellite countries, prewar facilities for the manufacture of electron tubes and electric lamps generally were small and were branch plants of Philips, UILCO "Tungsram," or Osram. No significant contribution is evident at this time from those plants which are still in operation.

D. Technology. 3/

1. USSR.

In general, electron tube manufacturing methods in the USSR are more similar to those of the US than they are to those of Germany. Technical plant equipment reported to be in the Soviet electron tube industry comprises a large amount of US prewar and Lend-Lease equipment and dismantled German Telefunken equipment, supplemented by an increasing quantity of postwar indigenous Soviet machinery. Most of the German equipment is less productive than similar US equipment. For example, German automatic exhaust machines produce 240 tubes an hour as compared with 500 to 600 tubes an hour produced on the US-built sealex units installed in the USSR. New tube machinery made in the USSR includes sealex machines, stem and glass-sealing machines, filament winders, grid lathes, and automatic glass-blowing machinery. These postwar Soviet units probably are basically similar to modern US designs. In at least one plant, native Soviet equipment is used generally for the manufacture of large transmitting tubes.

Competent tooling for efficient, low-cost structural designs is now evident. The Soviet tube and lamp plants make more of their required parts and fabricated production materials than do US plants. It is noted, in particular, that the major Soviet plants have their own glass-making shops integrated with their tube and plant factories. Testing of tubes in the USSR is reported to be generally in accordance with US Army-Navy specifications.

Large transmitting tubes and some special tubes, such as klystrons, frequently are of Soviet design. Small transmitting tubes and nearly all receiving tubes are essentially copies of US tube types. In general, the variety of types manufactured in the USSR is restricted in number, although the available Soviet tubes cover a full range of applications, both in power and in frequency. Soviet electric lamps manufactured include an adequate variety of general-service lamps, miniature lamps, and fluorescent lamps.

Changes are evident between the early postwar Soviet tube technology and that of 1950. At present there is evidence of excellent tooling, comparable to current US practice, and the quality of electron tubes appears to be quite acceptable, with the exception of possible heater trouble. Tube shrinkage, or the percentage of tubes rejected during manufacture, appears to be reasonable, although somewhat higher than the US average, probably ranging from 25 to 30 percent (higher on special types). Production of metal receiving tubes is limited, with most of the Soviet output composed of glass types, including sprayed shields where required.

The status of Soviet industrial technology for the manufacture of electron tubes is summarized as follows:

a. Tubes generally follow US designs, with little evidence of German influence.
b. Factory tooling is good.
c. Automatic plant equipment is available, including US, German, and postwar Soviet units.
d. Tube shrinkage is at an acceptable level.

e. At the more important tube and lamp plants there is evidence of a high degree of experience and technical competence throughout the management, supervisory, and top engineering personnel, and new technicians have been trained in considerable numbers.

f. If required, Soviet tube manufacturing operations should be satisfactory and readily expandable.

2. Hungary.

The Hungarian engineering industry is well organized and competent in its narrow areas of speciality. Historically a major contributor to world markets in electrotechnical products and developments and little disturbed during World War II, the Hungarian electronics industry enjoys a high level of technology. This industry is now producing mostly European-type tubes, but there is increasing evidence of greater production in US tube types. A wide range of general-service lamps and fluorescent lamps is manufactured.

The manufacturing efficiency of the Hungarian electronics industry is high, limited to some extent by shortages in the supply of such specialized critical materials as molybdenum, tungsten, mica, and pure nickel. Although plant efficiency is hampered by the occasional need to use inferior materials and by overworked factory labor, there is no evidence of reduced technological competence.

The Hungarian electronics industry has effectively and completely replaced its prewar plant equipment, using equipment of domestic design based upon the best features of US, Telefunken, and Osram machinery features. For example, new plant equipment includes entirely acceptable Ivanhoe glass bulb-blowing automatics and lamp-making machinery operating at a speed of 1,200 units an hour, as compared with 1,250 an hour for current US machines. It is possible that this new equipment installed in the Budapest tube and lamp industry may outweigh the other factors which detract from the efficiency of the industry.

In addition to its position as second in size within the Soviet Bloc, the Hungarian tube and lamp industry very probably is the most advanced in industrial technology and manufacturing efficiency.

3. East Germany.

The East German electron tube industry still is recovering from two drawbacks — its separation from West Germany and the effects of Soviet postwar dismantling. The industry is noticeably less efficient and less competent technically than would be normal for this sector of the German engineering industry. Furthermore, German methods and plant equipment in the electronics industry are notoriously wasteful of manpower, and an analysis of recent East German tube structures indicates the need for much hand labor.

One advantage of the East German tube designs is the greatly simplified tooling required, consuming much less tooling effort than that required in the US and the USSR. A second advantage is the general tendency to provide better quality of tubes than would be feasible in the US.

Although a wide variety of important materials for the production of tubes and lamps is readily available from indigenous supplies within East Germany, including excellent technical glass and electron tube ceramics, the tube and lamp industry still is dependent upon West German sources for a large number of more specialized materials. The frequent failure to obtain these materials in sufficient quantities and the need for substituting inferior items necessarily reduce the capability of the industry.

The East German tube plants are reported to use generally existing German types of technical plant equipment. Exhaust machines are the Telefunken 48-head automatic rotary pumps, operated at 200 tubes an hour. Although new 25-head units with Leyboldt diffusion pumps are being constructed and will operate at 350 tubes an hour, none of these units was in use in mid-1951.

The output of the East German tube and lamp industrial technology still is restricted by lack of special materials and necessary items of new plant equipment, and its labor productivity is relatively low even by European standards. The quality of its products, however, appears to be quite acceptable, and its rate of shrinkage appears to be entirely reasonable. On the basis of its level of technology, the East German tube and lamp industry ranks third within the Soviet Bloc.

4. Czechoslovakia.

Never a leading supplier of electronics products in the past, Czechoslovakia's present position in the tube and lamp industry is rather weak. Most of the tube effort of the industry is devoted to standard European types, such as Philips and Telefunken. It is reported that manufacturing was started on a few US types in late 1949 or early 1950.

Some new postwar plant machinery has been built, copied from older Philips and Osram models, and additional machinery has been imported from Western sources. Although the skill and efficiency in producing blown and formed glass parts has been high, frequent reports have been made of serious difficulties in glass-working at the tube plants. Pumping techniques at the tube plants have not been satisfactory.

The Czechoslovak industrial technology for the manufacture of electron tubes has been mediocre, with many instances of inferior methods, and its shrinkage rate has been high. In general, plant equipment in Czechoslovakia has been inefficient, being comprised of old prewar German and Dutch machines, but this equipment is slowly being replaced. Improvement in factory operations is to be expected at the new Roznov pod Radhostem plant facility when full operations are reached. It is probable that the Czechoslovak electron tube industry will continue for some time to be a high-cost producer of limited capabilities.

5. Other Satellites.

In the other Satellites there are no significant electron tube industries. Potential capabilities of these Satellites are not important, and their technology for the manufacture of tubes and lamps is relatively primitive. In Poland, where the electronics industry was almost entirely destroyed during World War II, a limited level of tube manufacturing had been reached by the end of 1950.

There is a relatively small production of electric lamps in tube facilities in Rumania, but there are no indications of any work being done on electron tubes.

In China a small tube and lamp industry has existed for some time, producing low-grade miniature and general-service lamps. One tube plant is known to exist, but its capabilities are extremely limited both in scope of product and in size of output.

E. Reliability of Estimates.

In order to indicate the degree of reliability of the quantitative data in this report, the total quantity, content detail, and apparent validity of the available information used to support the estimate of the output of the Soviet Bloc electron tube industry in 1951 have been reviewed. Four general conclusions may be made:

1. The accuracy of the estimate for output of the East German electron industry is reasonably good. The estimate for the Soviet industry is subject to wider tolerances than those for the Satellites.

2. The accuracy of the estimate for output of electric lamps is better than that for electron tubes.

3. Of the various types of supporting information available, the data for industry inputs are relatively more valid than are the data for output.

4. Estimates of output of the several countries are more accurate when expressed in terms of production value than they are when expressed in units.

In view of the lack of recent substantive data for some of the more important facilities, an estimate of the annual value of Soviet Bloc production is necessarily subject to error. The estimate used in this report -- $52 million -- is possibly too high or slightly low. It is believed that the actual output for the Soviet Bloc in 1951 would be no less than $35 million and no more than $60 million. For electric lamps, estimated at a total output for the Bloc of $22.5 million, the possible range is believed to be from $19 million to $26 million.

II. Organization of the Industry. 4/

A. USSR.

Electronics production in the USSR is administered by the Ministry of the Communications Equipment Industry, headed since May 1947 by G.V. Aleksenko. Electron tubes are produced under this Ministry according to a production plan determined by the Politburo and assigned by the Ministry to various organizations within the industry.

Although some radar equipment, probably for use on ships of the Red Fleet, is produced in plants under the Fourth Chief Directorate of the

Ministry of Shipbuilding Industry, no tubes are known to be produced under this Ministry. It must be assumed, therefore, that electron tubes for use in end equipment made under this Ministry are obtained from plants under the Ministry of Communications Equipment Industry. The Ministry of Shipbuilding Industry is headed by V.A. Malyshev. Commercial activities are carried on for the plants by the Ministry of Communications Equipment Industry, and this Ministry supplies many other Ministries with tubes both for original use and for replacement use.

B. Hungary. 5/

The integration of the Hungarian economy in the Soviet Bloc is well advanced, and Soviet-type controls are applied to the industrial sectors. The continued subservience to the USSR of top-level Hungarian administrators, many of whom are Soviet-trained, reinforces the Soviet economic hold on Hungary and promotes its increased dependence upon the USSR.

The Hungarian tube and lamp industry consists of two enterprises. The first and larger is the Egyesült Izzolampaés Villamosségi R.-T. (United Incandescent Lamp Company), commonly known as UILCO "Tungsram." The second enterprise, much smaller, is the Hungarian Transmitting Tube Factory, formerly the Hungarian Philips works. Both enterprises are administered by the Ministry of Heavy Industry. In matters relative to foreign trade, both company activities are controlled by Elektroimpex, an agency under the Hungarian Ministry of Foreign Trade.

As a foreign-owned enterprise, the former Netherlands-owned Philips Company was nationalized apparently late in 1950. Negotiations toward a settlement of differences resulting from this nationalization continued between the Dutch and the Hungarian governments through 1951. [redacted] an end of these discussions, with no satisfactory agreement being reached.

Before the nationalization of Hungarian industry, UILCO "Tungsram" of Hungary comprised the operations of Tungsram, the Hungarian Wolfram Company (Orion), and the Remix Electrotechnical Works Company Limited (Remix), together with several other smaller subsidiary plants in Hungary. Nationalization of the parent enterprise UILCO "Tungsram" was scheduled several years ago and probably was in effect for a very short time. However, in order to avoid foreign legal difficulties with respect to minority stockholders in the US, the UK, and the Netherlands, and with respect to Tungsram manufacturing and sales affiliates in foreign countries, the UILCO "Tungsram" combine in Hungary has been classified as a private company, although several of the smaller affiliated or subsidiary operations appear to have become fully nationalized. Actually, this maneuver is nothing more than a legal subterfuge, since well over 50 percent of the corporate stock of this combine is owned by the Hungarian government. In effect, its policies and operations are as fully government-controlled as if the organization had been nationalized.

Foreign subsidiaries directly controlled by the Hungarian enterprise UILCO "Tungsram" include the Watt AG plants in Vienna and Lambach, Austria, and smaller subsidiaries in Argentina, Switzerland, and Sweden. The several former UILCO "Tungsram" subsidiaries in the other Satellites are not controlled by the Hungarian company, since all of these have become nationalized in their respective countries. Four former UILCO "Tungsram" subsidiaries exist in the UK, France, the Netherlands, and Italy. At present, these four firms are neither owned nor controlled directly by the Hungarian parent company. However, an apparently valid long-term debt is owed to the Hungarian company by these firms in Western Europe, and it has been recently reported that an agreement reached in Paris between representatives of the West European interests and officials of the Hungarian Ministry of Finance provides for payment of this debt through exports of critically needed production materials from France to the Hungarian enterprise.

Therefore, although the major enterprise in the Hungarian tube and lamp industry has not been officially nationalized, it is clear that the entire tube and lamp industry of Hungary, together with its affiliated subsidiary activities, is completely controlled by the Communist government. The tube and lamp industry is completely staffed, operated, and managed by Hungarian personnel, and there is little evidence to indicate intimate association at the operational level between the Hungarians and Soviet administrators. However, the postwar acquisition by the USSR of a sizable block of UILCO "Tungsram" stock, together with the known joint Soviet-Hungarian control over industrial policies, insures the complete integration of this industry within the economic and military objectives of the Soviet Bloc.

Furthermore, there is confirmed evidence of a continuing and effective influence exerted by the parent Hungarian enterprise over the affairs of its prior-affiliated subsidiaries in Western Europe, and it must be concluded that these significant enterprises within the electronics industry of Western Europe are subject to pressures which encourage the movement of critical materials and technical information from the West to the East.

C. East Germany. 6/

In East Germany, all of the plants engaged in the development and production of electron tubes and electric lamps are either people-owned enterprises or members of a Soviet-owned stock corporation. None of the organizations is privately or locally owned.

A German Democratic Republic decree, issued in December 1950, called for a reorganization of East German economic ministries. This program was to modify effectively the previous structure of the Association of People-owned Enterprises (Vereinigung Volkseigene Betriebe -- VVB) for engineering industries and was scheduled to be completed 1 April 1951. The newly formed Ministry for Machinery Construction had its headquarters, after 1 May 1951, at the Knorrbremse Building, Warschauerstrasse, Berlin. At present, it heads six main administrations (HV's), including the HV Elektrotechnik, which controls all VVB plants and laboratories in East Germany which are concerned with either electronics or heavy electrical manufacturing.

This people-owned portion of the East German electrotechnical industry represents from 70 to 75 percent of the total East German effort in this industry. It is comprised of four groups divided as follows: VVB-VEM, made up of 23 consolidated firms with about 15,000 employees and engaged in the development and manufacture of electrical machinery; VVB-IKA, having 51 consolidated firms with about 20,000 employees and engaged in the production and supply of electrical fittings, insulation, cables, batteries, and some radio parts; VVB-RFT, with 39 consolidated firms having from 18,000 to 19,000 employees and engaged in the development and manufacture of electronic and telecommunications end equipment and component parts; and 17 key firms, with about 35,000 employees, reporting directly to the HV Elektrotechnik rather than through one of the VVB's (of these key firms, 10 are in the electronics field with about 15,000 employees).

In addition to the East German electronics firms controlled by the Ministry for Machinery Construction, there are 13 large and important electrotechnical firms which are Soviet-owned and which are controlled directly by Moscow through the Main Administration of Soviet Corporations in Germany. For purposes of planning, payment, and materials allocation, however, these 13 firms are affiliated with the economic ministries of the German Democratic Republic. All of these electrotechnical firms are organized under the Soviet-owned SAG (Sowjetische Aktien Gesellschaft) Kabel. Approximately from 30,000 to 35,000 employees at the SAG Kabel are engaged in the development and manufacture of electronic equipment, instruments, tubes, wire and cable, motors, batteries, graphite parts, and insulators.

Normally, it was intended that the entire output of the SAG firms in East Germany should be delivered to the USSR outside of reparations accounts. A significant portion of the SAG Kabel production, nevertheless, had to be shipped for the reparations account, and the SAG was reimbursed for these shipments by materials and component deliveries from German people-owned sources. In addition, the SAG has had to deliver certain items required by both the people-owned and the SAG enterprises of the German electrical technical industry.

The East German tube and lamp industry has been completely consolidated within this planned economic structure. There are four tube factories in East Germany, three of which are of significant size, the fourth being quite small. Of the three large firms, the first in importance is a key subsidiary of the SAG Kabel; the other two are people-owned firms which are administered directly as key enterprises by the HV Elektrotechnik rather than being subsidiary to the VVB-RFT.

In addition to the tube plants, there are seven electric lamp firms in East Germany, of which three are of significant size. These three large plants are listed as key enterprises of the HV Elektrotechnik and, like the tube plants, do not report to the VVB-RFT.

In addition to the normal planning procedures which are established by decree within the German Democratic Republic and which cover matters of planned production schedules, investment, and material allocations, a closer degree of cooperation between all interested elements of the East German tube and lamp industry is encouraged through the operations of the Special Commission for Radio Tubes. This Commission includes members from the tube and lamp facilities, from key suppliers of critical materials, from the SAG Kabel, from the Main Administration of the Ministry for Machinery Construction, and from the State Planning Ministry of the German Democratic Republic.

The organization of all the important facilities of the East German tube and lamp industry as key firms of the Ministry or of the Soviet-owned SAG, the obvious effort made to insure adequate supply of materials both from indigenous and from Western sources, and the establishment of a special commission to handle industry problems indicate that a high degree of importance is attached to this industry in East Germany.

D. Czechoslovakia. 7/

The latest reorganization of Czechoslovak industry brings productive resources under a system closely resembling the Soviet system. There are at present several ministries such as the Ministry of Heavy Engineering, the Ministry of Fuel and Power, the Ministry of Light Industry, the Ministry of Building Construction, and several others. It is thought that electrotechnical activities are under the administration of the Ministry of Light Industry. All of the Ministries are under the Chairman of the Party.

The Ministry of Light Industry is headed by Alois Malek. Under him are four housekeeping bodies which supervise such matters as personnel, planning, social and political activities, and finance. Also under the Ministry are several Central Managements which control the production of the various categories of products manufactured by plants falling under this Ministry. The Central Management for Precision Machinery is believed to have charge of the activities of the electronics industry.

Three organizations -- the VTU; the KOVO Company Limited; and Technospol -- are important in the administration of the Soviet electron tube industry.

The VTU (Military Technical Aviation Institute) is a governmental organization engaged in development work for the armed forces, including development in the electronics field. The VTU, which stands in much the same relation to Tesla and the other electrotechnical plants in Czechoslovakia as do the Army, Navy, and Air Force development activities to the electrotechnical companies in the US, is responsible for the development of practically all military equipment in Czechoslovakia.

The KOVO Company Limited, is a national importing and exporting organization under the administration of the Ministry of Foreign Trade. This national corporation is responsible for all of the importing and exporting activity carried on in behalf of the industries which it serves, one of which is the electronics industry. The chief of the KOVO Company Limited, is charged with the negotiation on behalf of these industries of trade instruments with foreign nations, with the carrying on of exporting and importing as related to domestic production, and with the furnishing of information for trading purposes, both to domestic and foreign firms. [redacted] 50X1
[redacted] The address of the 50X1
division of KOVO which handles imports into the electronics and electrical machinery industries is Karlovo Namesti 7, Prague 2, which also is the address of the management of the Tesla State Enterprise.

The large volume of business being carried on in 1951 by the KOVO Company Limited, as one of the largest corporations in the world, forced the division of the company into three independent licensed corporations. The three new corporations are as follows: Investa, which is responsible for trading in heavy machinery; KOVO, which handles trading in precision and electrotechnical goods; and Motokov, which deals with the products of light industry, including lamps. On 1 January 1951 the title of the parent KOVO was changed to KOVO Limited, Metal and Engineering Products and Raw Materials Trading Company, and the subsidiary, dealing in precision and electrotechnical goods, was changed officially to KOVO Limited, Precision Engineering Products and Import and Export Company.

The government organization Technospol under the Ministry of Foreign Trade is charged with the responsibility for obtaining and conveying of patent rights from and to foreign nations. Technospol also provides production data and other information of interest to the scientific and engineering industries.

The electron tube industry of Czechoslovakia is concerned principally with the supplying of domestic military requirements as well as of tubes for use in domestically made broadcast receivers. Some end equipment made in Czechoslovakia is sent to the USSR, but, except for some exports which are sent to the rest of the Bloc and perhaps to the West, tubes are utilized within the country itself. The industry concentrates on European tube types, although some US types have been copied successfully. The production of magnetrons and klystrons is very unsatisfactory, probably indicating an insignificant microwave radar program. In the CR tube field, modifications of foreign types are carried on reasonably successfully, but there is no development of native designs. Probably the major Czechoslovak electron tube effort is directed toward receiving types for domestic and military communications equipment.

Czechoslovakia is attempting to increase its tube manufacturing capacity, but there is a serious shortage of trained development, research, and production personnel.

III. Supply. 8/

A. Production.

The USSR produces a limited number of different types of receiving tubes, most of which are copies of US types. In general, the Soviets do not produce a new type for each new function but try to utilize the types already successfully in production for each new application encountered.

The limitations of this practice, which often results in somewhat unsatisfactory performance, have been admitted in Soviet technical publications. Types of receiving tubes produced in the USSR include metal, glass, metallized glass, miniatures, subminiatures, battery types, and small transmitting tubes produced by receiving tube methods, generally copies of US types.

The USSR produces the more conventional types of transmitting tubes, principally of Soviet design and with Soviet numberings. Also produced are microwave generating tubes such as magnetrons, as well as klystrons and lighthouse tubes, and CR tubes for direct-view television, radar, and test equipment applications, principally with Soviet numberings, indicating domestic design. [redacted] 50X1
50X1

The production effort of electron tubes in the Satellite countries is oriented primarily toward supplying the Satellites with tubes for their military needs. Thus the Satellites do not have a large output of US receiving types, although some tubes are made in East Germany. More common among the Satellites is the production of glass types, with a variety of bases common to the European tubes.

Power transmitting tubes of the more common types are produced in the Satellite countries. Although there were facilities on hand in East Germany for the manufacture of microwave tubes, it is thought that these facilities have been moved to the USSR, so that at present there probably is little or no production of these types. There is some CR tube production in the Satellites, principally for television and test equipment applications.

1. Soviet Tube and Lamp Industry. 9/

The most notable features of the postwar Soviet tube and lamp industry have been the considerable expansion of facilities, adequate training of both semiskilled and technical personnel, improvements in methods and tooling, and reduction in production shrinkage. Although the USSR still is partially dependent upon Western sources for a few specialized materials, shortages of materials have not been a limiting factor.

There are five principal tube and lamp manufacturing facilities in the USSR and at least seven lesser facilities. These major plants operating in the USSR under a Directorate of the Ministry of the Communications Equipment Industry are the following: Electric Lamp Works [redacted] 50X1
Moscow; Svetlana Plant [redacted] Leningrad; Institute [redacted] Fryazino 50X11

(Shchelkovo), Moscow Oblast; Electric Lamp Plant [redacted] Novosibirsk; 50X1
and Electric Lamp Plant [redacted], Tashkent. By the end of 1950 50X1
the industry personnel totaled approximately 35,000, including 29,000 in these five major plants.

Other Soviet firms believed to be manufacturing either tubes or lamps, or both, are the following: Vaists Elektrotechnika Fabrika (VEF), Riga; Electric Lamp Plant, L'vov; Solch Lamp Plant, Tirga (Prokopyevsk); Ryazan Electric Lamp Plant [redacted] Ryazan Oblast; and the Radio Tube Plant, Tomsk. 50X1

a. Output.

Before the effective utilization of the extensive postwar expansion the Soviet tube and lamp industry in general was operating inefficiently and at relatively low levels. The total output of the industry for the 3-year period of 1946 through 1948 is estimated to have been 3 million tubes of all types and categories, valued at $36 million, and 240 million lamps of all sizes and types, valued at $22 million. The Soviet tube and lamp industry manufactures a complete line of products. Tubes range from subminiature varieties up to water-cooled 250-kilowatt transmitting tubes. The production during recent years of the Soviet lamp and tube industry is summarized in Table 1.* (Production of electron tubes and electric lamps in the USSR is given by plant in Appendix D.)

Assuming that demand for its products continues to be high and that the potential increase in the skill of the labor force which is believed to be possible is attained, the Soviet tube and lamp industry will continue to expand. Summarized in Table 2** is the estimated production capacity believed to be possible by late 1952 or 1953.

b. Productivity.

The employment and production output data for the Soviet tube and lamp industry indicate that average productivity is on the order of $1,300 per employee per year. This measure of productivity is almost exactly half-way between the values measured for Hungary and for East Germany. The 1951 industry data for the USSR anticipate an increase in this average productivity to $1,450 per employee per year. For purposes of comparison, estimated productivity averaged six electric lamps per employee per hour and 0.9 receiving tube per employee per hour. For these

* Table 1 follows on p. 21.
** Table 2 follows on p. 22.

Table 1

Production of the Soviet Tube and Lamp Industry
1949-51

Year	Receiving Tubes		Special Tubes		All Tubes		All Lamps	
	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/
1949	21,000	12,300	790	11,600	21,790	23,900	109,000	9,800
1950	29,000	18,500	1,015	15,200	30,015	33,700	120,000	10,800
1951	33,800	21,400	1,283	18,800	35,083	40,200	125,000	11,200

a. Value data based upon current US f.o.b. prices for equivalent products.

Table 2

Estimated Production Capacity of the Soviet Tube and Lamp Industry
1952-53

Receiving Tubes		Special Tubes		All Tubes		All Lamps	
Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/
44,500	27,800	1,700	24,200	46,200	52,000	142,000	12,500

a. Value data based upon current US f.o.b. prices for equivalent products.

two categories the relative labor productivity of the Soviet industry would appear to be about one-sixth that of the US.

Female personnel predominate in the Soviet electron tube industry. Factory labor is reported as being well trained in the older establishments. The relatively recent improvement in Soviet productivity for this industry, as compared with its counterpart in East Germany, is attributed to new plant equipment, improved employee training, and satisfactory low-cost designs of products.

2. Hungarian Tube and Lamp Industry. 10/

The Hungarian tube and lamp industry is comprised of two enterprises. The larger is the UILCO "Tungsram" combine at Vaciut 77, Ujpest, and the Hungarian Transmitting Tube Factory, formerly Hungarian Philips, at Vaciut 169, Budapest 13.

a. Output.

For 1951 the output of the Hungarian tube and lamp industry is estimated to have been 4.5 million tubes, including all types, plus 41 million electric lamps, or a total value of $9.5 million. The extent to which the Hungarian tube and lamp industry can be expanded during the next 2 years appears to depend upon three factors: first, the availability of semiskilled labor in the Ujpest-Budapest metropolitan area; second, the success which Elektroimpex of Hungary will meet in obtaining specialized production materials from West European suppliers; and, third, the demand for tubes and lamps, both within the Soviet Bloc and from other world markets. At the present time there is no basis on which to predict the probable future effective production capacity of the Hungarian tube and lamp industry. Known expansions within Hungary for the production of technical glass and rare gases and for reported plant rearrangements indicate that the 1951 production level may be increased by 25 to 35 percent by 1953. (Production of electron tubes and electric lamps in Hungary is given by plant in Appendix D.)

b. Productivity.

An analysis of the 1951 data for the UILCO "Tungsram" tube and lamp complex at Ujpest indicates an output of $1,800 per employee per year as compared with the prewar output of $1,600 per employee per year. The increase is attributed to the almost complete set of new equipment, together with advances in processing methods. A further refinement in this over-all figure for 1951 results in a productivity ratio of 9 incandescent lamps per employee per hour and of 1.6 standard receiving tubes per employee per hour. Statistically, this productivity for the Hungarian industry is about midway between that of France and of the UK for receiving tubes and is about equal to West European productivity for electric lamps. For both product lines, in terms of units produced per employee per hour, Hungarian productivity is very nearly one-quarter of that of the US.

3. East German Tube and Lamp Industry.

Until early 1950, progress and development of the East German tube and lamp industry were seriously hampered by lack of skilled labor, by lack of engineers, and by recurring shortages in the supply of specialized production materials. More recently the materials problem has been eased, in part through the establishment of the local fabricating facilities and in part through increased imports. Recent information indicates that this industry, as a result of improved plant efficiency, was able in 1950 to increase total output over that of 1948 and 1949.

There are four principal facilities for the manufacture of electron tubes in East Germany, and references have been made to four less important establishments. The four larger plants are Werk fuer Fernmeldewesen HF (OSW), Berlin-Oberschoeneweide, Ostendstrasse 1-5, a member plant of the Soviet-owned SAG Kabel; Funkwerk Erfurt VEB, Rudolphstrasse, Erfurt, Thuringia, formerly a VVB-RFT plant, now controlled directly by the HV Elektrotechnik of the Ministry for Machinery Construction; Roehrenwerk Neuhaus VEB, 2 Waldstrasse, Neuhaus am Rennweg, Thuringia, formerly a VVB-RFT plant, now controlled directly by the HV Elektrotechnik; and the RFT Phonetika Radio VEB, Franz-Joseph Strasse 112, Berlin-Weissensee, a member of the VVB-RFT.

The less important establishments which have been referred to are enumerated as follows. Roehrenwerk in Radeberg, a former Lorenz factory and a postwar receiving tube plant which at one time had 120 employees, was dissolved in February 1949, the equipment and key personnel being consolidated with Funkwerk Erfurt. RFT Roehrenwerk VEB Senftenberg, 10a Bahnhofstrasse, Senftenberg, Nieder Lausitz, was formerly a branch plant of the German AEG RFO Factory (since Soviet control the OSW) and was reported earlier as making 180,000 East Deutsche Mark (EDM) worth a month of rectifiers and receiving tubes. It was not shown on the 1951 list of RFT plants and presumably is not presently engaged in tube work. Fernmeldewerk Arnstadt, 6 Bierweg, Arnstadt, Thuringia, engaged in television and CR tube development and production before mid-1948, at present is directly under the HV Elektrotechnik and is engaged in radio and apparatus construction only. Key personnel and all equipment relative to tubes have been removed to the Leningrad area. Technische Physische Werkstatten, in Thalheim, Gronsdorf, and in Zwoenitz, formerly the Erzyebirge complex of AEG, was organized as a SAG firm until mid-1948 and did work on CR tubes, electron optics, and oscillographs. It was dismantled and removed to Leningrad, along with Fernmeldewerk Arnstadt. The plant with the remaining employees was consolidated with the SAG Kabel member plant Siemens-Halske, Zwoenitz, and is not now engaged in tube work.

There are seven electric lamp manufacturing facilities in East Germany. The three largest of these firms, directly administered by the HV Elektrotechnik, are Gluehlampenwerk VEB Dresden, Dresden N 23 (N52/F 29), 92 Grossenhainerstrasse; Gluehlampenwerk VEB Plauen, Plauen/Vogtland (M51/K 12), 6 Dimitroffstrasse; and Berlin Gluehlampenwerk VEB (BGW), Berlin O17 (N53/Z 75), 20/23 Rotherstrasse. The four lesser lamp plants are Gluehlampenwerk VEB Zwickau, Zwickau, Saxony; Gluehlampenwerk VEB Eisenach, Eisenach, Thuringia; Gluehlampenwerk VEB Oberweinsbach, Oberweinsbach, Thuringia; and Gluehlampenwerk VEB Grossbreitenbach, Grossbreitenbach, Thuringia.

a. Output of the Tube Industry. 11/

The 1949-51 production of the East German electron tube industry is summarized in Table 3.* (Production of electron tubes and electric lamps in East Germany is given by plant in Appendix D.)

The East German tube industry, hampered greatly by shortages and lack of direction before 1949, was producing inefficiently and at a relatively low level. The total output for the 3-year period of 1946-48, including all classes of tubes, is estimated to have been approximately 2.6 million tubes, having a factory sales value of $1.7 million.

Assuming that demand for tubes continues to be high, expansion of the East German tube industry will provide an effective production capacity, by late 1952 or 1953, as indicated in Table 4.**

b. Output of the Lamp Industry. 12/

The East German producers of electric lamps were severely limited by materials shortages through 1949. Total industry production of lamps is estimated in Table 5.*** Further expansion in output of lamps

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* Table 3 follows on p. 26.
** Table 4 follows on p. 27.
*** Table 5 follows on p. 28.

Table 3

Production of the East German Electron Tube Industry
1949-51

	Receiving Tubes		Special Tubes		Cathode-ray Tubes		All Tubes	
Year	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/
1949	1,570	890	56	300	0	0	1,626	1,290
1950	2,750	1,495	60	526	1	20	2,811	2,041
1951	3,606	1,930	108	1,290	25	410	3,739	3,630

a. Value data based upon current US f.o.b. prices for equivalent products.

Table 4

Estimated Production Capacity of the East German Electron Tube Industry
1952-53

Receiving Tubes		Special Tubes		Cathode-ray Tubes		All Tubes	
Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/
4,470	2,680	155	1,770	50	1,000	5,175	5,450

a. Value data based upon current US f.o.b. prices for equivalent products.

Table 5

Production of the East German Electric Lamp Industry
1949-51

	General-service Lamps		Miniature Lamps		Special Lamps a/		All Lamps	
Year	Volume (Thousand Units)	Value (Thousand $ US) b/	Volume (Thousand Units)	Value (Thousand $ US) b/	Volume (Thousand Units)	Value (Thousand $ US) b/	Volume (Thousand Units)	Value (Thousand $ US) b/
1949	5,000	N.A.	3,000	N.A.	100	N.A.	8,100	650
1950	15,000	1,200	8,000	500	500	300	23,500	2,000
1951	2,800	2,300	12,000	700	900	600	40,900	3,900

a. Including fluorescent lamps.
b. Value data based upon current US f.o.b. prices for equivalent products.

is planned to attain five times the 1950 rate by 1955. In view of equipment and materials problems, it is unlikely that this goal will be met. An increase can be expected, however, probably reaching from 60 million to 70 million lamps by the end of 1953.

c. Productivity.

Employment and production output data for the East German tube and lamp industry in 1951 indicate that the average productivity can be closely measured at $750 per employee per year. This relatively low (labor) productivity is illustrated by the 1950 and 1951 average outputs of about 4.5 incandescent lamps per employee per hour and 0.45 receiving tube per employee per hour.

These very low values for labor productivity, appreciably less than any other European tube and lamp industry, can be attributed to four factors: an inadequate number of key machines, frequent failures to obtain required production materials and use of inferior materials, expensive structural design and manufacturing methods, and the frequent tendency to pad the payroll with unnecessary employees.

4. Czechoslovak Tube and Lamp Industry. 13/

Before early 1950, all of the electron tubes made in Czechoslovakia were produced in plants of the Tesla combine, principally in the two Prague plants, Hloubetin I and Hloubetin II, formerly owned by Philips of Eindhoven, the Netherlands, and in the Vrchlabi plant, formerly owned by Lorenz of Berlin. [redacted] a 50X1
proposed new plant was to be built in Roznov pod Radhostem. This plant, under the Tesla management, was to be the principal site for the manufacture of electron tubes. The Hloubetin and the Vrchlabi plants were to be incorporated into the new Roznov plant. Since there is no direct report on the productive facilities at this new Roznov plant, an estimate must be made of the capacity and output of the new plant by referring to its major constituents. It will be useful, therefore, to discuss the Hloubetin and Vrchlabi plants, even though it is now probable that they have been included in the Roznov plant.

Before World War II the two Hloubetin plants together produced between 2 million and 3 million tubes a year. In 1950, under Tesla, these plants were producing tubes at a yearly rate of 1.3 million, but the shrinkage rate was so high that the production of adequate tubes probably did not exceed 800,000. There was a secret section of Hloubetin II which made radar and special transmitting tubes.

The Tesla plant at Vrchlabi was partially dismantled by the Soviets after World War II. Equipment was removed in a careless fashion, and the result was partial disruption of production. As this plant is approximately one-half the size of the tube making facilities at Hloubetin, a rough estimate of its 1950 production rate would be 400,000 tubes of acceptable quality. Both the Hloubetin and the Vrchlabi plants produced receiving tubes, and both Hloubetin I and II are known to have produced transmitting tubes.

The new Tesla plant at Roznov pod Radhostem was planned to be a $10 million enterprise producing receiving and transmitting tubes. Under this proposal, all the tube-making facilities in Czechoslovakia were to be moved to Roznov, and additional machinery also was to be procured. The completion date was expected to be late in 1950, and 4,000 workmen were to be required.

The Tesla plant was rumored to be under construction by the Philips Company of the Netherlands, but to date this rumor has been unsubstantiated, although there are indications that Philips is interested in dealing with the Soviet Bloc. [redacted] 50X1
[redacted] It is 50X1
significant, however, that the prewar capacity of the Tesla properties was between 2 million and 3 million tubes a year. The site for this plant was chosen by the Soviets with security in mind. There is evidence of the production of such special types of tubes as iconoscopes and radar.

Four other plants in Czechoslovakia are believed to be producing tubes and lamps. At Elphys in Vilsnice a very small quantity of thyratrons is made at one plant, and in another the manufacture of US-type 10-millimeter miniatures is planned but as yet unrealized. In Dolny Kubin a factory was to be set up, reportedly to manufacture miniature and radio tubes, but as yet there is no report of output.

The Kavalier firm in Sazava was manufacturing a miniature or subminiature tube in late 1948, but it is reported to have discontinued production. The production of these types of tubes could conceivably have been an attempt to manufacture tubes for proximity fuses, [redacted] 50X1
[redacted] the manufacture of small shatterproof glass ampules at this plant. 50X1
[redacted] 50X1

a. Output.

As stated above, the total output of Czechoslovak electron tubes closely approximates the output of the Roznov plant, since all or most of the tube making facilities of the country were supposed to be concentrated there. On the basis of the production rates of Hloubetin and Vrchlabi for 1950, plus planned additions to the new Roznov plant, the output of electron tubes in Czechoslovakia was estimated to be approximately 2 million units for 1950 and approximately 2.5 million for 1951, having an approximate value of $3.5 million. (Production of electron tubes and electric lamps in Czechoslovakia is given by plant in Appendix D.)

These estimates are partially confirmed by published reports in Czechoslovakia and in the USSR. The published Plan for the Czechoslovak tube and lamp industry for 1949 called for the manufacture of 2.3 million tubes, and a Soviet magazine published in 1950 gave the Czechoslovak output as 1,652,000 units for 1947 and 2,388,000 units for 1948. Since this 1948 figure probably is intended to show an improvement caused by the change of regime in Czechoslovakia, it undoubtedly is too high, but it does indicate the general range of possibilities.

The following figures give an indication of the growth and planned growth in the Czechoslovak tube and lamp industry. In 1947 the value of the output of tubes and lamps in Czechoslovakia amounted to 330 million crowns, and in 1948 this value was 506 million crowns. The value of the planned output of the tube and lamp industry given in the Five Year Plan covering the period 1949 through 1953, in millions of crowns, was 574 for 1949, 610 for 1950, 670 for 1951, 718 for 1952, and 722 for 1953.

The Czechoslovak electron tube industry is hampered by a serious lack of capable engineers and technicians and by shortages of modern machinery. Difficulties with production of CR tubes are attributed to outmoded machinery. There also have been certain shortages of materials, particularly of molybdenum and tungsten filaments in the 10- to 30-micron sizes. In general, this industry is suffering from development and production problems, which will not be solved in the very near future unless outside aid, primarily of a technical nature, is procured. The new plant at Roznov, in all probability, was an attempt to make a fresh start in this industry, but results cannot be expected too quickly. Thus it is believed that the Czechoslovak electron tube industry will not be capable of furnishing much more equipment to the military and civilian sectors of the economy in the next 2 or 3 years than it already is furnishing.

b. Productivity.

The Czechoslovak electron tube industry is characterized by very low efficiency. [redacted] the shrinkage rate for receiving tubes is 60 percent, an alarmingly high rate in comparison with the US rate of about 20 percent. Furthermore, even tubes which are passed by the inspectors frequently are found to be defective or to operate in a satisfactory manner for only a very short time. Typical troubles are with microphonics and loss of vacuum. An attempt usually is made to obtain foreign tubes when special applications arise. Thus it is common for the Czechoslovak government to advertise for special types to be obtained from any source, with no questions asked.

Inability to obtain certain inputs is another disrupting factor in Czechoslovakia. Satisfactory cathode sleeves are hard to obtain, as are molybdenum and tungsten wire. Another item difficult to obtain is insulating material, presumably mica. Attempts are made to substitute less scarce materials, and the result often is poor-quality output. An example of this is the substitution of steel for molybdenum in certain applications, with a resultant deterioration of the product.

The labor force involved in Czechoslovak production of electron tubes consists mainly of young women — a standard practice in this industry elsewhere in the Bloc. The average rate of pay for workers is 4,500 crowns a year; for specialists, 5,000 to 7,000 crowns a year; and for engineers, 9,000 to 12,000 crowns a year.

On the basis of information on the Roznov plant the best estimate of the labor force engaged in the production of electron tubes in Czechoslovakia is 4,500 workers, including nonproduction workers. [redacted] 4,000 workers at Roznov, plus a figure of 500 to account for development and laboratory personnel engaged in this field at other locations. There is no good evidence from which to estimate the actual labor force engaged in lamp production in Czechoslovakia.*

There is evidence that Czechoslovak management does not make the most efficient use of whatever good equipment it has on hand. Some new equipment has been [redacted] deteriorating in storage while less effective machinery was in use. This situation may be caused by

* A figure of approximately 300 workers as the labor requirements in this industry may be obtained through the use of the input coefficients discussed in Appendix F.

lack of personnel qualified to use the newer types of machinery.

The number of projects in the Czechoslovak electron tube industry which have had to be discontinued, usually for failure to attain good-quality output, is generally strong evidence of ineffective management and inefficient engineering practices and techniques.

5. Tube and Lamp Industries of Poland, Rumania, and China. 14/

At the present time the manufacture of electron tubes is negligible in other areas under Soviet influence. A small tube plant is operated in China, with very limited output, apparently concentrating on a few simple types of tubes for communications systems. In Dzierzoniow, Poland, a small tube plant previously established by the Germans continues to produce a few simple types of receiving tubes at a low level of output. In Warsaw the former Philips-Wola tube and lamp factory, destroyed during World War II, was rebuilt during 1950 and 1951 with technical aid and machinery supplied by the Philips Company of the Netherlands. Although this plant is scheduled to become a significant producer of tubes, it is not an important factor at present. Incandescent lamps are produced in Poland and Rumania, but the total annual output is relatively small, being estimated at 30 million units, or under $3 million annually.*

B. Costs and Prices. 15/

1. Retail and F.O.B. Prices.

In the USSR, f.o.b. plant prices for receiving tubes and allied products range from 5.5 to 20 rubles a tube. For the group of receiving tubes most commonly used the average f.o.b. price is 7 rubles, and for this same group of receiving tubes the average retail price on the domestic market is reported to be about 12 rubles.

In East Germany the f.o.b. plant prices for receiving tubes and allied products range from 5.5 to 50 East Deutsche Mark (EDM). For the standard group of receiving tubes the average f.o.b. price is EDM 10. An estimate for domestic retail prices for such tubes is EDM 25.

In Czechoslovakia, only data for retail prices have been reported. These prices range from 40 to 290 crowns a tube, and the average retail price on the domestic market for the common receiving tubes is about 240

* For summary estimates of Soviet Bloc tube and lamp production, see Tables 16 and 17, following on pp. 59 and 60, and p. 61, respectively.

crowns.

2. Pricing Methods.

Pricing methods for electron tubes in the Soviet Bloc are indicated by the pricing methods known to be in use in East Germany. In relation to a measure of plant output, four sets of price data may be available: the gross production at planned statistical values, the net production at planned statistical values, the gross production at the average sales price, and the net production at the average sales price. Where available, value reported in terms of net plant production at the average sales price is preferred for intelligence analysis. Although variations between these four methods apparently are not great for a total industry average figure, discrepancies may be quite appreciable when the methods are applied to individual plants. In East Germany, actual sales prices for products are fixed by directive of the Price Office of the Ministry of Finance, Berlin. The current domestic selling price is based on a flat 30-percent increase over the 1944 ceilings. However, the price is modified by individual adjustments which are determined by government-approved costs, with the result that the average domestic f.o.b. selling price for the East German electron tube industry is approximately 45 percent above the applicable 1944 ceilings. Since current Soviet purchases for tubes, as well as other engineering industry products, are made at the 1944 ceiling prices, the actual weighted f.o.b. plant price for East German tubes will vary, depending upon the ratio of domestic tube sales to the Soviets.

In East Germany the intent is to apply to tube products statistical plan values which are a fair representation of actual weighted f.o.b. sales prices. Although no similar data are available for the tube industry in the USSR, it is believed that this same intent is applied in the USSR: that is, the values used for plan estimates are indicative of averaged f.o.b. prices.

3. Prices and Costs.

An analysis of both Soviet and East German data concerning the electron tube industry indicates that f.o.b. prices reflect costs, within practical limitations. In East Germany the output per employee per month is EDM 875 for the receiving tube category, and the cost of wages and salaries approximates 45 percent of net sales. In the USSR the output per employee per month is 1,350 rubles for this same category, and wages and salaries approximate 55 percent of net sales. This percentage is to be compared with the US industry average of wages and salaries to net sales of 52 percent. In the USSR, where such raw materials as glass and tungsten metal products are fabricated to a greater extent within the tube factories, the labor content should be higher than that of the US.

50X1

4. Relative Prices.

In the electron tube industries of the USSR, East Germany, and the US the ratio of wages and salaries to net sales decreases as the product line is changed to include a higher proportion of large special-purpose and transmitting tubes. The ruble is worth nearly EDM 2 when the comparison is based upon mass-produced receiving tubes which require a high proportion of skilled direct labor supported by extensive machinery and tooling. The Bloc-to-US price ratio decreases, however, on the large specialized transmitting tubes which require expensive materials but less labor and relatively less complex machinery. Table 6* gives a summary of averaged f.o.b. prices for electron tube categories, comparing USSR, East German, and US values.

C. Imports and Exports of Tubes. 16/

1. Imports from the West.

a. USSR.

Since most of the electron tubes which the USSR might wish to import are on various US export control lists and, to a lesser extent, on the export control lists of other Western countries, it is necessary for the USSR to resort to indirect means of obtaining these commodities. Some European countries, which have export control lists that are not so inclusive, ship directly to the USSR and especially to the Satellites. In addition, there are possibilities for illegal shipments from these countries, including particularly Italy, the Netherlands, West Germany, the UK, and France.

Of greater potential importance are imports into the USSR and the Soviet Bloc that are handled as transshipments. Goods produced either in the US or in Western Europe are reaching the Soviet Bloc through six principal channels as transshipments. These channels are across

* Table 6 follows on p. 36.

Table 6

Comparison of Net F.O.B. Unit Prices for Equivalent Categories of Electron Tubes

Product	US ($)	USSR (Rubles)	East Germany (EDM)	Ratio of Rubles to $	Ratio of EDM to $
Standard Receiving Tubes	0.54	7.0	13.3	13.2	25.0
Allied Types or Small Transmitting Tubes	1.50	16.5	N.A.	11.0	N.A.
Transmitting Tubes (under 100 Watts)	10.00	N.A.	186.0	N.A.	18.6
Transmitting Tubes (100 Watts to 1 Kilowatt)	35.00	N.A.	465.0	N.A.	13.3
Transmitting Tubes (10 to 20 Kilowatts)	270.00	N.A.	3,250.0	N.A.	12.0
Ultrahigh-frequency Transmitting Tubes	15.00	150.0	N.A.	10.0	N.A.
Transmitting Tubes (above 60 Kilowatts)	750.00	4,900.0	5,600.0	6.6	7.5

German interzonal borders, through Switzerland, Vienna, Sweden, and India and possibly through Indonesia and South America. A typical transaction involved the purchase by a Rumanian, for the Soviet account, of US subminiature tubes purchased from a US manufacturer by a Stockholm dealer.

The volume of these transshipments is difficult to establish, but it is thought that in some lines where domestic production is especially weak, great emphasis is placed on securing imports by these and similar means.

b. Czechoslovakia.

Czechoslovakia imports a large percentage of all the electron tubes which it uses. These tubes are obtained largely from Sweden, Switzerland, and Hungary and particularly from Philips in the Netherlands. Types imported range from the more complicated receiving types to special and large transmitting tubes. In general, Czechoslovakia tends to import those tubes which it is unable to produce for technical reasons.

c. East Germany.

East Germany's importations from the West probably are very rarely for its own account but rather are for transshipment to the USSR or perhaps to the Satellites.

d. Hungary, Rumania, and Poland.

Hungary, Rumania, and Poland have imported electron tubes from Switzerland and from the Netherlands for their own account and probably for transshipment to the USSR.

2. Exports to the West.

a. USSR.

It is not believed that the USSR exports many electron tubes out of the Bloc, except perhaps in finished equipment such as civilian radios which are exported to India and to other countries. These exports are not of significant size. Small shipments of tubes have gone to Finland.

b. Czechoslovakia.

Czechoslovakia, in spite of its own domestic difficulties in the electron tube industry, does attempt to export tubes to the West, sometimes on very favorable terms. For instance, US buyers have been offered Czechoslovak miniatures through a Stockholm intermediary at prices substantially below the best prevailing US prices for the same types. It is thought that this effort is directed toward establishing a favorable political environment for trading relations with the West in order to be able to obtain needed types of tubes in exchange.

c. Hungary.

Hungary's export of electron tubes to the West is of significant proportion. Shipments go to Argentina, Switzerland, Egypt, and other countries.

Historically, Hungary has been a large-scale exporter of electrical equipment, including electron tubes. Before World War II a large Hungarian sales force operated all over the world. This sales force still is in operation, and the pattern of output in the Hungarian electron tube industry reflects the needs of foreign buyers of electron tubes. Exports have continued to these buyers as a matter of established trading relations.

These established trading relations have been helpful to Hungary in its attempt to secure critical input materials from the West. For example, Hungary exports tubes to Argentina and is able to secure strategic mica in return. It is also of some interest that the USSR allows these exports of electron tubes outside the Bloc, for it is clear that if the USSR were feverishly in need of these tubes, it would require Hungarian production to be retained in the Bloc.

d. East Germany, Rumania, and Poland.

Available information indicates that East Germany, Rumania, and Poland do not have significant export trade in electron tubes with the West.

3. Inter-Bloc Shipments.

The USSR probably ships electron tubes to all of the Satellites and receives in exchange 2 million or 3 million tubes in excess of exports. The pattern consists of the Soviets' sending receiving tubes to all of the Satellites for civilian use and sending some transmitting tubes and special types for use in equipment made on the Soviet account. In return, the Satellites export to the USSR certain special types, and also some tubes, made domestically, which are incorporated into end equipment that is exported to the USSR. The favorable Soviet export balance possibly may be explained by the fact that exports are predominantly receiving types, whereas imports tend to be larger types, such as transmitting tubes. The balance probably is less favorable to the USSR on a value basis than on a unit basis, since receiving types are considerably less expensive than transmitting and special types.

IV. Input Requirements.*

A. USSR. 17/

1. 1951 Input Requirements.

Annual requirements for the critical production materials consumed by the Soviet tube and lamp industry for operations during 1951

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* The figures given in this section for input requirements have all been computed by the use of the input coefficients discussed in Appendix F.

are estimated in Table 7.

Table 7

Input Requirements of the Soviet Tube and Lamp Industry
1951

Material	Receiving Tubes	Special Tubes	Lamps	Total
Technical Glass (Tons)	1,700	200	6,300	8,200
Tungsten Wire (Million Meters)	27		113	140
Molybdenum Rods and Sheet (Lbs)		23,000		23,000
Grid Wire (Moly, Ni, and Fe Alloys) (Million Meters)	170			170
Nickel (Lbs)	270,000			270,000
Cathode Sleeves (Millions)	40			40
Tungsten Rods (Lbs)		19,000		19,000
Mica (Raw Block, Strategic Quality) (Lbs)	610,000			610,000

The annual consumption by the industry of other important metals, including copper, steel, and aluminum, is relatively small.

2. Sources of Supply.

For the requirements of the tube and lamp industry, the USSR is believed to be adequately supplied with nickel from indigenous sources. The USSR is an exporter to the East German industry.

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Domestic producers of technical glass for industry (including bulbs and tubing and both soft and hard glasses) are the Svetlana Plant [redacted] Leningrad; Institute [redacted] Fryazino (Shchelkovo), near Moscow; 50X1
the Electric Lamp Plant [redacted] Tashkent; the new glass department 50X1
at the Electric Lamp Works [redacted] Moscow; the Zaprudnya Electric Lamp 50X1
Works, Moscow Oblast; and the "October" Glass Plant, Kalashnikovo, Kalinin Oblast. A glass plant also may be included in the Electric Lamp Factory

[redacted] Novosibirsk. The combined raw glass-making capacity greatly exceeds total requirements, and the geographical dispersion reduces the vulnerability as compared with conditions in Western Europe and the US. It is noted that in 1944 the US shipped to the USSR four glass furnaces for bulb and tubing glass, having a combined maximum annual capacity of 20,000 tons.

Clear mica sheet and block are processed for the tube industry at two major plants -- the "8th of March" Mica Factory at Petrozavodsk and the Mica Trust Fabricating Plant at Irkutsk -- and at two smaller fabricating shops in Leningrad. Apparently the USSR imports very little high-quality mica from India, nor does it export Soviet mica to the electronics industries of the Satellites. It is concluded that the USSR is just about self-sufficient for its own domestic needs. Sources of the raw block mica are believed to be primarily the Siberian muscovite deposits in the Mama River area and good local deposits in the Karelian area.

Tungsten, molybdenum, and other refractory metal products required by the tube and lamp industry are known to be fabricated in the Svetlana [redacted] and the Moscow [redacted] lamp plants and possibly in another metal plant in northeast Moscow. Although facility expansions were reported in 1948 and 1950, the processing techniques are most difficult, and an extensive expansion takes a long time. At present the domestic production of these specialized metal products falls far short of meeting requirements.

In addition to the domestic production of glass parts and the import of some glass bulbs from Finland, during 1950 and 1951 the USSR imported glass bulbs from the Soviet-controlled Viennese firm Wiener Glasshuetenwerk at a rate of about 5 million units a year. The import of glass parts for the Soviet tube and lamp industry, however, is not essential.

During 1950 and 1951, heavy imports by the USSR of tungsten and molybdenum metal products, including fine wire, were reported. These imports provided from 50 to 60 percent of the total Soviet tube and lamp industry requirements for tungsten wire and about 30 percent of the requirements for ingots, rod, and sheet. The principal supplier for the wire is the Swedish firm Lumalampan AB, Stockholm, on direct contracts with the USSR. Other large suppliers of tungsten and molybdenum metal products are the Metallwerk Plansee, Reutte, Austria; Osram GmbH, Berlin; and the Vereinigte Drahtwerk, Nijmegen. These transactions generally are accomplished through Swiss and East German intermediaries. Termination of West European shipments of tungsten and molybdenum metal products into the Soviet Bloc would severely limit the Soviet tube and lamp industry, possibly reducing its present capabilities by one-half and thus would have a far-reaching effect upon the Soviet military electronics program. This effect would be aggravated by a similar termination of diamond-die and die-stone shipments, since these items are required in the USSR for wire-drawing.

B. Hungary. 18/

1. 1951 Input Requirements.

The output of electron tubes and lamps in Hungary in 1951 was as follows: receiving tubes, 4 million units; transmitting tubes, to the value of $2.6 million; and all lamps, 41.2 million units. Table 8* shows the amounts of certain critical materials required by Hungary in 1951 to support this volume of output in these industries.

2. Sources of Supply.

Hungary has two major plants engaged in the production of technical glass. These plants are capable of satisfying all domestic requirements and provide a surplus for export. Hungary also has a plant, UILCO "Tungsram," which is able to draw tungsten and molybdenum into wire for electron tube and lamp manufacturing. Most of the imports in this line are tungsten and molybdenum in the form of ore or in unfabricated shapes, some of which are obtained through Italy and some through Austria. In addition, the former Tungsram plant in Paris has agreed to ship to Hungary $2 million worth of tungsten and molybdenum ore, ingots, wire, and various rare gases in payment of an old debt.

Hungary imports from the West, particularly Austria, most of its supplies of nickel getter wire, nickel cathode sleeves, nickel sheets and plates and tubes, and nickel alloys for grid wire. Getter wire, from Leyboldt and Philips, Vienna, and other nickel products are obtained under a treaty arrangement with Austria. Hungary also has no domestic supplies of mica. Under a treaty with Argentina it is expected that Hungary will obtain the greater part of its requirements from that country.

It is evident that in some commodities, particularly nickel, mica, and unfabricated tungsten and molybdenum shapes, Hungary is very much dependent upon the West for its supplies. Although attempts to

* Table 8 follows on p. 42.

Table 8

Input Requirements of the Hungarian Tube and Lamp Industry
1951

Material	Receiving Tubes	Transmitting Tubes	Lamps	Total
Technical Glass (Lbs)	360,000	900	3,893,400	4,254,300
Tungsten Wire and Rods (Lbs)	680	2,418	1,831	4,929
Tungsten Wire (Meters)	3,200,000		32,960,000	36,160,000
Molybdenum Rods and Sheet (Lbs)		2,808		2,808
Grid Wire (Moly, Ni, and Fe Alloys) (Million Meters)	20			20
Nickel (including Cathode Sleeves) (Lbs)	40,000			40,000
Cathode Sleeves (Lbs)	1,200			1,200
Mica (Raw Block, Strategic Quality) (Lbs)	60,000			60,000

decrease this trade will hamper Hungary in its production efforts, most of the requirements will be obtained through more or less illegal means -- that is, by transshipments through West Germany, Switzerland, and Austria. The central direction of all importing activity in Hungary increases the effectiveness of such illegal trading.

C. East Germany. 19/

1. 1951 Input Requirements.

The output of tubes and lamps for 1951 in East Germany was as follows: receiving tubes, 3,606,000 units; transmitting tubes, 108,000 units; CR tubes, 25,000 units; lamps, including miniature lamps, 40 million units. On the basis of these estimates, Table 9* was constructed showing the requirements of certain critical materials in these

* Table 9 follows on p. 43.

Table 9

Input Requirements of the East German Tube and Lamp Industry
1951

Material	Receiving Tubes	Transmitting Tubes	Cathode-ray Tubes	Electric Lamps	Total
Technical Glass (Lbs)	324,540	9,720	200,000	3,780,000	4,314,260
Tungsten Wire and Rods (Lbs)	613	3,780		1,777	6,170
Tungsten Wire (Meters)	2,884,810			32,000,000	34,884,800
Molybdenum Rods and Sheet (Lbs)		3,780			3,780
Grid Wire (Moly, Ni, and Fe Alloys) (Meters)	18,030,000				18,030,000
Nickel (including Cathode Sleeves) (Lbs)	36,060				36,060
Cathode Sleeves (Lbs)	1,081				1,081
Mica (Raw Block, Strategic Quality) (Lbs)	54,090				54,090

industries for the volume of output.

2. Sources of Supply.

East Germany is entirely self-sufficient as regards the actual production of glass for tubes and lamps. A small amount of some raw materials for this production must be imported, but tube and lamp plants in East Germany are able to buy all their glass requirements domestically. Because of a lead shortage in East Germany, an attempt has been made to lower the lead content of all glass, in some cases substituting magnesium. In one instance the premature adoption of a new composition was responsible for the breakdown of several million lamps after a very short time in operation.

Tungsten and molybdenum are drawn into wire by the Werkfuer Fernmeldewesen HF (OSW), and by the Berliner Gluehlampenwerk, formerly an Osram plant, Berlin. Metallic tungsten and molybdenum are obtained from Austria and Denmark by means of transshipments through Switzerland and Sweden. A typical transaction may include an Austrian supplier such as Metallwerk Plansee, Tyrol, Austria, shipping to East Germany through an intermediary in Switzerland such as the B. & Ch. Elber firm, Zurich. Elber also is agent for another very important supplier of these materials, Heraeus in Hanau, West Germany.

Much nickel sheet is imported from the USSR. Nickel tubes for the manufacture of seamless nickel cathode sleeves are obtained from Heraeus in Hanau. It is necessary to import these tubes, since East Germany is incapable of producing them with sufficient purity for use in the fabrication of cathode sleeves.

Firms supplying East Germany with wire of various alloys are Heraeus, Hanau; Stahlwerke Ergste AG, Schwerte, Ruhr; Deutsche Edelstahlwerke AG, Stuttgart-Feuerbach; Stahlwerk Harkort-Eicken, Hagen, Westphalia; C. Kuhbier & Sohn, Dahlerbrueck, Westphalia; Siemens-Halske AG, Berlin; and Osram GmbH, Berlin. "Dumet" is supplied by Heinrich Lahr, Mainz; by Bruno Dietze, Coburg; and by Osram. Platinum-clad double metal wire is furnished to East Germany by the Heraeus, Lahr, and Dietze firms.

East Germany has had to rely on the West for its supply of mica. During World War II, when this supply was cut off, the use of ceramic spacers was begun. This substitution is at present being renewed. It is an expensive and difficult process, but there is an adequate supply of the raw material in East Germany, and the saving in dollar exchange is believed to justify the effort. East German firms engaged in production of ceramics for this purpose are Steatit-Magnesia AG, Berlin; Keramisches Werk Hescho-Kahla, Hermsdorf, Thuringia; and Electrotechnische AG, Neuhaus, Thuringia.

Aside from raw materials, vacuum pumps are another item which East Germany finds it necessary to import. Those built by the Holland-Merten Company failed to stand up well under heavy-duty operation. Thus it is necessary for East Germany to continue to use vacuum pumps supplied by Leyboldt in Cologne.

The dependence of East Germany on the West for critical materials is manifest. The attempt to substitute less scarce materials has resulted in an increase in the shrinkage rate, and lately resumption of the use of the best materials has occurred. It may be assumed that efforts of East Germany to obtain these critical materials from the West will continue and that by legal or illegal means a large part of the requirements of these industries will be satisfied.

D. Czechoslovakia. 20/

1. 1951 Input Requirements.

For the purpose of determining the input requirements of certain critical materials for the manufacture of electron tubes in Czechoslovakia, the rate of output for the year 1951 will be taken as 2.5 million tubes. Although input requirements for a given number of tubes vary as the product mix varies, calculations of Czechoslovak electron tube input requirements will be made on the basis that all of the 2.5 million tubes are receiving tubes. The reason for this position is twofold. On the one hand, the production of CR tubes, magnetrons, klystrons, and other special tubes is believed to be nominal. On the other hand, evidence is available that the greater part of the output of transmitting tubes is in the smaller types. [redacted] no tubes of plate dissipation 50X1 in excess of 9 watts are being produced. Even by allowing for some error in the report, it is clear that the error involved in assuming all production to be receiving tubes for purposes of input calculation will be relatively small.

The output of lamps is taken as being 20 million units for the year 1951. It is believed that this production consists principally of general-service incandescent lamps.

Table 10* gives the input requirements for 1951 in the Czechoslovak tube and lamp industry.

2. Sources of Supply.

Czechoslovakia is a prolific glass producer, and, in addition to producing all the glass for its domestic needs in the electron tube industry, it is able to export a very large amount both to the Satellites and to the West.

Previous to the Communist coup, nickel alloy cathode sleeves were obtained from the US, but afterward this material was difficult to obtain from the US and was sought elsewhere, principally from France, the UK, and Austria. Some attempt was made to fabricate these sleeves in Czechoslovakia from imported alloy, but poor results have been caused by

* Table 10 follows on p. 46.

Table 10

Input Requirements in the Czechoslovak Tube and Lamp Industry
1951

Material	Receiving Tubes	Lamps	Total
Glass Tubing (Lbs)	54,116	130,000	184,166
Glass Bulbs (Lbs)	108,333	1,760,000	1,868,333
Tungsten Wire (Meters)	2,000,000	18,500,000	20,500,000
Grid Wire (Moly, Ni, and Fe Alloys) (Meters)	12,500,000		12,500,000
Nickel (including Cathode Sleeves) (Lbs)	25,000	7,500	32,500
Cathode Sleeves (Units)	2,750,000		2,750,000
Cathode Sleeves (Lbs)	7,500		7,500
Mica (Raw Block, Strategic Quality) (Lbs)	37,500		37,500

unsatisfactory machinery. Thus the supply of cathode sleeves is critically short, since domestic production is insufficient and imports are difficult to obtain.

Molybdenum and tungsten wire were originally obtained from the US and Switzerland, but at the present time these materials are very scarce in Czechoslovakia. Attempts have been made to draw this wire domestically, but results have been unsatisfactory, particularly in the smaller sizes. Attempts also have been made to substitute less scarce materials but have led to lower-quality output. It is believed that some molybdenum wire is obtained from England.

Mica and nickel sheet used in Czechoslovakia probably are not domestically available. Most of the nickel sheet used in Czechoslovakia is obtained from the Heraeus firm in Hanau, West Germany. One possible source of supply of mica is India. A less likely source is the USSR. It is known that insulating materials, presumably including mica, are in short supply.

There is no doubt that the production of electron tubes in Czechoslovakia is hampered seriously by shortages of materials. It is difficult, however, to assess the exact damage caused by these shortages, since the situation is complicated by other lacks, particularly skilled personnel and some important types of machinery. It is probable that the principal bottleneck in lamp production is tungsten wire rather than machinery or personnel, but this has not been definitely established.

E. Soviet Bloc.

1. 1951 Input Requirements.

Annual requirements for the critical production materials consumed by the Soviet Bloc tube and lamp industry during 1951 are estimated as follows: technical glass, 15,000 metric tons; tungsten wire, 262 million meters; grid wire (molybdenum, nickel, and iron alloys), 225 million meters; tungsten rod, 30,000 pounds; molybdenum rod and sheet, 30,000 pounds; raw block mica, strategic quality, 765,000 pounds; nickel, 380,000 pounds; and cathode sleeves, 52 million.

2. Sources of Supply.

With six known producers of electrotechnical glass in the USSR and two major plants each in East Germany, Czechoslovakia, and Hungary, the indigenous supply of technical glass of the Soviet Bloc is adequate and geographically well distributed. The USSR produces radio-grade nickel in sufficient quantity to supply its own needs, plus some for the Satellites. The Satellite industry finds it necessary to import from Western Europe additional radio nickel, as well as all of the special nickel needed for cathode sleeves. The Soviet supply of strategic mica is adequate only for its own industry. The production and fabrication of refractory metal products is limited, being available only from two or three small facilities in the USSR and one each in East Germany and Hungary.

The Soviet Bloc tube and lamp industry is dependent upon imports for up to 50 percent of the USSR requirements for fine tungsten and molybdenum wire, 30 percent of the USSR requirements for other tungsten and molybdenum metals, and the entire Satellite industry requirements for refractory metal raw materials. Primary suppliers are Lumalampen, Stockholm, Sweden; Osram GmbH, West Germany; Metallwerk Plansee, Reutte, Austria; Tungsram, Paris, France; and branches of the Philips Company, the Netherlands. Most of the shipments are made through Switzerland, Sweden, and Berlin.

Mica for the Satellite industry is obtained from West European suppliers and originates in India and South America. Special cathode nickel tubing must be imported for the entire Satellite industry and is supplied mostly by Heraeus and the Philips subsidiary firm, Schoeller Werk AG. Diamond dies and die-stones must be imported to supply the entire Bloc requirements. The East German industry also is dependent upon West German sources for a relatively long list of specialized materials, including all forms of glass-sealing metals, tube getters, vacuum pumps, and diffusion pumps.

At present, and for some time in the future, the greatest vulnerability of the Soviet Bloc tube and lamp industry is in this dependence upon the West for these specialized production materials and for certain kinds of automatic machinery. It is estimated that a complete and effective embargo against the export into the Bloc of a few of the most important items would reduce the Bloc capabilities by as much as 50 percent.

V. Distribution of Supply.

A. USSR. 21/

1. Consumption Pattern.

A knowledge, within reasonable limits, of 1950 schedules for the Soviet manufacture of civilian radio and television receivers; partial information on tube production by type at two Soviet plants; and spot reports covering specific military electron tube programs permit a rough analysis of the recent end use pattern for the Soviet electron tube industry. As measured by product value, a large part of the output of the industry is in transmitting and special tubes -- a condition normally inconsistent with a heavy consumer-goods market. In those instances where schedules have been reported by type of tube, the product distribution does not match the types used in Soviet civilian radios. Tube types used in military communications sets, in altimeters, and in radar devices predominate. The output of civilian radio equipment has been kept at a low level. Replacement tubes still are not plentiful, even for such preferred services as some communications systems, wired radio, and Dosarm Club activities.

Soviet command communications equipment is far less complex and varied than is that of the US, so that, although the Soviet armed forces require large amounts of communications equipment for land, sea, and air use, the number of electron tubes required for these purposes is considerably smaller than for similar amounts of US equipment.

Radar and other electronic applications are produced in large quantities in the USSR for military uses, but the tendency is to try to keep the number of kinds of equipment to a minimum. Certain forms of radar, however, such as early warning and fire-control types, are held to be essential, and the output of electron tubes reflects this need. Wherever possible, the Soviets use and copy Western equipment.

The USSR relies heavily on radio communication for conducting government business and for the management and administration of industry. Short-wave networks are in use, and a series of decimeter relay nets is being built, some of which already are in operation. The electron tubes required for the short-wave networks are conventional transmitting and receiving types that are made in large quantity. Ultra-high-frequency and klystron tubes are used for the relay networks. Since these types also are of great importance in the radar program, there is a very large demand for them.

The part of total Soviet production of electron tubes devoted to tubes for civilian radio and television uses is very small in relation to US and Western standards. The limited number of radios produced for civilian use are very high in price, so that the number of owners of radios is rather small. However, since the Soviet government considers radio broadcasting of propaganda, news, and sociopolitical information to be of extreme importance to the success of the regime, the device of the wired radio has been developed. The output of one radio is wired to speakers in many homes, thus avoiding duplication of most of the tubes and components as well as controlling the listening habits of the populace. Electron tubes for the program are principally conventional types, mostly copied from US tubes, and the Soviets use types already in production rather than undertake the development of new types. The wired radio system was held inadequate in 1949, and plans were made for expanding it by 75 percent.

Television stations are telecasting only in the Moscow, Leningrad, and Kiev areas, and the number of receivers is very small, most of the CR tube production going to the armed forces.

Analysis of the consumption pattern of the Soviet electron tube industry indicates a continuing large production of conventional military communications equipment. There is good evidence of very heavy production of electron tubes for radar requirements, whereas the production of tubes for civilian consumer goods is relatively low.

2. Trends.

The most apparent trend is continuing pressure for increased output of the Soviet tube and lamp industry. There is no evidence of any plans for a significant increase in electron tubes for consumer use. There are increasing indications of accelerated production of tubes required for modern microwave radar.

3. Distribution of Output.

An estimated breakdown of the 1951 output of the Soviet electron tube industry is provided in Table 11.

Table 11

Output Distribution (Product Value)
of the Soviet Electron Tube Industry
1951

End Use	Percent of Total
Civilian Radios, Television Sets, and Replacements	13
Essential Domestic Services and Industrial Uses	16
Military Radio, Maintenance	23
Military Radar, Maintenance	45
Commercial Export (Mostly within the Bloc)	3

4. Indications of Specific Programs.

Based upon reported work at Institute [redacted] Fryazino 50X1
(Shchelkovo), the following specific military electronics programs in the USSR are identified: ground and shipboard fire-control radar in the S-band wave lengths, similar to US SCR-584, in quantity production; airborne radar, probably in the X-band as well as S-band wave lengths, also in quantity production; possible production for controls or low-acceleration proximity fuse devices for missiles.

Based upon reported work at the Svetlana Plant [redacted] the 50X1
following electronics programs are identified: the manufacture of super high-power transmitters for broadcast, communications, navigation, or jamming; production initiated of improved low-frequency (200-to-300-megacycle) radar systems of much higher power, for early warning or related applications; and reported output powers of 2,500-kilowatt peak and 10-microsecond pulse duration.

Work at Institute [redacted] Leningrad, indicates some production of military television devices. 50X1

B. East Germany. 22/

1. Consumption Pattern.

Good reports that provide details of production for all four manufacturers of electron tubes, plus frequent data on particular applications, permit a firm analysis of end use pattern for the East German electron tube industry. As compared with the Soviet industry, a higher proportion of the East German output is allocated to civilian radio and television receivers -- all of the latter for export to the USSR. A smaller but significant amount goes for domestic essential services, industry, and police needs. Although exports of electron tubes to the USSR are now less than in 1949, sizable shipments are still made, primarily for military application. The production of military electronic equipment manufactured in East Germany to fill Soviet orders is large.

2. Trends.

Pressure for increased production of electron tubes still continues. Apparently there is no large increase in tubes planned for the local civilian market. Starting in 1951, the major factor in modifying the East German electron tube industry plan has been the scheduling of the Soviet T-2 television receiver to be produced in East Germany instead of in the USSR. Requirements for this program will continue to absorb an increasing proportion of the output of tubes.

3. Distribution of Output.

A reasonably accurate breakdown for the 1951 output of the East German electron tube industry is provided in Table 12.*

4. Indications of Specific Programs.

Production of the T-2 television set started at Sachsenwerk Radeberg in the first quarter of 1951. Production of from 15,000 to 20,000 sets is probable for 1951, and 1952 production may exceed this amount.

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* Table 12 follows on p. 52.

Table 12

Output Distribution (Product Value)
of the East German Electron Tube Industry
1951

End Use	Percent of Total
Civilian Radios and Replacements	30
Essential Domestic Services	10
T-2 Television Sets (for the USSR)	33
Military Electronic Equipment (Mostly for the USSR)	15
Military Tube Exports (to the USSR)	10
Other Commercial Exports	2

Two models of decimeter radio-relay systems for military use were produced in quantity in 1950. Some production continued in 1951.

Quantity production of a low-frequency radar, or the transmitter components thereof, commenced in 1949 and continued at higher rates in 1950 and 1951, as indicated by the manufacture of TS-41 tubes at OSW and Funkwerk Erfurt.

The quantity manufacture of special high-pressure gas-discharge lamps to fill Soviet orders indicates the possibility of a sizable Soviet program for infrared systems requiring light sources.

C. Hungary.

1. Consumption Pattern.

Little information is available to indicate a detailed end use pattern for the Hungarian electron tube industry. The proportion of output electron tubes used for the domestic civilian radio market is not great, and tubes are available for export, primarily to other Satellites and to China, although some tubes are shipped to South America and Western Europe.

2. Trends.

The most apparent trend in the Hungarian electron tube industry is the plan to increase output.

3. Distribution of Output.

An estimated breakdown for the 1951 output of the Hungarian electron tube industry is provided in Table 13.

Table 13

Output Distribution (Product Value) of the Hungarian Electron Tube Industry
1951

End Use	Percent of Total
Civilian Radios and Replacements	12
Essential Domestic Services	6
Military Electronic Equipment	40
Commercial Exports	42

4. Indications of Specific Programs.

Evidence indicates production in Budapest of low-frequency (possibly about 300-megacycle) radar using Tungsram pulsed triodes.

D. Czechoslovakia. 23/

1. Consumption Pattern.

In terms of both units and value the greater part of the Czechoslovak output of electron tubes consists of receiving and small transmitting types. The principal customers for these types are the USSR, the Czechoslovak Army, and the makers of the Tesla radios for the domestic market and for export.

While the Czechoslovak electron tube industry is trying very hard to achieve competence in the production of radar and thus is trying to develop production of magnetrons and klystrons, there is no evidence of any substantial production in radar and radar tube types. Similarly, while CR tubes are in production, this production is small in numbers and consists only of a few copies of German and US types that have been modified to fit Czechoslovak needs and capabilities. The main Czechoslovak tube effort is in the manufacture of tubes for use in military communications equipment and for use and replacement use in civilian radios. The share of this equipment going to the USSR may be as high as 50 percent. Large numbers of Tesla radios containing domestically constructed receiving tubes are known to have been sold to Egypt, India, and other countries.

2. Trends.

Evidence indicates that there will continue to be a growing effort in Czechoslovakia to develop domestic radar and other military electronic equipment. Attempts to manufacture successfully the necessary special tubes may be expected to continue. In this connection, the new facilities at Roznov pod Radhostem should provide the basis for a fresh approach to these problems, but the basic difficulties lying in the way of really effective production of electron tubes will not have been fundamentally eliminated. Thus, while some progress can be expected, it is thought unlikely that Czechoslovakia will emerge as a quantity producer of special types of radar and special transmitting tubes in the very near future.

Generally speaking, the same conclusion also may be applied to receiving types of tubes. Some of the difficulties may be slowly ironed out, and production may be expected to rise gradually, but it is unlikely that there will be any startling developments in this field in Czechoslovakia in the near future.

Thus the pattern of consumption in Czechoslovakia may be expected to remain roughly what it is at present, with slow progress being made toward increased production of special-type and larger transmitting tubes.

3. Distribution of Output.

The distribution of effort between the civilian and military sectors of the Czechoslovak economy does not, over a period of time, seem to exhibit any consistency other than that the needs, presumably military, of the USSR take precedence over domestic requirements when the occasion demands. It is believed, however, that at present most of the Czechoslovak facilities are devoted to domestic projects.

Although the Czechoslovak Army seems to have preference over domestic civilian needs in the distribution of electronic equipment, it is not clear how this equipment is allocated. A large part of the output of electron tubes is known to go into civilian radios for domestic use as well as for export. The attempts, mostly abortive, of the Czechs to develop adequate radar tubes, or attempts to buy them abroad, indicate a strong desire to be able to build domestic radar and other electronic equipment in quantity. But it is believed that, since this desire is currently frustrated by inadequate development and technical personnel, there will not be much consumption of domestically produced tubes in the production of more complicated electronic equipment, leaving the domestic consumption of tubes to be divided between civilian radios and military and civilian communications. A pattern is not evident. The best estimate is that the distribution of consumption as between these two general categories varies widely from year to year as the requirements of the armed forces change.

4. Indications of Specific Programs.

[redacted] attempts to produce domestic radars 50X1
in Czechoslovakia, but it is believed that production of the necessary electron tubes is low and unsatisfactory. An example is the attempted proximity fuse project. The Tesla plant at Pardubice was attempting to develop a radio-operated fuse for a bomb based on a US design which appeared in a US periodical. Tubes made in the US were obtained for this project from Switzerland and France. Although six proto-type fuses were tested, only one fuse functioned at all, and that one prematurely. At that point the project was discontinued. There is evidence that a Tesla plant at Vilsnice intended to produce subminiatures, perhaps for this same project, but no production has been reported.

Magnetrons have been obtained through Sweden, and other radar tubes have been sought in the US and Switzerland. The Czechs have demonstrated their great interest in procuring these types by their persistence and by the fact that they are prepared to be generous in their outlays of foreign exchange. Domestic production of some of these tubes is at the very low rate of two a day.

E. Soviet Bloc.

Estimates based upon an analysis of the consumption pattern for electron tubes show that the more important military electronics programs of the Soviet Bloc appear to be concentrated primarily within the USSR. The Satellite electron tube industries make a significant contribution to less sensitive projects and, in proportion, contribute more heavily to the over-all Soviet Bloc civilian demand for tubes. Pressure continues for increased output from the Bloc electron tube industry. Recent expansions and plant rearrangements have been reported in the USSR, East Germany, Czechoslovakia, and Hungary. Although the total output of electron tubes was much higher in 1950 and in 1951 than for previous years, there are no indications of any significant increase in the portion allocated to Bloc requirements for civilian consumers.

Table 14 summarizes the over-all Soviet Bloc distribution in output in 1951 for the electron tube industry.

Table 14

Output Distribution (Product Value)
of the Soviet Bloc Electron Tube Industry
1951

End Use	Percent of Total
Civilian Radios, Television Sets, and Replacements	16
Essential Domestic Services and Industrial Uses	13
Military Electronic Equipment and Maintenance	64
Commercial Exports (Mostly within the Bloc)	7

VI. Summary Estimate for the Soviet Bloc: Capabilities, Vulnerabilities, and Intentions.

A. Capabilities.

The total output of electron tubes in the Soviet Bloc for 1951 is estimated to be 46 million tubes of all types at an estimated value of US $53 million. The production of electric lamps of all types is estimated for 1951 at 251 million at a value of $22 million.

Table 15* compares the productivity in the tube and lamp industries of the Soviet Bloc and of the US.

* Table 15 follows on p. 57.

Table 15

Productivity in the Tube and Lamp Industries
of the Soviet Bloc and of the US
1951

Country	Value of Output of Tubes and Lamps per Man-year ($ US)	Receiving Tubes Produced per Man-hour	Lamps Produced per Man-hour
USSR	1,450	0.9	6.0
Hungary	1,800	1.6	9.0
East Germany	750	0.45	4.8
Czechoslovakia	620		
US	4,512 a/	5.3	40.0

a. This figure is dollar output per man-year as of 1947 in the electron tube industry only.

It is estimated that the Soviet Bloc should be able to increase its output of tubes and lamps by January 1953 as follows: tubes of all types to a total of 61 million units, valued at approximately $70.6 million, and lamps of all types to a total of 307 million units, valued at approximately $27.5 million. Tables 16 and 17* give the production and estimated capacity for 1951 and 1953 of the Bloc tube and lamp industry.

At the present levels of output the Soviet Bloc is able to furnish its civilian population with a low but satisfactory level of broadcast radio service. The armed forces of the Bloc are furnished with a complement of equipment which is considered to be inadequate by Western standards but which seems to be satisfactory for the needs of the Bloc. This equipment consists of a large amount of relatively simple communications equipment; many kinds of radar, including relatively modern microwave types; and special equipment, such as guided missile guidance systems and presumably proximity fuses of certain kinds. Communications networks, especially in the USSR, also are furnished with adequate supplies from the electron tube industry.

* Table 16 follows on p. 59; Table 17, on p. 61.

At these levels of output the Soviet Bloc is forced to balance its interests very carefully. Military and communications requirements, however, are being fulfilled in terms of the Bloc's conception of its needs.

With the increased production estimated for the Soviet Bloc, it should be possible to increase to a significant degree the utilization of electronics by the Bloc's armed forces. In particular, it is felt that certain programs, such as the proximity fuse and other expendable programs which at the present time can be undertaken only with a significant sacrifice in output of other end items, will be well within the realm of feasibility, especially in the more important applications such as antiaircraft. The increased output also should allow the Bloc to increase the complexity of some of its types of equipment, but most types probably will remain rudimentary by US standards, since the tendency has been to increase equipment in terms of numbers rather than in terms of complexity. Certain devices, however, such as telemetering equipment for guided missiles, are necessarily complex, and the added output of electron tubes will make production of this relatively complex equipment possible to a greater extent than at present.

There are two factors that limit the ability of the Soviet Bloc to produce electron tubes and electric lamps. First, aside from further efforts by the West to interdict the shipment of supplies of critical materials to the Bloc, there already exist serious shortages that are hampering efforts to increase production. It is necessary for the Bloc to employ illegal means in order to obtain much vital input material, with the result that this material often is not available exactly when and where it is needed and often is of inferior quality. Thus, without any further attempts on the part of the West to stop the flow of critical materials going to the Bloc, these materials already are in very limited supply. The second limitation concerns the availability of skilled production, design, and development engineers and of trained laborers. Although this shortage of trained personnel is acute in Czechoslovakia, the rest of the Soviet Bloc is steadily training such personnel, so that, though at present there is some shortage, it is felt that it is diminishing and in a few years should not be a serious limitation.

An allied problem exists in East Germany, where labor productivity is low as compared with the West and with most of the Soviet Bloc. This problem is caused more by the customs of the trade in East Germany than by a low level of skill of the labor force, but the result is relatively less production than would be possible from the same labor force if such trade customs were dropped.

Table 16

Production and Estimated Capacity of the Soviet Bloc Electron Tube Industry
1951 and 1953

	1951					1953				
	Receiving Tubes		Other Tubes		All Tubes	Receiving Tubes		Other Tubes		All Tubes
Country and Plant	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Value (Thousand $ US) a/
USSR	33,800	21,400	1,283	18,800	40,200	44,500	27,800	1,700	24,200	52,000
Institute No. 160, Fryazino (Shchelkovo)	9,000	6,500	73	1,000	7,500	15,000	10,500	120	1,700	12,200
Svetlana No. 211	7,000	3,800	750	4,400	8,200	8,000	4,300	1,000	6,000	10,300
Moscow No. 632	3,500	1,900	150	2,900	4,800	5,000	2,600	200	4,000	6,600
Novosibirsk No. 617	8,500	5,100	280	9,000	14,100	10,000	6,000	330	10,000	16,000
Tashkent No. 191 (390)	3,800	2,100	30	1,500	3,600	4,500	2,400	50	2,500	4,900
Others	2,000	2,000	0	0	2,000	2,000	2,000	0	0	2,000
Hungary	4,000	2,200	510	2,600	4,800	5,000	2,750	638	3,250	6,000
UILCO "Tungsram"	4,000	2,200	500	2,100	4,300	5,000	2,750	625	2,625	5,375
Transmitting Tube Factory	0	0	10	500	500	0	0	13	625	625

a. Value data based upon current US f.o.b. prices for equivalent products.

Table 16

Production and Estimated Capacity of the Soviet Bloc Electron Tube Industry
1951 and 1953
(cont'd)

	1951					1953				
	Receiving Tubes		Other Tubes		All Tubes	Receiving Tubes		Other Tubes		All Tubes
Country and Plant	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Value (Thousand $ US) a/
East Germany	3,606	1,930	133	1,700	3,630	4,470	2,680	205	2,770	5,450
OSW	1,000	550	105	1,160	1,710	1,500	830	170	2,100	2,950
Funkwerk Erfurt	1,400	750	28	540	1,290	2,000	1,080	35	670	1,750
Others	1,206	630	0	0	630	1,470	770	0	0	770
Czechoslovakia	2,300	1,700	200	800	2,500	2,760	2,040	240	960	3,000
Tesla	2,300	1,700	200	800	2,500	2,760	2,040	240	960	3,000
Total	43,700	27,200	2,126	23,900	52,000	57,000	35,300	2,783	31,200	66,500

a. Value data based upon current US f.o.b. prices for equivalent products.

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Table 17

Production and Estimated Capacity
of the Soviet Bloc Electric Lamp Industry
1951 and January 1953

Country and Plant	1951		January 1953	
	Volume (Thousand Units)	Value (Thousand $ US)	Volume (Thousand Units)	Value (Thousand $ US)
USSR	125,000	11,200	142,000	12,500
Moscow No. 632	90,000	7,500	100,000	8,400
Svetlana No. 211	20,000	2,200	25,000	2,400
Tashkent No. 191 (390)	3,000	300	5,000	500
Others	12,000	1,200	12,000	1,200
Hungary	41,200	4,700	51,500	5,875
UILCO "Tungsram"	41,200	4,700	51,500	5,875
East Germany	40,900	3,900	66,500	6,330
Berlin Gluehlampenwerk	19,600	1,800	31,850	2,930
Others	21,300	2,100	34,650	3,400
Czechoslovakia	15,000	1,340	20,000	1,790
Tesla	15,000	1,340	20,000	1,790
Others	30,000	3,000	30,000	3,000
Total	251,000	22,500	307,000	27,500

B. Vulnerabilities.

The electron tube industry in the Soviet Bloc is subject to two principal vulnerabilities. First, and probably most important, the Bloc is greatly dependent upon the West for certain critical materials, such as refractory metals, in refined and fabricated forms, and diamond dies for drawing fine wire. In addition, although the USSR has enough mica for its own uses, the Satellites must rely on imports of this material. Roughly the same situation exists with regard to nickel, especially nickel for cathode sleeves. The USSR exports some nickel to the Satellites, but most of it must come from the West. The output of electric lamps also is peculiarly vulnerable to this sort of interdiction, since tungsten wire, largely obtained from the West, is essential to this production. It is believed that an effective embargo on these critical materials would cause the Bloc output of electron tubes to drop by 50 percent. Such an embargo, however, would be difficult to render completely effective, since the Bloc already is adept at circumventing such embargoes.

The second vulnerability of the Soviet Bloc tube and lamp industries is found in the fact that a relatively small number of plants are engaged in this line of activity. Although there is no one key plant, as such, there are only nine major facilities in the entire Bloc producing tubes: five in the USSR, two in East Germany, and one each in Hungary and in Czechoslovakia. Although it is possible to evacuate these plants if necessary, Soviet experience in World War II has shown that there is a large loss of output whenever evacuation is necessary.

C. Intentions.

1. There is some indication that the pattern of use of electron tubes by the Soviet Bloc is continuing along the lines of the past 5 years. The production of tubes in the Bloc has been heavily weighted in favor of types for use in military applications, and there does not seem to be a significant change in the pattern already established.

2. Examination of types of electron tubes commonly in military use in the Soviet Bloc indicates that the production of microwave radar is increasing.

3. There is some production of subminiature electron tubes in the Soviet Bloc. This production indicates a potential capability to deliver tubes required for proximity fuses and certain types of guided missiles.

APPENDIX A

TABLE 18

Classification Codes of Electron Tubes in the US and the UK, 1943; in East Germany, 1950*

Category of Tubes	US a/ 1943	UK b/ 1943	East Germany, 1950 c/
Mass-produced Receiving Tubes and Related Types	01	01	36651000 (5 subcodes)
	02	02	36654000 (3 subcodes)
	51	03	36656000 (4 subcodes)
	52	04	36657000 (3 subcodes)
	53	06	36683000
	54	07	
	55	08	
	PF	09	
		10	
		11	
		14	
		22	
Total Classification in Category	8	12	16
Large Transmitting and Special Tubes	03	05	36661000 (2 subcodes)
	04	51	36663000
	05	52	36665000
	06	53	36666000
	07	13	36671000
	08	15	36672000

* Footnotes for TABLE 18 follow on p. 64.

TABLE 18

Classification Codes of Electron Tubes in the US and the UK, 1943; in East Germany, 1950 (cont'd)

Category of Tubes	US a/ 1943	UK b/ 1943	East Germany, 1950 c/
Large Transmitting and Special Tubes (cont'd)	09	16	36673000 (4 subcodes)
	10	17	36674000 (2 subcodes)
	11	54	36675000
	12	55	36685000 (3 subcodes)
	13	19	36687000
	14	20	36690000
	15	21	
	16	23	
	17	30	
	18	56	
	19		
Total Classification in Category	17	16	19
Cathode-ray (CR) Tubes	41	12	36681000 (8 subcodes)
	42	18	36686100
	43		36686200
	44		36686300
	45		36681900
	46		
	47		
Total Classification in Category	7	2	12

a. US War Production Board, 1943.
b. UK Ministry of Aircraft Production, 1943.
c. German Democratic Republic Ministry for Planning, 1950.

APPENDIX B

THE ELECTRONICS INDUSTRY IN THE USSR

1. 1951 Output.

The broadest definition of electronic equipment is an apparatus which employs electron tubes as functional component parts together with other circuit elements. This definition implies that the total economic effort devoted to the industry manufacturing electronic equipment is related to the effort devoted to electron tubes. In practice the ratio of the total output of the electronics industry to the output of electron tubes falls within a predictable range, as modified by the following considerations:

a. The definition of the electronics industry frequently is such as to encompass the manufacture of wire communications equipment.

b. The product mix of electronic equipment may at times include a high proportion of items which are largely nonelectronic.

The relationship between the electronics industry and the electron tube industry is illustrated by the statistics given in Table 19.

Table 19

Ratio of the Annual Output of the Electronics Industry to the Annual Output of Electron Tubes: US, 1944, 1947, and 1951; East Germany 1951

		Total Output (Million $ US)		
Country	Year	Electronics Industry	Electron Tubes	Ratio of Industry to Tubes
US	1944	3,000	352.00	8.5
US	1947	1,200	125.00	9.6
US	1951	3,500	430.00	8.1
East Germany	1951	35	3.63	9.6

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The values for the total output of the electronics industry have been adjusted to exclude wire communications. The lower ratio for the US in 1951 is probably due to the predominance of the production of television sets, for which the value of tubes required is relatively high.

By extending this comparison to include the USSR and by employing as a base the estimate of $40.2 million for the 1951 Soviet output of electron tubes, a total annual output of about $340 million is indicated for the Soviet electronics industry. This figure is appreciably higher than earlier estimates, which have been based largely upon information predating 1949.

A further detailed study of various sectors of the Soviet electronics program is required to confirm or to amend this estimate of output. It is believed that the estimate is consistent with conclusions outlined in the text of this report, that the Soviet electronics industry is now operating at a level higher than previously suspected, and that an extensive effort is devoted to the military electronics program.

2. Total Employees.

The total number of employees in the Soviet electronics industry may be estimated in two ways: first, by relating this total to the employees of electron tube plants and, second, by estimating the industry output per employee, based upon the tube productivity. Both approaches indicate a total employment in the industry of about 150,000.

3. Energy Requirements.

a. Electric power consumed during 1947 by the US electronics industry was approximately 600 million kilowatt-hours (kwh). Factual data for the Soviet electronics industry are lacking. The 1951 requirements for electric power are estimated to be about 90 million kwh.

b. Fuel requirements for the Soviet electronics industry are mainly for coal. All plants using process gas (where information is available) have gas generators consuming coal. A small amount of tar oil is consumed at some glass furnaces. Total 1951 Soviet consumption of coal for the production of electron tubes is estimated at 170,000 metric tons.

4. Geographical Distribution.

A complete analysis for all sectors of the Soviet electronics industry is lacking, but the geographical distribution has been estimated through the use of four types of data as follows: the distribution of the electron tube industry, the distribution of the related electrical machinery industry, the location of 236 listed electronics plants, and the location of 69 larger electronics plants. The estimated distribution of output among the economic regions of the USSR is given in Table 20.* Derivative estimates are also given for the distribution of manpower, electric power, and fuel within the industry.

* Table 20 follows on p. 68.

Table 20

Geographical Distribution of the Soviet Electronics Industry
1951

Economic Region a/	Distribution of Output (Percent)	Manpower (Thousands)	Electric Power (Million Kilowatt-hours)	Coal (Thousand Metric Tons)
Northwest (Ia)	23.0	34.5	20.7	39.1
Northern European USSR (Ib)	0	0	0	0
Baltic (IIa)	Small	Small	Small	Small
Belorussia (IIb)	0	0	0	0
Ukraine (III)	8.0	12.0	7.2	13.6
Lower Don-North Caucasus (IV)	Small	Small	Small	Small
Transcaucasus (V)	2.0	3.0	1.8	3.4
Volga (VI)	5.0	7.5	4.5	8.5
Central European USSR (VII)	35.0	52.5	31.5	59.5
Urals (VIII)	7.0	10.5	6.3	11.9
West Siberia (IX)	15.0	22.5	13.5	25.5
Kazakh SSR (Xa)	0	0	0	0
Central Asia (Xb)	5.0	7.5	4.5	8.5
East Siberia (XI)	Small	Small	Small	Small
Far East (XII)	0	0	0	0
Total	100.0	150.0	90.0	170.0

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APPENDIX D

ELECTRON TUBE AND ELECTRIC LAMP PLANTS IN THE SOVIET BLOC

1. USSR.

a. Electric Lamp Works [redacted] Stalinskiy Rayon, Moscow. 24/ 50X1

Plant [redacted] Moscow, a major Soviet producer of tubes and lamps 50X1 and one of the four divisions of the former Kuybyshev combine. It covers an area of 30 acres and includes a number of four- and five-story brick buildings. Unlike other plants engaged in the manufacture of electronics, Plant [redacted] was not greatly dislocated during World War II and has been 50X1 an effective manufacturing enterprise since 1946. In 1945 the plant established a receiving tube department with personnel and equipment which were diverted from lamp production. Production of transmitting tubes was begun in 1947, and production of CR tubes in late 1948. This factory has been the major Soviet supplier of refractory metals for a number of years. The Soviet capacity to produce hard metals (tungsten, molybdenum, and tantalum) has been quite inadequate, and 1950 imports were heavy. Facilities for increased production of these metals were added to Plant [redacted] 50X1 in late 1949, and tantalum production was started in early 1948. A new production building for glass manufacturing, added in 1947, should reduce dependence on outside sources of glass parts. The factory complex uses city power but is reported to have its own large emergency power system.

The program of Plant [redacted] is concentrated primarily within the 50X1 following lines of activity: research and engineering related to electric lamps, electron tubes, specialized lamp and tube materials, and certain types of lamp-making machinery; large-scale manufacture of incandescent electric lamps and fluorescent lamps; large-scale manufacture of standard glass receiving tubes; production of CR tubes; and production of medium-to-very-large transmitting tubes. Wire and metal products are shipped to other lamp and tube producers.

Key personnel at Plant [redacted] are reported to include the following 50X1 G.N. Tsvetkov, plant director; Roman Alekseyevich Nialander, chief engineer; and Zinaida Kondroshova, head of the tube shop. Employees totaled from 6,000 to 7,000 in 1941, and were estimated to be 8,000 in 1950.

[redacted] plant output and 50X1 performance and on more numerous data relating to inputs, the 1950 output of Plant [redacted] is estimated to have totaled 85 million electric lamps of 50X1 all types and 3.1 million electron tubes of all types. Table 21,* outlining the volume and value of production for Plant [redacted] for different years, is consistent with all reported data. 50X1

b. Svetlana Plant [redacted] Engels Prospekt and V. Murinskogo, Prospekt, Leningrad. 25/ 50X1

Svetlana Plant [redacted], the largest prewar Soviet electron tube plant, as well as an important lamp producer, is located 5.5 kilometers north of the Neva River, just to the right of the main Leningrad-to-Viborg highway. Svetlana includes seven old and four postwar shops, plus warehouses and an administration building. Its total floor space is about 850,000 square feet. The original plant, built in 1908, was equipped in 1937 and 1938 by RCA as a modern tube factory. All important equipment, together with about 1,000 key personnel, was evacuated to the Novosibirsk Factory [redacted] in 1941, and about half of the major machines were lost in the removal. Starting in 1945, Svetlana was reequipped with plant facilities from Germany and the US. Prewar equipment remained at Novosibirsk, although many of the personnel returned to Leningrad. After 1947 some Soviet-made receiving tube and lamp machinery was installed; and plant equipment for the manufacture of larger transmitting tubes is reported also to be of Soviet design and manufacture. Svetlana Plant [redacted] includes a glass shop, capable of supplying the major part of the plant's requirements for tubes and lamps; and a refractory metal refining and wire-drawing plant which supplies a smaller portion of the plant's needs for tungsten and molybdenum metal products. Although electric power is purchased from outside sources, Svetlana has its own powerhouse, rebuilt in 1947, apparently for use as a supplementary and stand-by emergency system. 50X1 50X1 50X1

The plant director of Svetlana Plant [redacted] is Gal'din. Employees total about 5,000 and in the past included a number of German engineers and scientists. Although there are indications that the labor supply in the Leningrad area is limited, the plant appears to be adequately staffed with direct labor, generally with sufficient experience, and with fairly competent technical and supervisory personnel. The principal product lines are general-service incandescent lamps, airport and high-power lamps, fluorescent lamps, metal and glass receiving tubes and allied types of small transmitting tubes, medium- and high-power transmitting tubes, special tubes (including klystrons), and X-ray tubes. The evaluation in Table 22** of the output of Svetlana Plant [redacted] is based primarily on variously reported output data in 1947 and 1948, on spot reports for specific products in 1950, and on reported plant inputs of manpower and materials. 50X1 50X1

* Table 21 follows on p. 73.
** Table 22 follows on p. 74.

Table 21

Tube and Lamp Production of Soviet Plant Moscow 1947, 1949-53

Year	Receiving Tubes		Transmitting and Special Tubes a/		Lamps		All Tubes and Lamps
	Volume (Thousand Units)	Value (Thousand $ US) b/	Volume (Thousand Units)	Value (Thousand $ US) b/	Volume (Thousand Units)	Value (Thousand $ US) b/	Value (Thousand $ US) b/
1947	1,500	800	5	100	63,000	5,300	6,200
1949	2,500	1,300	30	600	78,000	6,500	8,400
1950	3,000	1,600	100	2,000	85,000	7,100	10,700
1951	3,500	1,900	150	2,900	90,000	7,500	12,300
1952-53	5,000	2,600	200	4,000	100,000	8,400	15,000

a. Including cathode-ray tubes.
b. Based on current US f.o.b. prices for equivalent products.

Table 22

Tube and Lamp Production of Soviet Plant [redacted] Leningrad
1947-48, 1950-53

Year	Receiving Tubes		Transmitting and Special Tubes		Lamps		All Tubes and Lamps
	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Value (Thousand $ US) a/
1947	3,500	1,900	300	1,800	13,000	1,400	5,100
1948	4,000	2,200	400	2,400	17,000	1,800	6,400
1950	6,000	3,300	600	3,600	20,000	2,200	9,100
1951	7,000	3,800	750	4,400	20,000	2,200	10,400
1952-53	8,000	4,300	1,000	6,000	25,000	2,400	12,700

a. Based on current US f.o.b. prices for equivalent products.

c. Institute [redacted] Fryazino (Shchelkovo), Moscow Oblast. 26/ 50X1

Information effective in late 1950 indicates that Institute [redacted] 50X1 has become the most important, if not the largest, enterprise in the USSR for the manufacture, design, and development of electron tubes. This factory complex, located in Fryazino, a village 4 miles north-northeast of the center of Shchelkovo and 22 miles northeast of the center of Moscow, comprises three main multistoried factory buildings, a glass-making plant, and eight smaller buildings. Three of these buildings are new and were under construction in 1950. The reported total floor space, excluding sheds, is approximately 620,000 square feet, including 250,000 square feet in the tube production shop alone.

The original tube-making machinery, evacuated to Siberia during World War II, was replaced with units obtained from the US under Lend Lease and with others removed in 1945 and 1946 from German, Czechoslovak, and Hungarian tube facilities. This postwar machinery was reported to have included from 40 to 50 US-built grid-winding lathes. Since 1948 the plant capacity has been further expanded through the addition of Soviet-made tube machinery generally copied from US models. Special tube machinery for Institute [redacted] and other Soviet tube plants is produced 50X1 under the direction of a separate design group and machine shop on the Institute [redacted] premises, apparently subcontracted for manufacturing 50X1 and assembly to several outside machinery factories.

Soviet personnel at Institute [redacted] reported as 5,000 in 1941, 50X1 1,200 in 1945, and 2,000 in 1946, is said to have reached 5,000 by the end of 1950, including 745 in the engineering and development departments. Several reports agree that the technology at Institute [redacted] and the 50X1 skill of its technical staff have improved greatly since 1946. The recent departure of German specialists from this plant should have no ill effect upon production capabilities. Key Soviet personnel are listed as including Golzov, plant director, a capable manager with good US training; Sorokin, chief engineer; Ratenberg, receiving-tube manager, an outstanding tube specialist with good technical ability; Susmanowskiy, head of the magnetron department, the most capable scientist at the Institute; Shutak, head of the CR tube department, transferred from the Ministry of Communications Equipment Industry, very capable and energetic; and Seebode, head of the test department, an experienced and skilled engineer. Young engineering graduates and technicians receive factory training at Institute [redacted] and are employed there and at other Soviet electron tube factories. 50X1

Materials, reported as limited in supply and of poor quality in 1946, were generally available in proper form and grade by 1950. Nickel was very plentiful, although there was difficulty in obtaining seamless cathode sleeves with adequate uniformity and purity of nickel melt. Glass tubing, and possibly the glass bulbs, are produced by Institute [redacted] for its own use. The Institute has its own thermal power plant, with a turbogenerator possibly rated at 3,000 to 5,000 kilowatts. It is probable that this is a stand-by supply to supplement a local outside system. Institute [redacted] has its own gas-generating plant for the process gas required in glass-working and in tube manufacturing. 50X1 50X1

By 1950 the program at Institute [redacted] comprised the following activities: the design and development of receiving tubes, smaller transmitting tubes, special tubes, and CR tubes; the coordination, and possibly the direction, of tube engineering for some product lines at other Soviet tube factories; central testing facilities for tubes under its cognizance; the mass-production of receiving tubes and related types of small transmitting tubes; model-shop production of magnetrons, klystrons, TR boxes, silicon crystal diodes, and CR tubes; and, possibly, small-scale production of a few larger transmitting tubes. No lamp manufacturing is carried on at this plant. 50X1

The following qualifying factors were considered in evaluating the present and future capabilities of Institute [redacted] as a manufacturing facility: (1) the organization is adequately staffed with experienced and competent key personnel; (2) lower-echelon engineering personnel and technicians have been made available in quantity, and these men were reported to have good basic education, to be industrious, and to have received on-the-job factory training; (3) good manufacturing equipment has been installed; (4) from the analysis of receiving tubes made in 1950 the manufacturing methods applied and the tooling for parts and subassemblies are generally on a par with the best current US practices, are definitely much lower in cost than counterparts made currently in East Germany, and should permit production at a reasonable direct-labor input and at acceptable shrinkage rates; and (5) critical tube production materials are available in sufficient quantity and of good quality. 50X1

Since no data have been reported on total plant output, several different types of information (primarily inputs, plus a knowledge of product mix) were combined to provide an estimate of the rate of production for Institute [redacted] at the end of 1950 as shown in Tables 23 and 24.* 50X1

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* Table 23 follows on p. 77; Table 24, on p. 78.

Table 23

Methods of Estimating Production of Receiving and Small Related Tubes at Soviet Institute [redacted] Fryazino (Shchelkovo) 1950

50X1

Type of Data	Magnitudes	Factor (Range)	Millions of Tubes a Year		
			Minimum	Probable	Maximum
Floor Space Square Feet, 1950	Shop, 250,000 Total, 620,000	100 Tubes per Square Foot 5 Tubes per Square Foot	3.0		25.0
Employees, 1950	4,000 in This Product Group	0.3 to 2.5 Man-hours per Tube; 1.0 Probable	3.2	8.0	25.0
Machinery after 1946	7 to 10 Unit Groups	2,000 to 10,000 per Day per Unit	3.5		27.0
Glass, 1947	500 Tons a Year	80 to 150 Lbs per 1,000 Tubes	7.0		13.0
Payroll, F.O.B. Price, Costs, 1950	800 Rubles per Month Average; Payroll at 0.55 Net Sales; Average Tube Price, 9 Rubles			7.8	
Sample Quantities, Tested	2,250 to 6,500, Tested per Week	JAN Quality Control a/	1.8		9.4

a. US Joint Army-Navy approved quality control.

Table 24

Methods of Estimating Production of Special and Cathode-ray Tubes
at Soviet Institute [redacted] Fryazino (Shchelkovo)
1950

			Output per Year		
Type of Tube	Employees	Space	Units	Dollars	Basis of Estimate
Magnetrons	75	4,500 Earlier; 10,000, Late 1950	2,500	300,000	Early World War II Experience, Model Shops
Klystrons	50	4,000	3,000	100,000	About 1 Man-hour per Dollar
Silicon Crystal Diodes	15	1,500	50,000	100,000	Reported Production Rate by Dec 1950
Cathode-ray Tubes	40	4,500	3,000	100,000	About 25 Man-hours per Tube

Manufacturing at Institute [redacted] was just being organized at the end of 1945, the equipment was almost completely installed by 1948, and the plant was reported in full operation. Improvement in tooling, in level of technology, and in rate of shrinkage was made by 1950, and further improvement in labor productivity was expected after the end of 1950. An estimate of electron tube production output at Institute [redacted] for different years is given in Table 25.* 50X1 50X1

Institute [redacted] is reported as the sole Soviet producer of silicon crystal diodes, but it acts rather in the capacity of a production-model shop and design center for magnetrons, klystrons, and CR tubes. These latter microwave radar tubes are manufactured in quantity at other Soviet tube factories, possibly klystrons at Svetlana Plant [redacted] CR tubes at the Moscow Plant [redacted] and magnetrons at the Tashkent Plant [redacted] (390) 50X1 50X1 50X1 50X1

d. <u>Electric Lamp Plant [redacted] Krasny Prospekt, Novosibirsk</u>. 27/ 50X1

Plant [redacted] was established in the buildings of an educational institution in Novosibirsk in late 1941 when not only machinery but also 1,000 key personnel were transferred from the Svetlana Plant [redacted] in Leningrad. By 1944 the plant employed several thousand people and produced about 4 million tubes a year, including all major categories of receiving, transmitting, and special tubes. Although many of the key personnel returned to Leningrad at the end of the war, Plant [redacted] in Novosibirsk was maintained and expanded. In 1944 the buildings that were used were temporary. It is reported that new factory buildings were in construction during 1948 and 1949, including a four-story receiving tube shop, and totaled about 160,000 square feet. 50X1 50X1 50X1

In 1949, Plant [redacted] was reported to have three Telefunken as well as several US-type automatic exhaust units. A practical production rate for the German machines would total about 8,500 receiving tubes a day, and by adding the greater capacity of the US machines a plant production capacity of about 25,000 receiving tubes a day is indicated. The US machines, two of the Telefunken machines, domestically produced exhaust machines, sealing equipment, and other tube-making machinery were being installed in the new four-story receiving tube shop. A considerable increase in plant capacity was scheduled for the several years following 1949. 50X1

There is good evidence to indicate that the production program of Plant No. 617 has been predominantly for Soviet military use. Transmitting and special tubes are included in the output of this plant, and [redacted] the plant effort devoted to this 50X1

* Table 25 follows on p. 80.

Table 25

Electron Tube Production of Soviet Institute [redacted], Fryazino (Shchelkovo)
1946, 1948, 1950-53

	Receiving Tubes		Magnetrons		Klystrons		Crystals		Cathode-ray Tubes		All Tubes	
Year	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/
1946	1,500	1,000									1,500	1,000
1948	4,000	3,000			b/		b/		b/		4,000	3,100
1950	7,000	5,200	2.5	300	3.0	100	30	60	3	100	7,038	5,760
1951	9,000	6,500	5.0	600	4.0	130	60	120	4	130	9,073	7,480
1952-53	15,000	10,500	10.0	1,200	5.0	160	100	200	4	130	15,119	12,190

a. Based on current US f.o.b. prices for equivalent products.
b. Small number of units.

latter category may exceed that devoted to the manufacture of receiving tubes.

The plant director is reported to be Dzhuk, who had RCA training in the US in late 1930. The total number of employees has been variously estimated at from 5,000 to 12,000. After 1946, German specialists were sent to Novosibirsk, as were the German manufacturing data for centimeter-frequency, metal-ceramic, and klystron tubes.

Although little information exists to permit a detailed analysis of current production programs, Table 26* provides a reasonable estimate for the annual levels of output at Plant [redacted] and includes data that are entirely consistent with reported inputs to this factory. 50X1

e. Electric Lamp Plant [redacted] 10 Uzbekistanska ul., Tashkent. 28/ 50X1

Plant [redacted] was established in a number of miscellaneous buildings during 1942-43 with lamp and tube equipment which was evacuated from Moscow, presumably mostly from Institute [redacted] in Shchelkovo. Wartime personnel of Plant [redacted] were reported to be about 2,500, and its products were primarily lamps and transmitting tubes. It was reorganized in 1946-47, automatic machinery being added. In 1949 additional units of German receiving tube equipment were reported to have been installed. There probably was also some consolidation of floor space. 50X1 50X1 50X1

Although recent details on facilities are not available, it appears that there are actually two manufacturing units in Tashkent. The first plant, at the above address, is commonly called Plant [redacted] and the second factory, located several kilometers away, is commonly referred to as Plant [redacted] Together, about 150,000 square feet of factory space are available in these plants. In 1950 the total number of employees at both plants was estimated at 2,500. 50X1 50X1

Lamp production at Tashkent increased during and after 1947, but there are indications that it has become of secondary importance. Production of glass receiving tubes was begun in 1947, with a considerable increase reported in 1949. Production of transmitting tubes has been continued. In addition to conventional medium- and high-power transmitting tubes, the transmitting tube department at Tashkent is reported to manufacture pulsed modulators and oscillators, probably including magnetrons. It is known that Plant [redacted] in Tashkent works closely with Institute [redacted] at Shchelkovo on engineering and production problems for 50X1 50X1

* Table 26 follows on p. 82.

Table 26

Electron Tube Production of Soviet Plant [redacted] Novosibirsk 50X1
1946, 1949-53

Year	Receiving Tubes: Volume (Thousand Units)	Receiving Tubes: Value (Thousand $ US) a/	Transmitting and Special Tubes: Volume (Thousand Units	Transmitting and Special Tubes: Value (Thousand $ US) a/	All Tubes: Value (Thousand $ US) a/
1946	3,500	2,300	85	2,500	4,800
1949	6,000	3,900	230	7,000	10,900
1950	7,500	4,500	260	8,000	12,500
1951	8,500	5,100	280	9,000	14,100
1952-53	10,000	6,000	330	10,000	16,000

a. Based on current US f.o.b. prices for equivalent products.

some classes of tubes.

Refractory metals and parts are obtained from Plant [redacted] in Moscow and mica from the Mica Trust Fabricating Plant at Irkutsk. The Tashkent plant has its own gas-generating plant using coal and is believed to have its own glass-making plant, which provides a portion of its glass requirements for tubes and lamps. 50X1

Based upon an analysis of the rather scanty information on both output and input, Table 27* outlines the estimated production levels of the Tashkent Electric Lamp Works complex, factories [redacted] for specified years. 50X1

f. Other Possible Soviet Tube and Lamp Producers.

In addition to the five major plants listed, [redacted] 50X1
[redacted] tube and lamp operations at other locations. With the possible exceptions of the plants listed under (1) and (2) following, about which very little is reported, the total production of these lesser plants is not great. Output for this remainder of the Soviet electron tube industry 50X1

* Table 27 follows on p. 83.

Table 27

Tube and Lamp Production of Soviet Plant [redacted] Tashkent 50X1
1947-48, 1950-53

Year	Receiving Tubes		Transmitting Tubes		Lamps		All Tubes and Lamps
	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Value (Thousand $ US) a/
1947	b/		5	250	1,500	150	400
1948	300	160	10	500	2,500	250	900
1950	3,500	1,900	20	1,000	3,000	300	3,200
1951	3,800	2,100	30	1,500	3,000	300	3,900
1952-53	4,500	2,400	50	2,500	5,000	500	5,400

a. Based on current US f.o.b. prices for equivalent products.
b. Small number of units.

is estimated for 1950 to be about 2 million tubes and 12 million lamps. A list of such producers and their probable status follows:

(1) The Ryazan Electric Lamp Plant [redacted] ul. Yanskaya, 50X1
Ryazan Oblast, was completed just before World War II. Since the war it has produced bulbs, lamps, and glass ampules. Miniature radio (panel) lamps were in production in 1949. The plant area was prohibited to prisoners of war. Indications are that this is a sizable operation, employing nearly 2,000 people. In March 1951, announcement was made that this factory was producing 15 new types of miniature radio tubes. The size of plant and the type of work indicate that Plant [redacted] may become 50X1
a significant producer of small tubes, possibly including both miniature and subminiature types.

(2) [redacted] the existence of a new 50X1
and unidentified tube factory on the Volga River north of Stalingrad or in the city of Saratov. Tube engineers and technicians trained at Institute [redacted] were said to have been assigned to this new factory. As a potential 50X1
producer of electron tubes, possibly for special applications rather than for conventional radio equipment, this facility will bear close scrutiny in the future.

(3) Vaists Elektrotechnika Fabrika (VEF), 19 Brivibas Gotve, Riga, is located in two factories in Riga. This plant is a very large producer of civilian radio equipment, telephones, and military communications equipment. One of the factories includes a department producing tubes and lamps, largely for local consumption. The total company personnel is about 5,000.

(4) A radio tube factory which is not believed to be a large producer is located in Tomsk. In view of plans for postwar rearrangement at Novosibirsk Plant [redacted] it is considered likely that sections of 50X1
No. 617 may have formed the base for the Tomsk plant.

(5) Electric Lamp Plant [redacted] located in the small town of 50X1
Zaprudnya, in the Moscow Oblast, about 60 kilometers north-northwest of Moscow, was originally a producer of raw glass and glass parts for tubes and lamps. Since the war it has been reported as a manufacturer of electric lamps in varied sizes and of some radio tubes, as well as of raw glass. This plant is not believed to be a large producer of lamps or tubes.

(6) Two associated electric lamp plants at Lvov, started after World War II, are engaged in producing lamps at an estimated rate of 1 million a year. There is no evidence of tube work as yet.

(7) The Solch Lamp Plant in Tirga (Prokopyevsk) has 1,500 employees and produces special lamps for mines and transformers. No tube work is undertaken.

(8) Additional research into information available from various recent sources indicates at this time that tube manufacturing is not conducted at the Frunze Radio Factory in Gor'kiy or at tube plants in Sverdlovsk, Rybinsk, Ufa, or Tbilisi. Older information had reported these as possible tube producers.

2. Hungary.

a. UILCO "Tungsram." 29/

The plant and home office of Egyesült Izzolampaes Villamossagi R.-T., commonly known as UILCO "Tungsram," is located in its own large factory area in Ujpest, just outside of Budapest. The plant is comprised of 18 buildings, including 6 major shops and laboratories. The total plant floor space is somewhat more than 700,000 square feet. Plant machinery is largely new, obtained or built in the postwar period to replace those items removed by the Soviets. In 1947, UILCO "Tungsram" was reported to have been equipped with nine automatic lamp machine groups and two or three automatic tube units, and in mid-1949 four new complete lamp groups were reported to have been under construction. This enterprise is capable of constructing all items of specialized technical plant manufacturing equipment required for the production of lamps and tubes.

Employment at this plant was reported as 3,450 workers in early 1948, 4,000 in early 1949, and 5,000 by mid-1950. The latter two figures include employees for the Orion apparatus assembly plant located on the same premises at that time. By mid-1951 the employment at the UILCO "Tungsram" tube and lamp complex was reported to have reached 5,000. Because of requirements for increased floor space needed for apparatus assembly, the Orion division was moved to new quarters in Budapest in mid-1951, thus placing all of the plants at the Ujpest location at the disposal of UILCO "Tungsram" tube and lamp manufacturing operations.

All comments by postwar observers through mid-1951 indicate that this enterprise is efficient in its operations, that it is still staffed at the engineering and production supervision level by old employees with good experience, and that the quality of the product is as good as prewar. Although difficulties, resulting primarily from material shortages, are reported, it was estimated in 1949 that the new plant equipment had improved operations to the point where productivity per man-hour had increased 20 percent over the prewar level. This high degree of manufacturing efficiency

is generally confirmed [redacted] 50X1
[redacted] 50X1

The unfortunate lack of recent detailed statistics on this enterprise has made it necessary to base the estimate of tube and lamp output given in Table 28* upon five sets of supporting data as follows: known figures for prewar and 1947 production performance, [redacted] 50X1
[redacted] current employment, competent estimates for relative productivity, known key units of machinery installed by 1949, and reported imports of specialized tube and lamp materials. 50X1

b. Hungarian Transmitting Tube Factory. 30/

Although little recent detail is available on the Hungarian Transmitting Tube Factory, a former Philips branch plant in Budapest, it is known to be concentrating exclusively on the manufacture of large transmitting, special, and X-ray tubes. Although a small plant, it is reported to be both efficient and profitable. Its staff comprises several hundred employees. A very approximate estimate for the 1951 output at the Hungarian Transmitting Tube Factory is $500,000, comprising from 5,000 to 10,000 tubes.

3. East Germany.

a. Werk fuer Fernmeldewesen (OSW). 31/

The leading electron tube manufacturing and development enterprise in East Germany is the Werk fuer Fernmeldewesen (OSW). It is Soviet-owned and controlled through the SAG Kabel. At present this enterprise is a consolidation of the OSW tube facility and the NEF apparatus model shop in the Ostendstrasse, Berlin-ober-Schoeneweide, location, plus the TBN communications equipment production and development shop in the Knorrbremse building, Berlin-Rummelsberg. OSW is engaged in the production of receiving, special, transmitting, and CR tubes, and specialized tube materials. It also participates in tube development and research and in the development and small lot production of microwave and other specialized test equipment.

Electron tube output of OSW has been reported in detail and is summarized in Table 29.**

By 1951, 90 percent of the OSW receiving tube production was reported to be types of tubes required for Soviet television receivers.

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* Table 28 follows on p. 87.
** Table 29 follows on p. 88

Table 28

Tube and Lamp Production of Hungarian Plant UILCO "Tungsram," Ujpest
1946-49, 1950-51

Year	Receiving Tubes		Transmitting Tubes		Incandescent Lamps		Fluorescent Lamps		All Tubes and Lamps
	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Value (Thousand $ US) a/
1946-49	7,300	4,000	700	3,000	70,000	7,000	400	300	14,300
1950	3,500	1,900	400	1,600	30,000	3,000	1,000	600	7,100
1951	4,000	2,200	500	2,100	40,000	4,000	1,200	700	9,000

a. Based on current US f.o.b. prices for equivalent products.

Table 29

Electron Tube Production, 1949-51, and Planned Capacity of the East German OSW Plant, Berlin

Year	Receiving Tubes		Transmitting and Special Tubes		Cathode-ray Tubes		All Tubes	
	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/	Volume (Thousand Units)	Value (Thousand $ US) a/
1949	200	110	40	320			260	430
1950	600	330	55	440	1	21	656	791
1951	1,000	550	80	640	25	520	1,102	1,710
Planned Capacity	1,500	830	120	1,030	50	1,070	1,670	2,930

a. Based on current US f.o.b. prices for equivalent products.

and military electronics equipment. These types normally are not required in the local East German economy except as needed to produce apparatus for the USSR. Eighty percent in value of the special tubes is reported in the production of the TS-41 high-frequency-pulsed triode oscillator, the "PRK" Soviet quartz ultraviolet lamp, the metal-ceramic decimeter tubes, and metallurgical X-ray tubes. Most of the output of CR tubes comprised 9-inch tubes for direct-view television receivers.

In October 1949, employees totaled 2,200, with 600 in research, 1,600 in production, and 350 in the administrative sections. In April 1950, employees totaled 2,400. By mid-1951, after consolidation of OSW, NEF, and TBN, total employees were reported at 4,400, with 2,200 in tube production and 1,100 in the administrative sections.

Expansion was effected at OSW during 1950 and 1951 through space rearrangement and the addition of equipment, including refractory metal facilities and automatic stem and exhaust machines. [redacted] 50X1
[redacted] Soviet instructions that OSW plan for a 10-fold expansion in capacity. 50X1
The possibility of doing this was seriously doubted [redacted] in 50X1
view of lack of technicians, of problems in acquiring technical machinery, and of the need for new floor space. There is no indication to date that any serious attempt has been initiated to implement such a plan, but there is evidence that OSW is engaged in expanding tube capacity to approximately double the capacity that was in effect at the end of 1950.

b. Funkwerk Erfurt VEB. 32/

Funkwerk Erfurt, second in size in the East German tube industry, is a people-owned enterprise, directly controlled as a key firm by the HV Elektrotechnik. The plant is divided into two works. The main building, a large four-story structure located on Rudolfstrasse, Erfurt, houses the administration and central offices, the tube laboratory, and the receiving tube and transmitting tube shops. The high-frequency equipment department, engaged in the design and manufacture of apparatus and precision electronic measuring equipment, is housed in another building located on the other side of Erfurt.

Funkwerk Erfurt is engaged primarily in the production of German series E and series U receiving tubes and, to a lesser extent, in the design (copy) and limited production of transmitting tubes, comprising 500-watt to 2-kilowatt medium-sized tubes and from 10-kilowatt to 30-kilowatt standard German copper-anode types. The plant also produces, against specific contracts, special tubes, including metal-ceramic decimeter types for the USSR and the SAG Kabel plant Sachsenwerk Radeberg, the TS-41 pulsed triode and 50-watt PA triodes, the design (copy) and construction of special tube and lamp machinery as required in the German

Democratic Republic, and electronic test equipment for Soviet military use. The estimate of production data given in Table 30, for tubes only, is not so accurate as that for OSW but is believed to be reasonably so.

Table 30

Electron Tube Production, 1949-51, and Planned Capacity of the East German Plant, Funkwerk Erfurt

	Receiving Tubes		Transmitting and Special Tubes		All Tubes	
Year	Volume (Thousand Units)	Value (Thousand EDM)	Volume (Thousand Units)	Value (Thousand EDM	Volume (Thousand Units)	Value (Thousand EDM)
1949	450	5,000	16	700	466	5,700
1950	1,100	12,300	5	2,200	1,105	14,500
1951	1,400	15,800	28	7,200	1,428	23,000
Planned Capacity	2,000	22,500	35	9,500	2,035	32,000

By the beginning of 1951 it is estimated that employees at Funkwerk Erfurt totaled 2,500, divided as follows: receiving tubes, 1,100; special tubes, 500 (divided between 400 administration and 1,200 direct labor); RFT Leipzig laboratory, 150; instrument shop, 450; machinery and maintenance shop. 300.

Although there is a research laboratory attached to Funkwerk Erfurt, apparently the tasks are assigned by the Ministry for Machinery Construction independently of Funkwerk Erfurt management, and most effort is not devoted to tube problems. The engineering capabilities of Funkwerk Erfurt appear to be quite limited in the tube field, and it does not seem that this establishment can be considered much of a research and development factor for electron tubes and their applications.

The Funkwerk Erfurt, established by Telefunken as a new plant just before World War II, suffered dismantling by the Soviets only to the extent of selected items of metal-tube machinery. Since 1946 a few additional items of equipment have been installed to round out the facilities. Present operations are built around three 48-head automatic Telefunken exhaust machines, three automatic button-stem machines, and two stem machines for large disk stems such as those used in metal-ceramic tubes and CR tubes. Undoubtedly the large increase in special-tube production scheduled for 1951 requires supplementing exhaust and test units, but the main problem would appear to be an adequate supply of special materials and of experienced technical help. No major plant expansion has been indicated, but the 1955 goal of 3 million tubes would require both additional space and additional key machinery.

c. Roehrenwerk Neuhaus VEB. 33/

Roehrenwerk Neuhaus, the third largest tube plant in the German Democratic Republic, was formerly a Telefunken factory and is now a people-owned enterprise, directly controlled as a key firm by the HV Elektrotechnik. All reports indicate that this plant produces only receiving tubes of the German series A, series E, and series U, plus a small number of inactive receiving types. There is no evidence of any significant production of special and transmitting tubes or of any significant effort in vacuum-tube research and development. Roehrenwerk Neuhaus does produce certain tube materials for sale, in addition to finished tubes, and supplies OSW and Funkwerk Erfurt with cathodes (redrawn from Heraeus, Hanau, nickel tubing), with some alloy grid wire, and with getters.

For 1947, planned production was 589,000 receiving tubes, valued at EDM 4,600,000, and production worth EDM 1,100,000 was realized in the first quarter. In mid-1948, actual monthly production was reported as 90,000 tubes, only 5,000 less than the planned total of 95,000. At the beginning of 1951, Roehrenwerk Neuhaus employed a total of 1,200 people and was scheduled to produce 1 million radio tubes.

d. RFT Phonetika Radio VEB (since June 1951 Known as Stern-Radio), Franz-Joseph Strasse 112, Berlin-Weissensee. 34/

Phonetika Radio, a small postwar enterprise, was reorganized in 1950 to produce limited quantities of receiving tubes and radio receivers and was incorporated into the VVB-RFT as of 1 April 1951.

The firm was founded by a few former employees of the Askania Werk AG in the buildings of an Askania World War II branch factory, and it obtained some plant equipment formerly owned by the Loewe-Opta-Radio AG. The firm has been under public administration since 1947, Production is confined to the assembly of the model RFT-1 Ull radio receiver, plus the manufacture of seven types of Telefunken type receiving tubes, primarily rectifiers and simple pentodes. No evidence of plans for the manufacture of special or transmitting tubes or for any significant effort in tube reception and development has been discovered.

For 1951, planned production was 206,000 tubes, valued at EDM 2,400,000, or about $100,000. It is believed that this schedule could be met, and that a 30 percent increase for 1952 is probable.

As of May 1951, Phonetika Radio had 480 persons employed in tube manufacture and radio assembly. For its size, this plant is reported to possess a large number of machine tools and key units of tube machinery, including automatic presses, coil winders, grid lathes, and automatic sealing machines. Tube exhaust and test facilities appear to be primitive and limited in extent, although good results are obtained.

e. Phoenix Roentgenroehren.

The Phoenix Roentgenroehren plant in Rudolstadt, Thuringia, is engaged in the manufacture of X-ray tubes, possibly special types of lamps, and transmitting tubes of special types, the transmitting tubes using much of the same equipment as is used in the manufacture of the other products. The X-ray tubes produced are apparently not of a conventional kind, and X-ray tube production appears to be a special development and expediting effort that involves visits of Soviet civilians and very strict security precautions.

Formerly the Seimens Reineger Werke and now employing 400 workers, Phoenix Roentgenroehren is divided into several sections, including a tube evacuation section and a section in which the special gases are pumped into the tubes. In 1948 most of the output went to Koch and Sterzel in Berlin and Dresden, while in a report dated 1950 mention is made of exports to Eastern and Southeastern European countries. The plant receives molybdenum rods and tungsten wire from Switzerland, but in general it is having difficulty importing rare metals, liquid air, and liquid oxygen.

In the same city as the Phoenix Roentgenroehren plant is the Otto Kiesewetter X-ray tube plant, which is engaged in similar activities.

4. Czechoslovakia.

a. Tesla Hloubetin.

The Tesla Hloubetin facilities consist of the two former Philips plants in Prague, called Hloubetin I and Hloubetin II. It is difficult from available evidence to separate their operations. Therefore, description will be based on both plants, taken together and referred to as one plant.

Tesla Hloubetin makes tubes, civilian radios, transmitters, and electronic equipment in general. In 1949 there were approximately 2,000 workers operating on one shift, 6 days a week. [redacted] 50X1
[redacted] the labor force as 1,400 to 1,600, mostly young women. The 50X1
decline in the labor force may be explained either on the basis of poor information or because of the shutting down of certain operations which are known not to have been successfully undertaken. On the other hand, since it is known that the tube-making facilities were to be moved to Roznov pod Radhostem in late 1950, it is possible that this decline in number of workers reflects that shift. Since the above-mentioned 1950 report giving a reduced labor force for the plant also gives figures on tube production, it is conceivable that the tube manufacturing equipment was moved to Roznov pod Radhostem gradually, thus accounting for the conflicting information.

Under Philips before World War II, this plant produced between 2 million and 3 million tubes a year, depending on the market. The Philips management was very competent, and the plant had all automatic equipment. Since the plant was taken over by Tesla, however, the production rate has been reduced by the low level of technical and engineering talent available and by shortages of materials which have resulted in unsatisfactory substitutions, such as steel for molybdenum in certain applications. The result has been a very high rate of rejects and a reluctance to use domestic tubes if foreign tubes are available.

Production includes receiving tubes and small transmitting tubes.
[redacted] the plant is devoted to the production of 50X1
special transmitting tubes and radar tubes.

b. Tesla Vrchlabi.

The amount of information on the Tesla Vrchlabi plant, formerly owned by Lorenz of Berlin, is much less than that on the Hloubetin plant. It is known that tubes are manufactured here and that before World War II this plant made tubes, radios, and aeronautical instruments.

The labor force, as of 1950, is thought to have been between 500 and 600 workers on a single shift day, 6 days a week. It is largely on the basis of this information that the production of this plant was estimated as compared with the production of the Hloubetin plant.

c. Roznov pod Radhostem.

The Hloubetin and the Vrchlabi plants were scheduled to be moved to Roznov pod Radhostem where a new tube-making facility was to have been completed by late 1950. [redacted] the 50X1
production of certain standard types at Roznov pod Radhostem as of July 1950. These types were previously made at Hloubetin.

The former manager of Vrchlabi is believed to be the present head of the Roznov plant. The plant was intended to make miniatures, CR tubes, radar tubes, amplifying tubes, and ultra-high-frequency types. A work force of 4,000 was planned. Transmitting tubes and all tube-making machinery are to be made, the former according to techniques learned from the Marconi firm in the UK. The site for the plant was chosen by the Soviets, presumably for its remoteness, as a security precaution.

There is some indication that the firm of Philips in Eindhoven, the Netherlands, may be aiding in the construction and operations of the Roznov pod Radhostem plant. Since Philips has extensive trading relations with the Satellites and since Czechoslovakia is in need of technical and material assistance, this indication is probably correct.

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APPENDIX F

METHODOLOGY

1. General.

In view of the wide scope in subject matter and geographical area covered, various methods have been employed in this report. In general, it has been necessary to depend on a combination of the following methods, the effectiveness of which has varied according to the adequacy of available information and the requirements of the subject material:

a. Analysis of statistical reports dealing with plans and industry performance.

[redacted] 50X1

c. The determination, within reasonable limits, of the magnitudes of key inputs consumed by the industry sectors and by the principal manufacturing enterprises.

d. A detailed analysis of the important input factors, including key machinery, manpower, and critical materials, as an indication of product mix, level of output, and industrial technology.

e. An engineering review of general electron tube technology and its application to an estimate of Soviet Bloc methods, productivity (including labor productivity), and pattern of uses.

2. Methodology for Development of Input Factors.

a. Estimating Output by Means of Input Coefficients.

The volume of production of an economic unit is a function of, or depends upon, the quantities of the various inputs used in the production process. An input coefficient is defined as the quantity of that input necessary to produce one unit of product. If A produces a product P, then $\frac{A}{P} = a$ is the input coefficient of A in the production of P. If B is also required to produce P, then $\frac{B}{P} = b$ is the input coefficient of B in the production of P.

Input coefficients are calculated from the input-output relations existing in economic units for which this information is available. By means of these coefficients the outputs of other economic units may be estimated from the quantities of inputs used by them.

For example, if it is known that 50 units of input A are required to produce one unit of product P, and then if it is known that 500 units of A are used by a given economic unit, the estimate of the output of this unit will be 10 units of P. If it is also known that this unit uses 40 units of input B, and if 4 units of B are required to produce one unit of P, then it is possible to make a second, independent estimate of the output of the economic unit.

Two basic conditions must be satisfied in order that input coefficients may be employed in this fashion. Input coefficients must be (1) stable through time (intertemporal stability) and (2) stable from one economic unit to another or from one geographic region to another (interspatial stability). The likelihood that these two conditions are satisfied will be considered in this section.

In the production of any given product the values taken by the input coefficients depend upon the particular production methods employed. The criterion used as a guide by an economic unit in the choice of a production method is, in general, related to the relative costs of alternative methods. An economic unit desires to minimize cost for a given level of output and will choose accordingly the method requiring the least-cost combination of inputs. The enterprise, of course, does not have complete freedom in its choice of method, for the area of its choice is bounded by technical conditions unique to the particular product produced.

Any change in the price of one input relative to that of another introduces an important incentive for the economic unit to substitute more of the cheaper input for the dearer input, subject, of course, to technical restrictions. Thus intertemporal stability of input coefficients will depend in part upon the stability of the relative prices of the various types of inputs used, relative to their technical substitutability in the production process.*

Further variations arise from the differential time periods required for adjustments arising from changes in resource supplies and in levels of output. These differentials are so pronounced that inputs are frequently classified as fixed and variable inputs, according to the length of the time periods required for adjustments to be made. It is implied in this distinction that at least some of the coefficients will tend to vary with the level of output.

There is also a considerable amount of variation in input coefficients among economic units producing similar products in different geographical locations. The chief cause for this variation is that different regions, both international and intranational, possess resources in varying proportions. Given this unequal distribution of resources, the least-cost combinations of inputs, or production methods, will vary with respect to geographical areas. It follows that substantial error may result from incautious application of input coefficients calculated in the US as a basis for estimating input coefficients for other areas of the world. However, these variations will be smaller as the degree of technical substitutability of processes and inputs is more limited. The making of electrolytic copper, for example, requires a fixed amount of electricity per unit of copper wherever it may be produced.

Methods of collecting input coefficients so as to avoid most of these potential difficulties are suggested below. It is clear, however, that all input coefficients will not be equally stable. When applying them, it is important, where choice is possible, to place the greatest reliance upon those input coefficients that are the more stable.

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* In a free-market decentralized economy where prices are flexible, price changes result from two possible sources: (1) given the total amount of the resources available, changes occur in the amounts of the resource desired for employment in alternative uses; or (2) given the types of alternative uses and the respective quantities used, a change in the over-all quantity of the resource available occurs. The solution of this resource allocation problem in a decentralized economy is achieved through adjustments in the proportions in which the inputs are employed, on the level of the individual enterprise. In a planned economy, where the allocation of resources is determined by a central planning board, a similar result is accomplished by an entirely different means. Both types of economy are subject, of course, to the same constraints: that it is not possible to use more of a resource than is available and that it is undesirable for resources to be unemployed.

(1) Choice of the Economic Unit to Be Studied.

The choice of the economic unit to be studied depends upon the nature of the problem to be solved. The desirable economic unit is an operation or a department within a plant performing a single operation. The focus on such a narrow category facilitates the comparison of input coefficients among economic units. However, inasmuch as information on inputs sufficiently detailed to permit a departmental breakdown is seldom available, a workable compromise is to concentrate on the plant level. Extreme care must be taken in a study made at this level that the input coefficient used to estimate output be obtained from an economic unit performing a comparable number of operations. For example, if a labor input coefficient is used to estimate the volume of output of a plant which makes all of its own parts, the input coefficient must not be taken from a plant which purchases all of its parts and performs an assembling operation only.

(2) Information Required.

The use of input coefficients to estimate output requires two types of information in addition to the values of the coefficients. This additional information may be classified as (a) information concerning the quantities of inputs used and (b) information concerning the product mixes.

Frequently, when study is focused on the departmental level, and almost always, when focused on the level of an entire plant, it will be found that many different products have common inputs but differing requirements per unit. In this case, given the quantities of the inputs used, the absolute volume of output will be a function of the proportions in which the various products are produced, or the product mix. Where information is known concerning inputs which are not common to more than one product, this problem will not occur. Otherwise, it will be necessary to have independent information on the proportions in which the products are produced in order to estimate the volume of output by the application of input coefficients to input quantity data.

(3) Conclusions.

An important feature of estimating output by means of input coefficients is the mechanical and explicit manner in which the estimates are derived. It may appear that at times intuition would be a more useful, or more reliable, method, producing more reasonable results. This, however, is not the case. Intuition and judgment enter into the construction and choice of the mechanical devices employed. But once these devices have been selected, use of them should be made in a completely explicit manner. Such explicit use makes possible a check of the estimate by other persons and will facilitate a reestimation at a later date by the same analyst in the light of additional or improved information.

b. Calculation of Input Coefficients.

(1) Choice of a Product Definition.

Two procedures of defining products for purposes of calculating input coefficients have frequently been followed. They outline two possible extremes. In one, input coefficients have been calculated for single narrowly defined products. In the other procedure, products have been aggregated into commodity classifications, dividing an entire economy into from 50 to 450 commodity categories.

For most purposes related to intelligence research, a compromise between these two procedures is indicated. Many of the products of interest to intelligence research would be completely buried in the 450 industry approach. On the other hand, inasmuch as there are thousands of individual products -- and the possibilities of further narrowing the definitions are almost infinite -- it is necessary to combine products to some extent.

The appropriate method for combining groups of products for the purpose of calculating input coefficients is based on some one element, or unit of measure, common to all. This common element may be an exterior characteristic, a principal input, or, in cases where the products are exceedingly heterogenous, money values. It is desirable that this common element, if not an input itself, be proportional in amount to the amounts of the principal raw materials inputs. For example, the combination of many types of electric motors by kilowatt capacities is useful when, as one moves from motors of lesser kilowatt capacities to motors of greater kilowatt capacities, the amounts of the inputs required to produce them increase proportionately. In this fashion, one may speak unambiguously of the amount of copper, for instance, required to produce electric motors per kilowatt. If the relation is not proportional or does not even approach proportionality, it is always necessary to specify the composition of the particular product category (or product mix) on which such a figure is based, in terms of the types and quantities included. The resultant input coefficients will be applicable only in cases where the composition of product is identical.

Because of the necessity of making international comparisons, it is more useful to use physical units rather than value as a unit of measure. The calculation of "purchasing power parity" conversion factors for detailed product types is difficult and time consuming. In many cases, where proportionality does not hold because of the heterogeneity of the product mix, it is possible to break down the definition of the product only slightly in order to approximate this proportionality.

(2) Dealing with Interspatial Instability.

Because of the possibility of substantial variations in input coefficients as a result of differing production methods, little reliance should be placed upon coefficients calculated on the basis of the production method employed in a single plant. It is highly desirable that as many separate calculations as possible be made of the same input coefficient in order to check the spread of the coefficients. It is likely that the spreads of the coefficients will not be the same for different types of inputs. There will be little or no spread between enterprises of some coefficients, because of the limited technical possibilities for substitution. On the other hand, for some coefficients the spread is likely to be great. Because these variations will not be due significantly to errors of measurement but to variations of circumstance, the taking of an arithmetic mean of the coefficients is meaningless. These variations can serve to indicate the degree of reliance which may be placed upon their application to other plants.

In general, it is to be expected that the coefficients relating to raw materials and semifabricated products will show the smallest amount of spread, whereas the coefficients related to energy, "capital," and especially labor, will show the greatest amount of spread because of the greater technical freedom for substitutions.

(3) Dealing with Intertemporal Instability.

This class of problems is probably the most difficult to be encountered. Again the coefficients derived from raw materials and semifabricated inputs will show the greatest stability. Significant shifts in the proportions in which these inputs are employed usually are accomplished only very slowly and painfully. On the other hand, coefficients of energy, "capital," and labor are likely to prove highly unstable. In response to changes in the over-all availability of the inputs, rather large substitutions can frequently be made.

Capital, energy, and labor input coefficients will also vary importantly with the level of output. Capital, defined here as buildings, moving and fixed machinery, and such, measured in terms of either value or of physical units such as number of machines, horsepower of prime movers, or square feet of floor space, is ordinarily not variable with respect to short-run fluctuations in output. The greater the capacity utilization at the time of the calculation of the input coefficient, the smaller the value of the coefficient will be. The same is true of energy, although to a lesser extent, because a certain proportion of energy purchased will fluctuate with the volume of output. On the other hand, the labor coefficient will decline up to a certain point as capacity utilization is increased.

It is desirable that the calculations of input coefficients for a given product at a given plant be made for varying levels of output, with an explicit effort made to obtain the measures at or near the level of designed or "normal" capacity utilization. The spreads of the values of the coefficients between differing levels of output will again suggest the reliability of the coefficients between differing levels of output and will indicate the reliability of the coefficients for application to other plants.

In the absence of fairly detailed information on such matters as the history of resource supplies and technological change, there is no criterion which may be applied to limit the length of the time period which may be permitted to elapse between the calculation of the input coefficients and their employment for estimating output in other plants.

3. Collected Input Coefficients.

The input coefficients as used in this report do not fulfill in all cases the requirements outlined above. The following is an attempt to evaluate them in the light of the criteria presented above and to present those which are believed to be the most useful.

a. Electron Tubes. 35/

On the basis of the criteria established in the earlier section, the most useful classification of electron tubes for the calculation and the use of input coefficients is as follows:

(1) Receiving and allied tubes. This category includes all classes of small transmitting tubes (such as types 807, P50, etc.), special subminiature tubes, and standard receiving tubes.

(2) Large transmitting and special tubes.

(3) Cathode-ray tubes.

The input coefficients for electron tubes found to be the most useful for this report and believed to be the most useful for future research are given in Table 31.

Table 31

Input Coefficients for Receiving and Allied Electron Tubes*

Input	Quantity per Thousand Tubes
Labor	**Man-hours**
US Method (Assembly Only, All Parts Bought) p/**	150
US Method (Integrated Tube Manufacture) c/	240
UK Method c/	600
French Method k/	700
German Method h/	2,500
Material	**Pounds**
All Receiving and Allied Tubes	
Mica (Raw Block before Punching) p/	15.00
Tungsten Wire g/	0.17 (or 750-800 Meters)***
Grid Wire (Including Moly, Ni, or Fe Alloys) p/	1.2 (or 5,000 Meters)***
Glass (Distributed about 1/3 as Tubing and 2/3 as Bulbs Excluding Metal Types) p/	90.0 (Glass Tube Types) 40.0 (Miniature Types) 18.0 (Metal Types

* These figures are based upon those presented in Table 35 but have been adjusted for plant integration, year, and country.
** Footnotes in lower-case letters refer to those for Table 35.
*** Weight varies substantially with product mix — length does not; so length is the preferred input coefficient.

The material input coefficients for subminiature tubes, included in Table 31 with all receiving and allied electron tubes, are presented separately in Table 31-A.

Table 31-A

Material Input Coefficients for Subminiature Tubes

Input	Quantity per Thousand Tubes Pounds
Glass Tubing	15
Mica (Raw Block, Strategic Quality)	4
Dumet Sealing Wire	7

All input requirements for large transmitting and special tubes will vary widely with differing product mixes. When the small, mass-produced types are eliminated from this category, the ranges of input coefficients are as given in Tables 32 and 33.*

The glass for the glass envelope appears to be the only input coefficient for CR tubes which has a reasonably stable relation to the volume of output. The coefficient must be estimated in each case, taking account of the sizes of CR tubes in production.

Labor requirements will vary widely with the design of the CR tube produced. Current US methods of producing television tubes are not believed to be applicable to foreign estimates, because of the extremely low labor content. An estimate for European labor requirements of 10,000 to 40,000 total man-hours per 1,000 tubes is suggested.

b. Electric Lamps. 36/

The input coefficients for electric lamps found to be the most useful are given in Table 34.**

* Tables 32 and 33 follow on p.

** Table 34 follows on p.

Table 32

Input Coefficients for Large Transmitting and Special Tubes*

Input	Quantity	
	Per Thousand $ US of Tubes	Per Thousand Tubes
Labor	Man-hours c/, x/	
US	180	
Europe	800-2,000**	
General		4,000-25,000
Material	Pounds	
Tungsten Rod and Heavy Wire (Lbs) v/, w/	1.0	15-35
Molybdenum Rod and Sheet (Lbs) c/	1.2	15-35

Table 33

Input Coefficients for Medium and Small Radar Magnetrons***

Input	Quantity per Thousand Tubes
Material	Pounds
OFHC**** Copper Rods, Bars, Tubes, and Heavy Sheet	5,000
Kovar Sealing Metal	100
Molybdenum	6

* Footnotes in lower-case letters refer to those for Table 35.

** Depending upon the amount of automatic equipment used, the degree of employment padding, and other factors.

*** See footnote j for Table 35.

**** Oxygen-free high-conductivity.

Table 34

Input Coefficients for Electric Lamps

Input	Quantity per Thousand General-service Lamps**
Material	
Glass Bulbs (Lbs) b/*	88.0
Glass Tubing (Lbs) b/	6.5
Tungsten Wire (Meters) c/	800.0*** - 1,050.0****

Labor input coefficients vary with the use of automatic equipment and with the proportion of parts made within the plant. The labor input coefficient for a US plant making extensive use of automatic equipment and making all parts except glass bulbs and tubing is 25 man-hours per 1,000 lamps (general-service). For European plants the range is from 250 to 100 man-hours per 1,000 lamps, depending on the amount of automatic equipment used. For plants purchasing parts rather than making them themselves, while the same spread occurs, depending on the degree of utilization of automatic equipment, the labor input coefficients will be about half of those above.

The data in Tables 35 and 36***** appear to be generally applicable to all classes of lamps for the typical product mix.

* Footnotes in lower-case letters refer to those for Table 35.
** Good lamps only.
*** For 120v lamps.
**** For 220v lamps.
***** Table 35 follows on p. ; Table 36, on p.

Table 35

Input Requirements for Electron Tubes*

Per Thousand Tubes a/

Item	Total Man-hours c/	Direct Man-hours d/	Tungsten Wire (Lbs)	Molybdenum Wire (Lbs)	Tungsten Rod (Lbs)	Glass (Lbs)	Mica b/ (Lbs)	Gas (Cu. Ft.)	Power (kwh)	Nickel (Lbs)	Molybdenum, Rod and Sheet (Lbs)
All Tubes, US, 1944 e/	704										
Receiving and Allied Tubes f/											
Receiving and Allied Tubes, US, 1944 g/	500		0.13	0.30							
Receiving and Allied Tubes, UK, 1944 h/			0.17	0.62							
Receiving and Allied Tubes, France, 1949 i/	700	500									
Receiving and Allied Tubes, US, 1951 j/			0.044							4.81	
Receiving Tubes Only, US, 1947 k/	189							2,500	280		
Receiving Tubes Only, US, 1944 l/	400										
Receiving Tubes Only, UK, 1944 m/	769										
Receiving and Allied Tubes, East German Plant, 1951 n/	2,500										
Receiving and Allied Tubes, East German Plant, 1951 o/	2,000		0.57	0.72							
Receiving and Allied Tubes, East German Plant, 1951 p/	3,200										
Small Transmitting Tubes, US, 1944 q/	1,190										
Subminiature Tubes, US, 1944 r/	602										

* Notes to Table 35 follow on p.

Table 35

Input Requirements for Electron Tubes
(cont'd)

Per Thousand Tubes a/

Item	Total Man-hours c/	Direct Man-hours d/	Tungsten Wire (Lbs)	Molybdenum Wire (Lbs)	Tungsten Rod (Lbs)	Glass (Lbs)	Mica b/ (Lbs)	Gas (Cu. Ft.)	Power (kwh)	Nickel (Lbs)	Molybdenum, Rod and Sheet (Lbs)
Receiving and Allied Tubes f/ (cont'd)											
Receiving Tubes Only, US Plants, 1951 s/	154	83									
Receiving Tubes Only, US Plant, 1951 t/	189								150		
Receiving Tubes Only, US Plant, 1951 u/	109	77						330	150		
Receiving Tubes, Typical Types, US Plants, 1951 v/											
T9			0.095			84	14.70				
T-5½ Miniatures			0.046			37	5.93				
Subminiatures							3.67				
Large Transmitting and Special Tubes											
Transmitting Tubes US, 1947 w/	2,326							31,000	3,600		
Transmitting Tubes US, 1944 x/	3,400				31.0						15.7
Transmitting Tubes UK, 1944 y/					31.3						48.5
Transmitting Tubes, France, 1949 z/	9,000	5,000									

Table 35

Input Requirements for Electron Tubes
(cont'd)

Per Thousand Tubes a/

Item	Total Man-hours c/	Direct Man-hours d/	Tungsten Wire (Lbs)	Molybdenum Wire (Lbs)	Tungsten Rod (Lbs)	Glass (Lbs)	Mica b/ (Lbs)	Gas (Cu. Ft.)	Power (kwh)	Nickel (Lbs)	Molybdenum, Rod and Sheet (Lbs)
Transmitting Tubes, East Germany, 1951 aa/	25,000										
Transmitting Tubes bb/											
8011 (Br VT 90)		6,150									
813		2,100									
Br VT98		25,000									
Br CV 92		10,300									
VU 504		5,600									
Cathode-ray Tubes											
US, 1947 cc/	11,363							150,000	17,200		
US, 1944 dd/	286										
East German Plant, 1951 ee/	62,000										
US, 1944 ff/											
5BP1		920									
5FP7		3,160									

Table 35

Input Requirements for Electron Tubes
(cont'd)

a. Good tubes only.
b. Raw block mica.
c. Includes all employees.
d. Includes only those employees engaged in actual production work.
e. WPB (War Production Board), Radio and Radar Division, official records and reports.
f. The category "Receiving and Allied Tubes" includes standard receiving tubes, small transmitting tubes, and special subminiature tubes, unless otherwise indicated.
g. Includes receiving tubes and small transmitting tubes made in the same facilities of plants with varying degrees of vertical integration. Source: WPB.
h. Data comparable to the preceding US figure. Two major differences between US and British methods are evident. British methods require substantially more man-hours per unit of receiving and allied tubes, and also more molybdenum wire per unit (this latter difference is attributed to the relatively greater US use of other alloy grid wire as a substitute). Source: WPB.
i. Syndicate National de L'Industrie Radio-electrique, official data for the French electron tube industry for 1949. Figures include plants of varying degrees of vertical integration.
j. Excluding subminiature tubes. Product mix for receiving tubes as follows: miniature tubes, 57 percent; glass tubes, 37 percent; metal and loctal tubes, 12 percent.

Critical materials per $1,000 of transmitting, special, and microwave tubes are as follows: tungsten, 0.93 lbs.; molybdenum, 1.08 lbs.; nickel, 3.75 lbs.; kovar, 4.30 lbs.; OFHC copper, 46.00 lbs.

Input requirements for magnetrons per 1,000 tubes are as follows:

Input Requirements for Magnetrons

Pounds per Thousand Tubes

Item	OFHC Copper	Kovar	Molybdenum
Small Magnetrons	1,800	40	8
Medium Magnetrons	16,000	150	3
Large Magnetrons	72,300	6,150	4,600

Source: National Production Authority, Electronics Division, data for the fourth quarter, 1951.
k. US Census of Manufactures, 1947. Inputs were distributed among the various categories of tubes on the basis of value of gross shipments. Figure includes plants of varying degrees of vertical integration.
l. WPB figures. Data includes plants of varying degrees of vertical integration.
m. WPB data.
n. Data from an East German plant for mid-1950. Man-hours were allocated among the various categories of tubes on the basis of their production values. Degree of vertical integration not given.
o. Data from an East German plant for late 1950. The plant used three 48-head Telefunken exhaust machines, with an input requirement of 5 hours per machine per 1,000 tubes. Degree of vertical integration not stated.
p. Data from an East German plant for late 1950. While the degree of vertical integration of the three East German plants is not stated precisely, it is believed that they are comparable with respect to this variable.

Table 35

Input Requirements for Electron Tubes
(cont'd)

q. Source: WPB data, 1944. Includes plants with varying degrees of vertical integration.
r. Source: WPB data, 1944. Includes plants with varying degrees of vertical integration.
s. Source: US manufacturer, 1951. Data refers to the entire receiving tube production division of the firm.
t. Source: US manufacturer, 1951. Data refers to a fully integrated plant where parts and machines are constructed. US sealex exhaust machine input requirements for this plant are 0.8 hours per exhaust unit per 1,000 receiving tubes.
u. Source: US manufacturer, 1951. Data refers to a nonintegrated plant assembling receiving tubes. US sealex exhaust machine input requirements for this plant are 1.3 hours per exhaust machine per 1,000 receiving tubes. For a third plant of the same firm, making subminiature tubes only, input requirements are 1.19 hours per exhaust unit per 1,000 tubes.

Gross inputs of selected materials, based upon a weighted product mix in pounds per 1,000 tubes, are as follows:

Input Requirements for Certain Tubes

Material	Pounds per Thousand Tubes		
	T9 Receiving Tubes	Sub-miniature Tubes	T-5½ Miniatures
Nickel	8.41	3.25	4.00
CR Radio Steel	9.8	0.22	9.76
Copper	1.25		0.31
Tungsten Filament Wire	0.095		0.046
Raw Block Mica	14.7	3.67	5.93
Bulb Glass	57.0		25.0
Glass Tubing	27.0	15.0	12.0
Dumet Lead Wire	0.31	6.51	0.10

For oxide-coating emission mix, average usage for all plants is 180 grams per 1,000 tubes.
v. Source: US manufacturer, 1951.
w. Source: US Census of Manufactures, 1947. Includes special tubes. See footnote k.
x. Source: Includes special tubes. See footnote e.
y. Source: Includes special tubes. See footnote e.
z. Source: See footnote i.
aa. Source: See footnote n.
bb. WPB data, 1944.
cc. Source: See footnote k.
dd. Source: See footnote e.
ee. Source: See footnote n.
ff. Source: See footnote e.

Table 36

Input Requirements for Electric Lamps*

Per Thousand Lamps

Item	Total Man-hours	Direct Man-hours	Glass Bulbs (Lbs)	Glass Tubing (Lbs)	Tungsten Wire (Meters)	Process Gas (Cu. Ft.)	Power (kwh)	Molybdenum Wire (Meters)
All Lamps, US, 1947 a/	29	24						
Large Incandescent a/	29					880	63	
Automotive a/	24					750	52	
Miniatures a/	10					310	21	
Fluorescent Lamps, Hot C a/	133					4,250	295	
Incandescent Lamps, GS, 25w to 200w b/	10	5	88	6.5		520	23	
Incandescent Lamps, GS, 120v to 220v c/					800 - 1,050			
Incandescent Lamps, GS, All Sizes d/	103				1,020			119
Incandescent Lamps, GS, All Sizes e/	233							
Incandescent Lamps, GS, All Sizes f/	208							
Incandescent Lamps, GS, All Sizes g/	182							
Incandescent Lamps, GS, All Sizes h/	91							

* Footnotes to Table 36 follow on p.

Table 36

Input Requirements for Electric Lamps
(cont'd)

a. Data obtained from US Census of Manufacturers, 1947. Direct man-hours refers to Census category "production workers." Product mix of the lamp industry for 1947 is as follows:

Item	Volume (Million Units)	Gross Value of Shipments (Million $ US)
All Lamps	1,786.0	194.4
Large Incandescent	946.6	103.1
Automotive	272.8	24.3
Other Miniatures	203.8	8.1
Christmas Tree	223.5	9.7
Hot C Fluorescent	83.8	42.5

The input coefficients were calculated by distributing inputs among the lamp categories on the basis of shipment values, after adding the inputs from plants supplying lamp components but not included in the "lamp" industry by the Census.
b. Data obtained from a US manufacturer for the month of December 1951. The plant made 25-watt to 200-watt incandescent lamps only, buying all parts. Process gas per 1,000 lamps used was 640 cubic feet in winter, including space heating.
c. For the same firm as in b, making all parts except glass bulbs and tubing.
d. Data from an East German plant, 1951.
e. Data from an East German plant for the first quarter, 1951. This plant makes all of its parts except glass bulbs and tubing. Man-hour requirements per 1,000 lamps for mid-1950 were 270.
f. Data derived from the total lamp production of three major German plants for early 1951. These plants make all parts except glass bulbs and tubing.
g. Data from the Osram Company, West Zone, Berlin, 1950. The plant does not make all of its own parts.
h. Data from the UILCO "Tungsram" plant, Budapest, Hungary, 1950. The plant makes all parts except glass bulbs and tubing.

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