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ECONOMIC INTELLIGENCE REPORT

THE ELECTRON TUBE INDUSTRY OF THE USSR 1955-60

CIA/RR 59-34
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THE ELECTRON TUBE INDUSTRY OF THE USSR* 1955-60

Summary

The rapid expansion of production of electron tubes in the USSR, which first became apparent in about 1950, has continued with only a slightly diminished average annual rate of growth since 1955. The total value in constant 1955 prices of electron tubes produced in the USSR, estimated to have been US $92 million** in 1950 and $260 million in 1955, should reach approximately $553 million by 1960. Estimates of both volume and value of current production are substantially higher than those which have been published previously. The increase in production has been achieved through the installation of modern machinery in several new and enlarged plants, thus resulting in a more efficient use of labor in the industry. Nevertheless, the USSR still is using relatively more hand fabrication and hand assembly in production of electron tubes than is the US.

Although the percentage of electron tubes allocated to military use in the USSR has declined gradually since 1955, the total value of production of tubes for military use has increased from approximately $68 million in 1950 to $160 million in 1955 and should reach approximately $272 million by 1960. The allocation of more than $215 million for tubes for military use in the USSR in 1957 is slightly more than the expenditure of $200 million for such tubes by the US in that year.

Adequate quantities of electron tubes are believed to be available for industrial electronic programs in the USSR. The estimated proportion of the value of total production devoted to cathode ray tubes has increased from 5 percent in 1950 to 16 percent in 1958 and will reach approximately 27 percent by 1960, reflecting the rapid growth of production of television and radar equipment in the USSR. A rapidly increasing quantity of tubes has been made available for civilian radio and television receivers, although the original goals

* The estimates and conclusions in this report represent the best judgment of this Office as of 1 April 1959.

** Dollar values are given in US dollars throughout this report. The rate of exchange for electron tubes has been determined to be 7.5 rubles to US $1 in 1955. For methodology, see Appendix B.

for production of consumer entertainment equipment* in 1960 have been reduced considerably under the directives of the Seven Year Plan (1959-65). This reduction is believed to have been brought about at least partly as a result of Soviet failures to meet the original Sixth Five Year Plan (1956-60) for production of electron tubes.

Although the original Sixth Five Year Plan called for production of electron tubes in 1960 to be 2.6 times the level in 1955, the rates of growth observed since 1955 indicate that this goal has been abandoned. Soviet production of transistors,** however, has been expanding at a rate faster than that originally envisioned in the Sixth Five Year Plan, a fact which suggests a deliberate policy directed toward the increased use of transistors in many applications where electron tubes currently are used.

The quality of Soviet electron tubes, in terms both of technical characteristics and of reliability of performance, has improved substantially since 1954. Standard Soviet tubes are for the most part equal in quality to Western tubes of similar types. There is evidence, however, that in the category of transmitting and special-purpose tubes numerous difficulties are still being encountered in quantity production of critical items having the required reliability and performance characteristics for use in military applications. Reject rates reportedly are abnormally high in some categories of special-purpose tubes.

Details of trends in production of electron tubes for specific applications indicate that the USSR is now carrying into production a variety of high-power and other special-purpose tubes which will permit increased capabilities of weapons systems, including greater radar range and resolution capability through lowered noise figures in radar return amplifiers; more complicated and more effective equipment for electromagnetic warfare and electronic countermeasures through the use of wide-range, tunable magnetrons, carcinotrons, and other types of traveling wave tubes; and greater capability of air weapons in high-resolution air-intercept radar in the K and Q radar frequency bands and in precision doppler navigation systems. These developments will increase Soviet capabilities in both offensive and defensive operations requiring aircraft and missiles. Details on Soviet

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* Including civilian radio and television receivers and also phonographs.

** Transistors are solid-state devices which are capable of duplicating a number of functions performed by electron tubes. The substitution of transistors for electron tubes in many applications is highly desirable because of their miniature size, long service life, shock resistance, and high efficiency.

efforts to produce smaller and more rugged electron tubes are not sufficient to indicate a trend, but there is evidence that the USSR is under the same urgent pressures in this field as is the US.

I. Introduction

A. Purpose and Scope

This report provides an evaluated estimate of the current status and future trends in production of electron tubes in the USSR. In the USSR as in the US the value of production of electron tubes is believed to exhibit a fairly close relationship to the total value of production of the entire electronics industry.* 1/** In addition, details of specific efforts in production of electron tubes provide some evidences of the direction of Soviet choices in the larger area of weapons systems.

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50X1

This report derives total production of electron tubes in both unit and value terms. The product mix is estimated according to the following three main categories of tubes: receiving tubes, cathode ray tubes, and power and special-purpose tubes. An estimated allocation of these tubes by sector of use is provided. Information on Soviet facilities for producing tubes has been included to provide detail on trends in new products and technology and to provide some limited cross checks on the statements of the volume of production obtained from official Soviet announcements.

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* The electronics industry contains a very broad and diverse group of products produced by that branch of electrical engineering which deals with the passage of electricity through a tube, semiconductor, or transistor by which means the flow of electrons is emitted, controlled, and directed. Electronic products are found primarily in the following equipment: sighting and fire control equipment; computing and accounting machines; electric measuring instruments and test equipment; radio and television receiving sets; radio and television transmitting, signaling, and detection equipment; and electronic components and accessories.

50X1

B. Organization of Production

Before the industrial reorganization of 1957 the responsibility for design, manufacture, and distribution of all electron tubes was assigned to the Ministry of the Radiotechnical Industry, under the immediate control of the Main Administration for Vacuum Techniques. Exceptions to this administrative control are believed to have been limited to relatively minor schedules of production for some types of industrial control equipment and X-ray tubes, plus some prototype work done at laboratories not subordinate to this Ministry. 2/

In December 1957 the Ministry of the Radiotechnical Industry was abolished, and a State Committee for Radioelectronics was formed and attached to the Council of Ministers, USSR. The new State Committee is located in the quarters of the former Ministry, and the former Minister of the Radiotechnical Industry, V.D. Kalmykov, was appointed Chairman of the State Committee. The State Committee is believed to be the central governmental body presently responsible for establishing the technical and quantitative requirements for electron tubes for the USSR, although very little information on the functioning of this State Committee was known as of April 1959.*

II. Production

A. Facilities

1. General

Soviet facilities for manufacturing electron tubes have continued a steady and rapid expansion in equipment and plant, although the average annual rate of expansion since 1955 appears to have decreased from the rate evidenced during 1950-55.** Official Soviet photographs and press releases, [redacted] 50X1 [redacted] indicate that the additional equipment installed in recent years is of modern and efficient design. 4/ The trend toward more automatic methods of production is apparent in the USSR as in the US, [redacted] 50X1 [redacted] indicates [redacted] 50X1 50X1

** Calculated by value in terms of 1955 rubles. Estimated production expanded during 1951-55 by 293 percent, whereas under the current estimate that the original goal of producing 200 million tubes in 1960 has been revised downward to approximately 153 million tubes, the expansion during 1956-60 probably will reach only 224 percent. For methodology, see Appendix B.

that the USSR still is using relatively more hand fabrication and hand assembly than is the US. Seven known machine design bureaus and production shops concentrate on producing equipment for manufacturing electron tubes and electric lamps and support the Soviet program for expansion and modernization of the electron tube industry. A number of lesser facilities also are engaged to some extent in the production of specialized machines designed by the electron tube industry.

The installation of more modern equipment in new and enlarged plants reportedly has resulted in a significant improvement in the efficiency of labor in this industry, creating the basis for a large part of the gains in total production without significant additions to the labor force.

Soviet production of electron tubes continues to be heavily concentrated in five very large plants which produce approximately 90 percent of the total volume of production. Three of these plants, located in the industrial areas of Moscow and Leningrad, have a combined production of 45 percent of the total number of units. Additionally, 35 percent of production is accounted for by Electrovacuum Plant [redacted] Saratov, and 10 percent by the Novosibirsk Tube Plant. The remaining 10 percent is produced in several plants of lesser importance in L'vov, Tashkent, and in the area around Moscow. Although this industry includes relatively few major plants, they are fairly well distributed geographically. The construction of the Saratov plant suggests that a planning feature may have been to decrease the vulnerability of this industry to strategic air attack. This plant is located approximately 20 kilometers (km) outside the city of Saratov. 50X1

2. New Plants and Major Expansions*

Construction was started after 1947 on Electrovacuum Plant [redacted] which is believed to have begun operations between January 1950 and December 1952. This plant probably did not begin operating at full capacity before 1958, but by 1957 it had become the main plant in the USSR for production of electron tubes, measured in terms of units produced. Also it may be the largest plant in terms of value of production. 50X1

At Electrovacuum [redacted] "Svetlana," Leningrad, all manufacturing of electric lamps has been eliminated, and the plant now concentrates solely on production of electron tubes. Svetlana was reorganized in 1956, with an expansion program for the future based on automatic equipment. Although in the past this plant 50X1

[redacted] 50X1

has been hampered by space problems and poor layout, developments indicate that Svetlana ranks as one of the largest electron tube plants in the USSR.

An electrovacuum plant at Tomilino, Moskovskaya Oblast, [redacted] possibly in Moscow, reportedly have been converted from other work or established to produce electron tubes. Plant [redacted] Zaprudnya, Moskovskaya Oblast, reportedly has initiated production lines for cathode ray tubes to be used in television receivers. 50X1 50X1

B. Estimates of Production

The estimated volume and value of production of electron tubes in the USSR during the years 1950, 1955-58, and 1960 are shown in Table 1.* The growth in the value of production of electron tubes in the US and the USSR during the same years is shown graphically in Figure 1.** The use of more expensive television picture tubes has increased the average unit value of tubes since 1950, and, as a result of more precise information, the estimated volume of production is believed to be quite accurate through 1958.

As indicated in Table 1, the total production of electron tubes tripled during 1950-55 and probably will double during 1956-60. Although the goals of the original Sixth Five Year Plan called for a tripling of production between 1955 and 1960, actual production during the first 3 years of this period grew at an average annual rate of only 13 percent. In spite of this apparent lag, all Soviet announcements of the results of annual plans through 1958 have stated that the plans for production of electron tubes have been exceeded. The USSR has not elaborated on this paradox and has not provided a firm indication that the original goal has been revised downward. In order to meet the original goal for 1960, however, an average annual rate of growth of 35 percent would be required in 1959 and 1960. The announcements of planned production of consumer entertainment equipment during 1958-65 imply that production in 1960 will be well below the goals announced previously. Therefore, it is believed that an unannounced downward revision in planned production of electron tubes has taken place and that the effect of this revision will be felt most severely in the consumer entertainment sector. The failure to maintain growth as originally planned could have been based on the rapidly increasing rate at which the USSR now finds it can begin to substitute semiconductors for electron tubes. This substitution requires a reallocation of facilities for the production of

* Table 1 follows on p. 8.
** Following p. 8, below.

transistors.* A second factor contributing to the failure to maintain growth is the increased versatility of new types of tubes as a result of the technological trend to place multiple units in a single envelope. This versatility, in turn, causes rapid obsolescence of old models.

Based in part on incomplete information on schedules of specific products and in part on analogy with US industrial patterns, the analysis of production of electron tubes by function and use has resulted in a production-value series which necessarily is more approximate than is the total unit series.

C. Trends in Product Mix

Data on product mix in the electron tube industry of the USSR for 1950, 1955, 1957, and 1960 are provided in Table 2.** For comparison, similar US data are provided for 1950, 1955, and 1957. The data in Table 2 are shown graphically in Figure 2.*** These data reflect the significantly increased share of effort devoted to the manufacture of cathode ray tubes in the USSR since 1950 -- an effort which resulted from the rapid growth of production of television and radar sets. The continuing high percentage of effort devoted to production of transmitting and special-purpose tubes in the USSR is a measure of the high-priority requirements of the military electronics programs as well as the growing importance of such tubes in the industrial electronics program.

As shown in Table 1, the variety of electron tubes in the USSR is weighted heavily in favor of the more expensive types of non-entertainment tubes. The estimated average unit f.o.b. (free on board) factory price for electron tubes was $1.46 in the US during 1955, contrasting with $3.40 in the USSR.**** As a result, the total value of production of the Soviet electron tube industry is significantly higher than would be indicated by comparing only the quantities produced in the US and the USSR.

The rapid expansion of television in the USSR during the last few years has placed heavy requirements on the industry for television picture tubes and reportedly has created a severe strain on the electron tube industry. In 1950, production of television picture

* There is evidence that production of transistors is expanding faster than was originally planned. The shift in emphasis in production could result in a temporary dislocation of production which would make it necessary to reduce the combined numbers of tubes and transistors available for consumer use.

** Table 2 follows on p. 10.

*** Following p. 10, below.

**** The rate of exchange for electron tubes has been determined to be 7.5 rubles to US $1 in 1955. For methodology, see Appendix B.

Table 1

Estimated Production of Electron Tubes in the USSR a/
Selected Years, 1950-60

Type of Tube	1950		1955		1956		1957		1958		1960	
	Million Units	Rubles b/	Million Units	Rubles b/	Million Units	Rubles b/	Million Units	Rubles b/	Million Units	Rubles b/	Million Units	Rubles b/
Receiving tubes	20.8	358.1	65.5	1,029.0	76.4	1,217.3	83.2	1,355.4	94.1	1,512.2	132.2	2,077.3
Cathode ray tubes c/	0.08	32.6	0.77	277.0	0.93	338.3	1.08	392.6	1.29	467.9	3.35	1,190.5
Transmitting and special-purpose tubes	4.3	275.2	10.3	648.1	12.3	781.8	13.7	873.1	14.6	922.7	17.4	1,104.6
Total d/	25.2	665.9	76.6	1,954.1	89.6	2,337.4	98.0	2,621.1	110.0	2,902.8	153.0	4,372.4

a. For [redacted] additional details, see Appendix B. For a graphic presentation of the data in Table 1, see Figure 1, following p. 8. 50X1
b. Factory prices of 1955.
c. Because of the heavy price weight of cathode ray tubes, unit computations are expressed to one additional decimal place.
d. Totals are derived from unrounded data and may not agree with the sums of the rounded components.

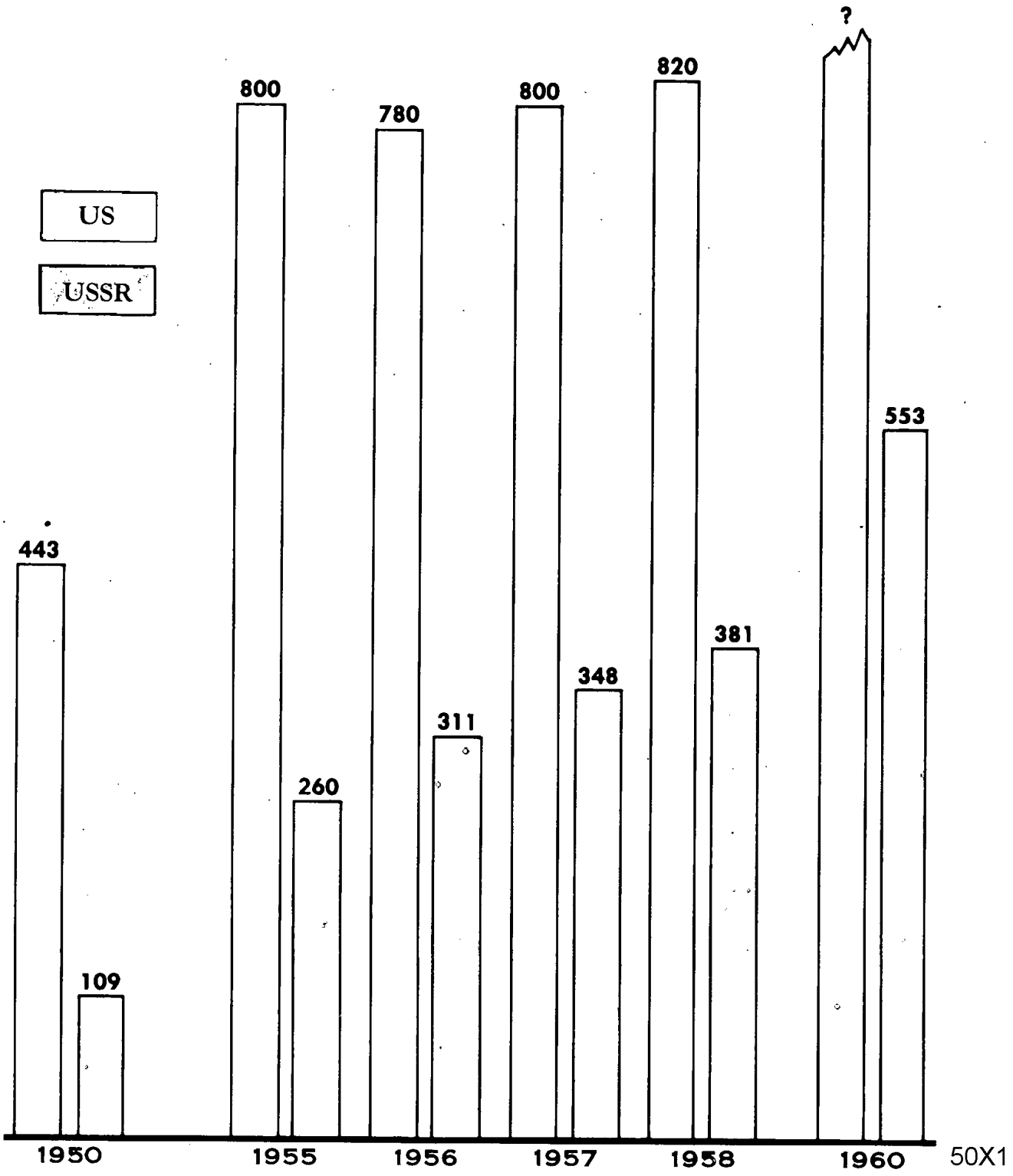
Figure 1 50X1

US AND USSR

ESTIMATED COMPARATIVE GROWTH IN PRODUCTION OF ELECTRON TUBES

(Selected Years, 1950-60)

Million current US dollars



50X1

Note: US data are given in current US dollars. For an explanation of converting the Soviet constant value of 1955 to current value, see Appendix C.

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tubes amounted to perhaps 15,000 units and was limited to small departments in the Scientific Research Institute (Nauchno-Issledovatel'skiy Institut -- NII) [redacted] at Fryazino. By 1955, production reached 550,000 units, produced at four separate plants. Probably the expansion rate for television picture tubes was a principal limiting factor in the rate of growth of television reception in the USSR through 1956 at least. Additional facilities for production are reported to be under construction or planned at two major Soviet glass-bulb factories. Machinery of a more automatic design is being constructed, and attempts to purchase machinery from the West have been noted. 50X1

III. Trends in Technology

A. Quality of Products

Detailed examination and analysis of representative Soviet electron tubes produced between 1954 and 1957 reveals that although these tubes frequently differ from US tubes of similar types both in alloy-metal content and in processes, the techniques employed to construct the tubes are similar to those in the US. The observed variations from US practice are compatible with the available supply of raw and processed materials, the cost factors in Soviet industry, and the development and production techniques that are available to Soviet production engineers. Optimum performance of electron tubes is a function not only of design and materials but also the processing of the tube structure. [redacted] 50X1
50X1
in the Soviet electron tube industry high-quality materials and efficient production techniques are used in the construction of most of the tubes to insure maximum longevity and rated performance. Soviet entertainment tubes are considered equal to comparable US entertainment grade tubes. 5/ The Soviet press, however, on several occasions has voiced severe criticism of the high rate of rejection in this industry. [redacted] 50X1
in the manufacture of electron tubes, losses from rejects at the final testing stage alone amounted to 260 million rubles in 1956. This loss represented 80 percent of the total loss from rejects of the entire electronics industry. Losses reportedly increased during the first quarter of 1957, amounting in some cases to 13 to 15 percent of production. 6/ [redacted] 50X1
the leading Soviet electron tube plants provide no grounds for suspecting that large losses occur in the manufacture of standard receiving tubes, 7/ nor is there reason to believe that the rate of rejection is abnormally high for normal cathode ray tubes for television sets. Losses are believed to arise chiefly in the manufacture of transmitting and special-purpose tubes for military purposes, a process in which a high rate of rejection is expected. 50X1

Table 2

Product Mix for the Electron Tube Industry in the USSR and the US
Selected Years, 1950-60

		Percent of Total Value			
Country	Type of Tube	1950	1955	1957	1960
USSR	Receiving tubes	53.8	52.6	51.7	47.5
	Cathode ray tubes	4.9	14.2	15.0	27.2
	Transmitting and special-purpose tubes	41.3	33.2	33.3	25.3
US	Receiving tubes	70	52	55	N.A.
	Cathode ray tubes	4	29	22	N.A.
	Transmitting and special-purpose tubes	26	19	23	N.A.

B. Development of Products

Soviet development of electron tubes actually began to assume large-scale proportions about 1948, although even after that time the USSR continued the thorough exploitation of all known developments and technology on electron tubes. 8/ Soviet technology has continued to improve and, among many other significant developments, has led to the design and production of traveling wave tubes [redacted] 50X1 50X1

Developmental work is carried out in a number of important plants and institutes. The most important facility engaged in initial developmental work is NII [redacted] located at Fryazino, and known as the Institute of Vacuum Techniques. This institute is made up of a number of divisions and sections and includes sections working on cathode ray tubes, magnetrons, high-power and low-power klystrons, and movable field tubes, as well as a section working on shock-resistant receiving tubes having long life and high reliability. Smaller subdivisions also exist at this institute to develop experimental lots of tubes and to manufacture small lots of special-purpose tubes. Many of the production problems arising in initial developmental work are resolved by developmental sections which also are attached directly to the Soviet electron tube plants. 10/ 50X1

At the International Microwave Tube Conference held in Paris during May and June 1956, Soviet scientists reported the development

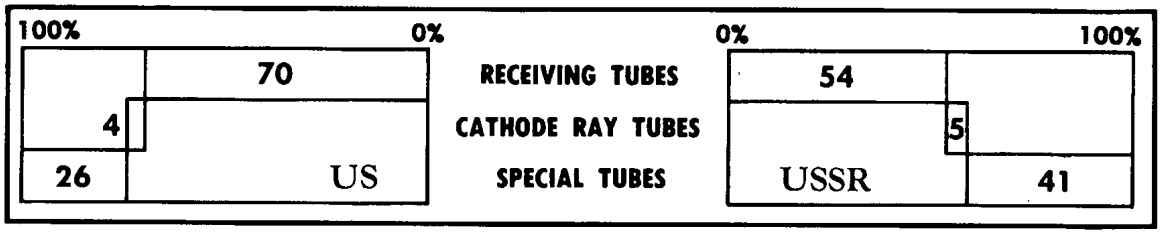
50X1

Figure 2

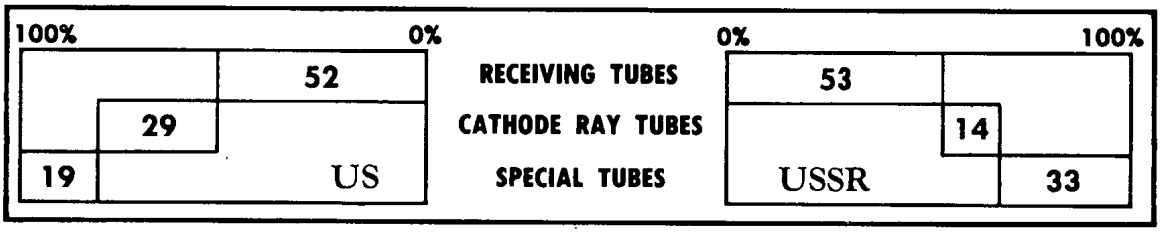
US AND USSR

ESTIMATED PERCENTAGE DISTRIBUTION OF ELECTRON TUBE VALUE, BY CLASS OF TUBE

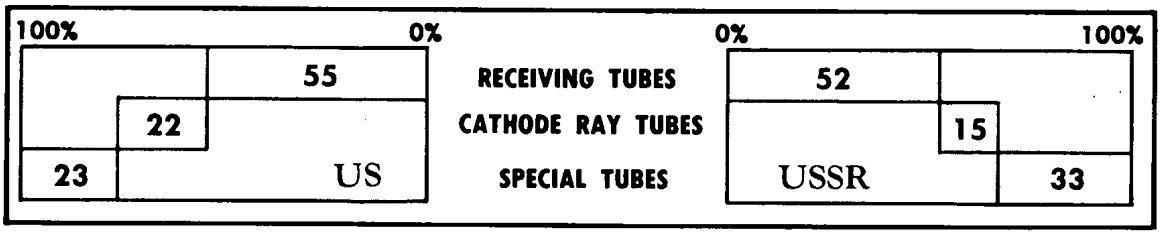
(Selected Years, 1950-60)



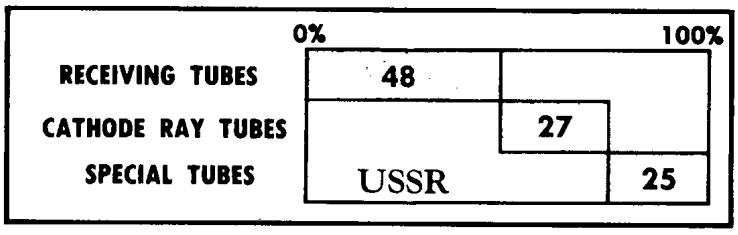
1950



1955



1957



1960

Note: US data for 1960 is not available.

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50X1

of a new type of traveling wave tube. The tube was designated as "Spiratron." The Spiratron was essentially a centrifugal type of tube requiring no magnetic focusing. Although this type of tube had to a certain extent been described theoretically in the West several months before the meeting in France, credit for actual development of the device has been given to the USSR. 11/ At that time the Soviet scientists also presented a paper entitled Wide Tuning Range Millimeter-Wave Reflex Klystron Oscillators. Essentially, the paper described a pair of tubes capable of tuning within ranges of 7 to 11 and 11 to 19 millimeters. The tuning range of klystrons at these frequencies is a unique achievement. Although the tubes had an operational life of only a few hours, the implications of their future uses, particularly in missiles, are significant. The USSR also indicated at the conference that its scientists were working on a 5-megawatt pulse magnetron. 12/ [redacted] 50X1 50X1 [redacted] It is evident from the above illustrations that the USSR has progressed in the past few years from a nation weak in the technology of electron tube devices to a level comparable with that of the West.

C. Plant Equipment and Methods

The Soviet electron tube industry is a composite of the old and the new in plant layout, machinery, and methods. Soviet practice has been to augment machinery where necessary to increase production without destroying the old equipment, provided that the old equipment may be modified to produce tubes with the desired technical qualities. New machines usually are modified copies of Western machinery, with modifications to simplify set-up time and to permit more automatic features. Factory space in the older plants reportedly is cluttered and overloaded with various types of equipment, and discontinuous production procedures are often dictated by the poor layout of equipment. Cleanliness in plants frequently is reported to be at a minimum. 14/

The electrovacuum plant in Saratov is an example of a new Soviet productive facility of modern design. It is highly mechanized, and its production machinery is laid out for continuity of operation. In general, the procedures at this plant are similar to those of good US plants. Tubes when completed are stored provisionally for from 3 to 10 days, after which time they are subjected to thorough testing. This testing reportedly is equal to that for US military specifications, and tubes passing this inspection are considered to be equivalent to good US commercial types. 15/

D. Reliability of Electron Tubes

[redacted] to test the reliability of electron tubes, this problem is believed to be receiving as much serious attention in the USSR as in the West. An article by an official of the former Ministry of the Radiotechnical Industry severely criticized the reliability of electron tubes as early as 1955. This official reported that two-thirds of the defects in radio equipment were traceable directly to failures of electron tubes. 16/ More recently, criticism has been leveled at the metallurgical industry for supplying poor quality metals to an electron tube plant, resulting in tubes of non-uniform quality. 17/

50X1
50X1

In addition to Soviet literature stressing the importance of reliability of electron tubes, information has been cited also on improvements in production machinery and processes and on observed improvements in the qualities of sample tubes. Also reported recently is the production of a family of receiving tubes with features of design and process controls established to insure a high degree of reliability of performance under exacting operating conditions. Tubes with greater reliability would contribute significantly not only to the reliability of the system in all communications and control applications but also would be of particular importance in early warning, fire control, and guidance systems for military programs of the highest priority.*

IV. Consumption of Electron Tubes in the USSR

A. Pattern of Use

Total production of electron tubes in the USSR, by type of tube, is shown in Table 1.** Electron tubes are used throughout the electronics industry for the manufacture and maintenance of civilian radio and television sets, for the support of essential domestic communications services and industrial operations,*** for the manufacture of military electronic equipment, and for the maintenance of military

* For details on Soviet electron tube plants, see Appendix A.

** P. 8, above.

*** The industrial sector of use is defined roughly to include all electronic equipment not used directly for military purposes or as consumer goods. The items in the industrial sector include equipment for domestic communications, for radio and television broadcasting, for industrial control processes, for signaling and automation, for medical use, and for computers, as well as instruments for industrial and scientific measuring and testing.

equipment and the supply of spare parts. The distribution of electron tubes by sector of use during 1950, 1955, 1958, and 1960 is shown in Table 3. The impact of the demand of the growing civilian sector for radio and television receivers is quite apparent, representing the requirements for initial production and also reflecting the continued growth in demand for replacement of electron tubes.

Table 3

Distribution of Electron Tubes in the USSR, by Sector of Use a/
Selected Years, 1950-60

	1950		1955		1958		1960	
Sector of Use	Million Rubles	Percent	Million Rubles	Percent	Million Rubles	Percent	Million Rubles	Percent
Civilian	53.8	8	489.9	25	821.5	28	1,888.3	43
Industrial	106.6	16	265.0	14	369.3	13	440.7	10
Military	505.5	76	1,199.2	61	1,712.0	59	2,043.4	47
Total	665.9	100	1,954.1	100	2,902.8	100	4,372.4	100

a. For [redacted] additional detail, see Appendix B, Table 8, p. 32, below. Values are given in 1955 prices. 50X1

Although a slow decline in the proportion of electron tubes allocated to military use is indicated in Table 3, this decline is more than offset by the over-all increase in the value of production by the industry. The total value of electron tubes allocated for military use, measured in rubles of 1955, is estimated to have increased from 506 million rubles in 1950 to nearly 1,200 million rubles in 1955 and probably will exceed 2.0 billion rubles in 1960. This growth represents an increase in production in 1955 compared with that in 1950 of approximately 137 percent and in production in 1960 compared with that in 1955 of slightly more than 70 percent. The estimated allocation of more than 1.6 billion rubles ($215 million) to electron tubes for military use by the USSR in 1957 compares with the figure of approximately $200 million for the US for that year. 18/ This comparison indicates that in 1957 the USSR required more electron tubes by value than the US to support a military electronics program only about 70 percent as large as that of the US. This fact is attributed to the

lower reliability and shorter service life of the more expensive types of special-purpose military tubes in the USSR. Finally, in spite of the requirements for both military and civilian uses, an increasing supply of electron tubes in terms of value is also being allocated for essential industrial applications.*

B. Indications of Specific Programs**

1. High-Power Radar

Reports of developments of products and schedules for production at Soviet tube plants, together with data from catalogs published in 1955, indicate an intensive program for production of electron tubes with high-peak-power applications. 19/ Work on pulse magnetrons with up to 5 megawatts peak power and on pulse klystrons with up to 30 megawatts peak power has been reported. More concrete details on Soviet rectifiers, diodes, VHF (very high frequency) oscillators, and modulators provide information which suggests the following possible trends in Soviet high-power radar applications: (a) improved VHF early-warning radars with greater power and probably more precise pulse characteristics; (b) multi-megawatt VHF radars and radar jammers, possibly for antimissile applications; and (c) multi-megawatt microwave precision radars, possibly for longer range ground control intercept and for missile guidance.

2. Frequency Coverage

To date, deployment of Soviet operational radar has indicated a relatively narrow concentration in several selected frequency bands. A broader frequency coverage of Soviet microwave radars in the near future is suggested by the development of klystrons covering wavelengths from 0.8 to 6 centimeters and by the development and production of two families of traveling wave tubes covering wavelengths from 7 to 12 centimeters and from 30 to 60 centimeters.

* For methodology, see Appendix B.
** For additional detail, see Appendix A.

APPENDIX A

DETAILS ON KEY ELECTRON TUBE PLANTS IN THE USSR

A. USSR

1. Electrovacuum Plant [redacted] "Svetlana," Leningrad [redacted] 50X1

[redacted] "Svetlana," was founded in 1913 and is the oldest electron tube plant in the USSR. In 1956, Svetlana was still one of the two or three largest electron tube plants in the USSR. Although the plant still is hampered by poor layout and inadequate floorspace in the older buildings, the temporary structures used immediately after World War II have now been replaced by new buildings constructed between 1950 and 1955. Some new Soviet machinery for manufacturing tubes has been installed, although this plant reportedly still has a greater proportion of old equipment than newer tube plants in the USSR. A reorganization was undertaken in 1956, and a significant expansion program was scheduled for the future through the addition of new automatic equipment. 50X1

The development of greatest industrial importance to Svetlana probably was the removal of lamp manufacturing operations from the facility, permitting Svetlana to concentrate on production of electron tubes. As of 1956, Svetlana was engaged in the development and production of receiving tubes, including metal tubes, Soviet lock-in tubes, and standard glass tubes, as well as the limited production of miniature tubes, mercury and gas-filled rectifiers and thyratrons, small transmitting and special-purpose microwave tubes, medium-power transmitting tubes, pulse radar tubes, large transmitting tubes with ratings from 1 kilowatt to 250 kilowatts, and certain types of equipment for making and testing tubes. Work is conducted on semiconductors, and series production of transistor triodes was reported to have started in November or December 1956.

Production of gas-filled tubes includes a series of large mercury thyratrons for industrial applications, with current ratings between 6 and 85 amperes, including types TR 1-6/15, TR 1-15/15, TR 1-40/15, and TR 1-130/15; large ignitrons for electrification and process rectifiers, including type I-100/5000; and several gas-filled and vapor-filled rectifiers and triodes for use in radar, communications, and industrial apparatus.

The special-tube section manufactures Soviet reflex klystrons, the Soviet version of US type 2C40 centimeter-wave planar triode, several high vacuum diodes, and small power tubes, including types GI-30 and GU-15, GU-29, GU-32, and GU-50. The principal application of this group of tubes apparently is in military electronics, including low-power radar sets.

The medium-power tube section manufactures types GK-71 and GU-80 for communications transmitters and several pulse modulators and oscillators for radar sets, including types GI-8, a 3.5-kilowatt peak power pentode; GI-18B, a pulse triode rated at 300 kilowatts peak power at 300 kilocycles or lower; and type GMI-83, equivalent to US type 5D21.

The large transmitting tube section produces mainly high-power water-cooled and forced-air-cooled tubes for broadcasting, communications, and jamming transmitters in the medium-frequency and high-frequency bands. These tubes include types GU-27B, GU-5B, GU-10A, and GU-10RA, GU-12A, GK-3A, and GK-1A.

Information available pertinent to estimating the volume of production at Svetlana includes the following:

a. Estimated employment of 5,500 persons in 1950, 6,500 in 1956 (5,000 laborers and 1,500 engineers and technicians), 8,000 in 1957, and 10,000 in 1959. Two shifts are in operation.

b. Production in 1956 reported to be 2.5 times that of 1950.

c. Receiving tube capacity in 1956 of 69 mount assembly groups, each averaging 1,500 mounts per day, and with a grid department capacity in excess of 75 million grids per year.

d. Production of 20 million tubes of all types in 1957 and a planned production of 30 million tubes in 1958.

e. Spot information on processing or exhaust rates for specific types of transmitting and special-purpose tubes. During 1959, 1.8 million medium-power tubes and about 15,000 high-power tubes are to be produced.

f. The value of plant production in April 1959 was about 50 million rubles per month.

[redacted] the continuing rate of expansion is limited by physical facilities. The rate of expansion will be significantly less than that for the Soviet electrovacuum industry as a whole. By comparing the expansion at Svetlana between 1950 and 1956 with expansions in over-all industry from 1950 to 1956 and with planned expansions from 1956 to 1960, it is concluded that production in 1960 at Svetlana probably will not exceed 1.4 times the volume of production in 1956. 50X1

2. Moscow Electric Lamp Plant [redacted] "Melz," Moscow 21/ 50X1

Recent information, primarily from the Soviet press [redacted] 50X1
[redacted] indicates that the program for 50X1
manufacturing electron tubes at [redacted] "Melz," is considerably larger than described in previous intelligence reports. New construction, amounting to about 100,000 square feet, reportedly was underway in 1953. Some new manufacturing machinery has been added, especially automatic lines for receiving tubes, fluorescent lamp equipment, and cathode ray tube equipment. The major products are subminiature and standard receiving tubes, cathode ray tubes, incandescent and gas-filled lamps, refractory metals, and machinery for special lamps. It is believed that the over-all effort devoted to production of electric lamps at Melz still exceeds the effort devoted to electron tubes. 50X1

Production of receiving tubes in 1956 consisted mainly of 7-pin and 9-pin miniature tubes; subminiature tubes in production at least since 1953, including both filamentary and cathode types; standard glass tubes; and a family of tubes designed and constructed for critical environmental conditions to meet special requirements for mechanical shock and for a specified operating life. The limited information on product mix suggests that the receiving tubes produced at Melz include a preponderance of the more costly types. This conclusion is supported by the relatively lower rates of assembly and speed of evacuation reported at the plant.

The gas tube department is reported to produce photocells, including four types of photomultipliers, voltage stabilizers, cold-cathode rectifiers, rare-gas thyratrons, including type TG 1-0.1/1.3 and hydrogen thyratrons for radar modulator service. As of March 1956, two types of hydrogen thyratrons were in quantity production, using automatic exhaust machinery capable of finishing 500 to 600 tubes per day, and three new types were in development at that time. One production type is believed to be type TGI 1-400/3.5, a line-type modulator switch, rated at 400 peak amperes and 700 kilowatts peak operation at 20 microsecond pulse length and 50 pulses per second. The second type may be type TGI 2-325/16, rated at 2,600 kilowatts peak operation similar to US type 5C22.

The cathode ray tube department, established in 1946, produces various types of cathode ray tubes for television receivers and for radar indicator service. This plant produces indicator tubes for both the Neptun and the GYUIS-1-M radars. Production of television picture tubes, initiated in 1953, has increased rapidly and reportedly was about 440,000 tubes per year by 1957. Production planned for 1959 is 700,000 tubes. The manufacturing program in this department has comprised one of the major expansions at Melz. Oscilloscope tubes produced at Melz include types 13L037, 13L054, 18LM35, 18L047, 23LM34, 23L051, and 31LM32. Production of television picture tubes until 1956 consisted mainly of the round 12-inch tube, type 31LK2B. Production of a 14-inch rectangular tube, probably type 35LK2B, was begun late in 1955. A 21-inch rectangular tube is currently produced in small quantities, but the major production effort is devoted to 43-centimeter (17-inch) tubes.

[redacted] it is believed to be concerned primarily with medium-size power tubes for communications equipment and pulse oscillators for radar service. Types known to have been produced at Melz have included a 500-watt modulator and type GI-1, the output tube for the P-3 and P-8 radars. 50X1 50X1

Information available pertinent to estimating the volume of production at Melz includes the following:

a. Employment of about 5,000 persons in 1950.

b. Labor productivity of 31,500 rubles per production worker per year in 1957.

c. In 1956 an assembly rate for receiving tubes of 500 mounts per shift per 6-operator brigade for 50 brigades, resulting in an annual output of about 12 million tubes.

d. Spot information on processing rates for specific types of cathode ray and special-purpose tubes.

e. Production at the rate of 58,000 television picture tubes per month in April 1959.

3. Scientific Research Institute (NII) [redacted] Fryazino 22/ 50X1

[redacted] NII [redacted] is concerned with the developmental and design activities at this facility. [redacted] 50X1 50X1

[redacted] the institute is the primary scientific and technological center for the Soviet electron tube industry. Production departments are engaged in the manufacture of (a) receiving tubes, including 7-pin and 9-pin miniature tubes, standard glass tubes, subminiature tubes, and high-reliability, high-performance tubes; (b) cathode ray tubes; (c) microwave tubes, including klystrons, traveling wave tubes, magnetrons, and antenna switches; (d) high-vacuum power tubes, including pulse rectifiers, modulators, and oscillators for radar service; (e) gas-filled tubes, including hydrogen thyratrons; (f) semiconductor devices; and (g) vacuum tube machinery and test equipment. Details since 1952 are limited, but the available information suggests that much production consists of new types, which, after being fully developed, are frequently transferred to other Soviet plants for mass production. 50X1

[redacted] a major expansion program, planned at NII [redacted] was in fact established at the plant in Saratov in 1952. [redacted] A new building has been constructed at NII [redacted] and was in partial operation by 1956. NII [redacted] is now well equipped with excellent test equipment and production tools, and its engineering and technical staff is very large. [redacted] in 1957 [redacted] 30 percent of the employees had acquired engineering or technical educations and that there were more qualified specialists than job opportunities. 50X1 50X1 50X1 50X1 50X1 50X1 50X11

Some of the more advanced work underway in 1957 at NII [redacted] is briefly summarized as follows: 50X1

a. The development and possible production of a large hydrogen thyratron for radar modulators, rated at 700 peak amperes and 8.4 peak megawatts, at an 0.0014 duty cycle; this type includes an internal hydrogen reservoir, for long life.

b. A lead-shielded high-power pulse klystron, operating at 350 kilovolts, with a reported peak output of 30 megawatts.

c. A high-power klystron operating at 20 kilovolts at 35 percent to 40 percent efficiency.

d. One-kilowatt CW magnetrons for the 3-centimeter and 7-centimeter bands.

e. A series of reflex klystrons, covering wavelengths from 0.8 to 6 centimeters and from 5.5 to 60 centimeters.

f. A series of traveling wave tubes, covering wavelengths from 30 to 60 centimeters.

g. Four types of traveling wave tubes, covering wavelengths from 7 to 12 centimeters, including a low noise preamplifier tube, a voltage amplifier tube, and an output tube rated at 5 watts. Series production of these tubes was estimated at 2,000 per month in 1956.

h. A family of four high-reliability receiving tubes in production, all having high performance ratings. Internal dimensions are reported to be extremely small: 5-micron to 8-micron diameter grid wire and 20-micron wire spacing; transconductance ratings are from 18,000 to 45,000 micromhos. Life expectancy for these tubes is reported to be rated at 5,000 hours average life and less than 2 percent failure at 1,000 hours.*

Production estimates for NII [redacted] can be only approximate, especially because it is known that a large proportion of the effort is concentrated on design and development. Production at NII [redacted] in 1955 was estimated [redacted] to have been approximately 1 million tubes of all types per month. 50X1 50X1 50X1

4. Electrovacuum [redacted] Saratov 23/ 50X1

The first known reference to the plant in Saratov was a Soviet press announcement of 23 August 1947, reporting that a plant was being built in Saratov for the manufacture of tubes, lamps, and other products. A plant to produce machinery for manufacturing tubes was under construction adjacent to the tube plant. [redacted] 50X1
[redacted] the tube facility in Saratov was established and personnel were being trained during 1950-52. After 1952, products of this plant are known to include standard glass tubes and miniature receiving tubes, magnetrons, klystrons, TR tubes, and small transmitting tubes. Other products, such as test instruments and electronic equipment, may be manufactured, but no firm evidence of this is known. The plant is not believed to be engaged in the manufacture of electric lamps. At Saratov, the design and production of machinery for producing tubes are conducted in facilities which are not part of this enterprise. 50X1

* This development indicates that Soviet workmanship compared favorably with some of the best work done in the West at that time. It is extremely doubtful that tubes with these technical characteristics are being produced with the life expectancy rating quoted. Similar tubes produced in the West have life expectancies rated in hundreds of hours instead of thousands.

The tube plant is housed in a new building consisting of a long structure with four lateral wings and is reported to have ample space and good lighting. As of 1956 the enterprise was still in process of considerable expansion, and a large amount of equipment was yet to be added. Firm estimates of production at the Saratov electrovacuum plant are precluded by lack of adequate data; information available pertinent to estimating the volume of production at Saratov includes the following:

a. In February 1956, a competent observer estimated that actual production amounted to 36 million receiving tubes per year. This figure would indicate that this plant may now be operating at approximately half capacity.

b. Receiving tubes were being produced as early as 1952, and radar microwave tubes reportedly were being produced in large quantities in 1953. [redacted] 50X1
[redacted] a rate of production in 1953 of several 50X1
thousand tubes per month of each of the categories of magnetrons, klystrons, and TR tubes.

c. German electronic engineers estimated that the plant would have an eventual capacity of 6 million to 8 million receiving tubes per month, with production concentrated on miniature tubes. A total of 51 automatic grid winders was installed as of 1956.

d. Employment totaled 9,000 persons as of August 1956.

e. The value of production planned for 1960 is scheduled to be 17.55 times that of 1954.

The evidence suggests that this new facility has been designed to become the major plant producing tubes in the USSR. Apparently, the plant in Saratov had become a major plant by 1956 and by April 1959 had become the largest center in the USSR for producing tubes.

It is estimated that in order for the USSR to meet the original plan for 1960, the plant at Saratov must reach full capacity operation and produce between 40 and 50 percent of total Soviet receiving tubes, plus a significant output of special-purpose tubes. Production of this magnitude would require approximately doubling the labor force of 1956 to a total of 18,000 employees.

5. Other Electron Tube Plants in the USSR

Information on the older large tube plants at Tashkent and Novosibirsk is insufficient to modify earlier intelligence estimates. 24/ Both enterprises continue to operate as important suppliers of tubes. [redacted] 50X1
[redacted] Tashkent, produces types RR-11 and RR-200, believed 50X1
to be TR and ATR tubes. This evidence tends to confirm earlier estimates of work at this facility on microwave tubes for radar. Plans were drawn up in 1951 for large-scale production of 8-millimeter magnetrons, 25/ but there is no evidence that either the Tashkent or Novosibirsk plant has initiated the production of television picture tubes.

Since 1953 a significant number of Soviet tubes have been noted bearing the trademark, "Diode," including standard glass tubes, miniature receiving tubes, and silicon diodes. Although there is no firm evidence to support an estimate of the size of the plant, it is believed that this product mix would not be scheduled at a small facility. [redacted] a new 50X1
tube factory was being completed in 1949 or 1950 near Kalinin; there is a Kalinin near Tomilino, the location of an electrovacuum plant which advertised for employees in Vechernyaya Moskva, 9 May 1950. The trademark "Diode" may well be associated with the plant at Tomilino.

[redacted] believed to be in the Moscow area, manufac- 50X1
tures gaseous-conduction devices bearing the trademark EL. Products are known to include barreters, discharge tubes, gas rectifiers, and stabilizers.

The L'vov Electric Lamp Plant, L'vov, was established in 1950 and 1951. Equipped with mechanized lines and automatic processing machinery, this plant has become one of the major producers of incandescent and fluorescent lamps in the USSR. Production at the plant in 1960 is scheduled to be three times that of 1955, and the plant is expected to become the largest Soviet lamp plant. Probably because of the large increase in planned production of television receivers, the plant began to manufacture cathode ray picture tubes by 1954. Production appears to be concentrated on the 43-centimeter, 70-degree rectangular tube with metal cone. The plant, with a reported production of 350,000 cathode ray tubes per year in 1956, is now an important supplier of cathode ray tubes to the Soviet television industry. The plant was producing at a rate of 400,000 tubes per year in April 1959. 26/

Evidence suggests that the large requirement for television picture tubes resulted in the initiation of production lines for cathode ray tubes at two of the major Soviet glass bulb plants, [redacted] in Moscow, and [redacted] Zaprudnya, Moskovskaya Oblast. 27/ 50X11

APPENDIX B

METHODOLOGY

A. Introduction

Official Soviet statistics on the volume of production of electron tubes, undifferentiated by type, value, or use, have been used to estimate the quantities of tubes produced during 1955-60. A production index for the years 1940 and 1950-60 is available from official sources and is amplified by announcements of fulfillment of production plans for 1957 and 1958. 28/ These published announcements of the volume of production generally are substantiated by estimates of production derived from available details on individual electron tube plants. The announcements have received general acceptance within the US intelligence community as the most reliable available statistics of total unit production of electron tubes in the USSR. 29/ No information is available to indicate the revised goals for electron tubes for 1958-65, but, based on the rate of growth achieved in 1956-58, it is estimated that the original planned goal of 200 million tubes will be underfulfilled by at least 45 million tubes.*

[redacted] 50X1

B. Estimates of Production

1. Summary of Estimating Procedures

As stated above, the aggregate production series in units was derived from official announcements, generally validated by plant information. The annual requirements for electron tubes for the consumer entertainment sector were estimated directly from official Soviet data, and from these two sources a residual series

* See Table 5, p. 28, below.

was derived representing the numbers of tubes available for military and industrial uses. [redacted] 50X1

[redacted] 50X1

The allocation of tubes by use within each category was derived by estimating the requirements for each category of tubes when Soviet sector value weights are assigned to a detailed US model. These requirements were converted to percentage relationships to provide an estimate of the unit distribution of Soviet tubes to military and industrial uses. Estimates of value in rubles for tubes in each category of use were then calculated by attaching representative ruble value weights for each category of tube to the US average price. [redacted] 50X1

[redacted] 50X1

The following sections provide more detailed information and the step-by-step procedures used in the derivation of the quantity and value series.

2. Derivation of Estimates

a. Estimates for the Total and for the Consumer Entertainment Sector

Based on known annual production of civilian entertainment equipment plus the existing number of radio and television receivers and phonographs for 1950-60, requirements for initial production of tubes and tubes for replacement for this sector were estimated in unit terms. Calculations of value based on Soviet prices were made in 1955 rubles and 1955 dollars. These data are provided in Table 4.* The physical unit series for consumer entertainment uses was subtracted from the annual total production series, leaving a residual representing the quantities of electron tubes available for the Soviet military and industrial programs. These data are provided in Table 5.**

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

Table 4

Consumer Requirements for Receiving Tubes and Cathode Ray Tubes in the USSR a/
Selected Years, 1950-60

Product	1950			1955			1956			1957			1958			1960		
	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles
Receiving tubes																		
Radio receivers and radio-phonograph combinations, original production b/	6.6	6.5	43.6	21.0	20.7	138.6	22.8	22.4	150.5	21.6	21.3	142.6	23.1	22.7	152.4	27.5	27.1	181.4
TV receivers, original production c/	0.2	0.3	2.7	8.4	10.7	115.0	10.0	12.8	137.0	11.9	15.2	163.0	15.4	19.7	211.0	34.0	43.5	465.8
Replacements required for maintenance d/	1.1	1.1	7.5	5.1	5.4	43.8	6.7	7.2	58.9	8.5	9.3	77.4	11.5	12.6	108.1	18.2	20.8	191.1
Total e/	7.9	7.9	53.8	34.5	36.8	297.4	39.5	42.4	346.4	42.0	45.8	383.0	50.0	55.0	471.5	79.7	91.4	838.3
Cathode ray tubes f/																		
TV sets, original production g/	h/	h/	h/	0.50	N.A.	N.A.	0.60	N.A.	N.A.	0.70	N.A.	N.A.	0.90	N.A.	N.A.	2.50	N.A.	N.A.
TV sets, replacements g/	h/	h/	h/	0.05	N.A.	N.A.	0.08	N.A.	N.A.	0.10	N.A.	N.A.	0.10	N.A.	N.A.	0.50	N.A.	N.A.
Total e/ g/	h/	h/	h/	0.55	21.8	192.5	0.68	27.0	238.0	0.80	31.8	280.0	1.00	39.7	350.0	3.00	119.3	1,050.0
Grand total e/	7.9	7.9	53.8	35.0	58.6	489.9	40.2	69.0	584.4	42.8	77.6	663.0	51.0	94.9	821.5	82.7	210.7	1,888.3

a. Values are given in 1955 prices. 30/ Unit production requirements were calculated from announced annual production and from plan data. Replacement requirements calculated on basis of tube failure rates applied to total sets in use.
b. From a sample of 33 common radio receiver tubes, the calculated average price was 6.6 rubles per tube, and the ruble-dollar ratio was 6.7 to 1.
c. From a sample of 16 miniature receiving tubes, the calculated average price was 13.7 rubles per tube, and the ruble-dollar ratio was 10.7 to 1.
d. Annual weighted average of tube price and ruble-dollar ratio.
e. Totals are derived from unrounded data and do not always agree with the sums of the rounded components.
f. Because of the heavy price weight of cathode ray tubes, unit computations are expressed to one additional decimal place.
g. The most commonly used Soviet picture tube was used as average. The price was 350 rubles, and the ruble-dollar ratio was 8.8 to 1.
h. Negligible.

Table 5

Quantities of Electron Tubes
Available for Consumer Use and for Military and Industrial Uses
in the USSR
Selected Years, 1950-60

Million Units

Sector of Use	1950	1955	1956	1957	1958	1960
Consumer	7.9	35.0	40.2	42.8	51.0	82.7
Military and industrial	17.3	41.6	49.4	55.2	59.0	70.3 a/
Total	25.2	76.6	89.6	98.0	110.0	153 b/

a. The distribution of electron tubes between sectors of use in 1960 will be affected to a degree by the introduction of transistorized equipment. Present information does not indicate the relative requirements for transistors which will be experienced by 1960. To the extent that transistors replace electron tubes in consumer entertainment equipment, the number of tubes available for military and industrial use will be greater than shown.

b. The original directives of the Sixth Five Year Plan (1956-60) called for the production of 200 million electron tubes of all types. Although no official revision of this goal has been announced, the figures of plan fulfillment for 1956-58 indicate that a substantial reduction in the plan has taken place. Based on official production announcements through 1958 and expected increases in individual plants, production of 153 million tubes for 1960 was estimated. This production represents an average annual increase of 15 percent since 1955.

b. Allocation of Electron Tubes for Military and Industrial Use, by Tube Category

The residual quantities of tubes obtained as described above, representing the numbers available for the combined military and industrial electronics sectors, were distributed by the following method:

(1) In the electronics industry of the US, the military and industrial equipment sectors use receiving tubes, cathode ray tubes, and transmitting and special-purpose tubes in different proportions. Changes in levels of production of these sectors (with a constant product mix maintained within each sector) which result in changes in the sector ratios will change the proportions and the absolute numbers of tubes required in the economy. Under conditions of similar state of the art and similar product mix within each sector, the distribution of electron tubes can be estimated for different sector value ratios. The above is shown in Tables 6 and 7.*

* Tables 6 and 7 follow on pp. 29 and 30, respectively, below.

Table 6

Expenditures for Electronics
for Military and Industrial Uses
in the US and the USSR a/
1957

Sector of Use	US		USSR	
	Billion $	Percent	Billion Rubles	Percent
Military	3.9	75	14.9	82
Industrial	1.3	25	3.3	18
Total	5.2	100	18.2	100

a. 31/

(2) In Table 7 the known distribution of electron tubes in the US electronics industry for 1957 is shown in columns 1 and 2. This distribution occurred when the total expenditures for electronics for military and industrial uses in the US amounted to $5.2 billion, as shown in Table 6. The ratio of military expenditures to the industrial expenditures was 3 to 1. The first calculation was carried out under the assumption that the combined level of production for military and industrial electronic equipment would remain the same but that the ratio of sector values would become 4.52 to 1, to be equal to the Soviet ratio. This ratio applied to $5.2 billion yields value levels of $4.26 billion for the military equipment sector and $0.94 billion for the industrial sector.

(3) From information contained in Tables 6 and 7, it is seen that 36 million receiving tubes are used by the US military sector in the production of equipment valued at $3.9 billion, or .0092 receiving tubes per dollar. At the assumed value of $4.26 billion for the military equipment sector, the implied requirement for receiving tubes is calculated at 39.3 million tubes. This calculation is carried out for each type of tube for both the military and industrial equipment sectors and entered in column 3 of Table 7. These unit relationships are converted to percentage terms (column 4) to permit their use as analog data in the Soviet model.

Table 7

Requirements for Electron Tubes in Military and Industrial Uses in the US
1957

Type of Tube	Category of Use	(1) Distribution a/ Million Units	(2) Distribution a/ Percent of Total Units	(3) Requirements b/ Million Units	(4) Requirements b/ Percent of Total Units
Receiving tubes	Military	36.0	60.3	39.3	68.1
	Industrial	5.3	9.0	3.8	6.6
	Combined	41.3	69.3	43.1	74.7
Cathode ray tubes c/	Military	0.16	0.27	0.17	0.30
	Industrial	0.14	0.23	0.10	0.20
	Combined	0.30	0.50	0.27	0.50
Transmitting and special-purpose tubes	Military	3.6	6.0	3.9	6.8
	Industrial	14.4	24.2	10.4	18.0
	Combined	18.0	30.2	14.3	24.8
Total		59.6	100	57.7	100

a. [redacted] The distribution shown corresponds to actual expenditures for military electronic equipment of $3.9 billion and for industrial electronic equipment of $1.3 billion, or a sector value ratio of 3 to 1. 50X1

b. Derived as explained in text, p. 29, above, by applying the USSR 1957 sector value ratio of 4.52 to 1 to obtain the implied requirements for total tubes and for the three tube categories by sector of use.

c. Because of the heavy price weight of cathode ray tubes, unit computations are expressed to one additional place.

(4) The percentage distribution derived in column 4 of Table 7 is then used to allocate the total number of tubes in the USSR. The unit distribution so derived for the years 1950, 1955-58, and 1960 is shown in Table 8.* The assumption of comparability between the state of the art in the US and in the USSR, which is necessary to this procedure, rapidly becomes more tenuous the further the series departs in time from 1957. The estimates for the years 1950 and 1960, therefore, must be considered to be only approximations. In 1950 the Soviet electronics industry was much less comprehensively developed than the US industry, and there is growing evidence that by 1960 revolutionary changes in the state of the art will lead to greatly modified patterns of use of electron tubes in both the US and the USSR.

(5) Estimates of the value of tubes used in the consumer entertainment sector are explained in the footnotes to Table 4. Estimates of the value of Soviet military and industrial electron tubes were derived by using US analog data on average prices of each category of tube in each sector, then applying ruble-dollar ratios calculated from Soviet price catalogs and US manufacturers' data. The US average factory shipping price for receiving tubes for both military and industrial uses was $2.36, and the ruble-dollar ratio was calculated at approximately 10 to 1. For cathode ray tubes the average price was $60.00 per tube for military shipments and $24.00 per tube for industrial shipments, and the ruble-dollar ratio for both types was 8.8 to 1. For transmitting tubes and special-purpose tubes the average price was $30.60 for military tubes and $4.40 for industrial tubes, and the ruble-dollar ratio for tubes in both uses was 5.46 to 1.

C. Check on Unit Production from Tube Plant Information

Some detailed information on production of electron tubes by individual plants is available for recent years and may serve as a very rough check on the total numbers of units claimed in Soviet official announcements. The announcements are imprecise, however, because (1) they are not available over the range of plants for the same year -- therefore, outputs of different plants for different years often have to be added to get a total; (2) they are often casual observations, and, although they are made by experienced technicians, they lack precision; and (3) they are often based on total capacity rather than actual current output. Nevertheless, it is considered to be worthwhile to relate detail of plant production to the aggregate production estimate wherever possible. In this report, details on the activity of major tube plants during 1956-58 and also new data available indicate a total production of 85 million tubes.** This

* Table 8 follows on p. 32.

** For details of this discussion, see Appendix A.

Table 8

Production of Electron Tubes in the USSR a/
Selected Years, 1950-60

Type of Tube and Sector of Use	1950			1955			1956			1957			1958			1960		
	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles	Million Units	Million US $	Million Rubles
Receiving tubes																		
Civilian use	7.9	7.9	53.8	34.5	36.8	297.4	39.5	42.4	346.4	42.0	45.8	383.0	50.0	55.0	471.5	79.7	91.4	838.3
Military use	11.8	27.9	278.4	28.3	66.8	667.9	33.6	79.3	793.0	37.6	88.7	887.4	40.2	94.9	948.7	47.9	113.0	1,130.4
Industrial use	1.1	2.6	25.9	2.7	6.4	63.7	3.3	7.8	77.9	3.6	8.5	85.0	3.9	9.2	92.0	4.6	10.9	108.6
Total	20.8	38.4	358.1	65.5	110.0	1,029.0	76.4	129.5	1,217.3	83.2	143.0	1,355.4	94.1	159.1	1,512.2	132.2	215.3	2,077.3
Cathode ray tubes b/																		
Civilian use	c/	c/	c/	0.55	21.8	192.5	0.68	27.0	238.0	0.80	31.8	280.0	1.00	39.7	350.0	3.00	119.3	1,050.0
Military use	0.05	3.0	26.4	0.12	7.2	63.4	0.15	9.0	79.2	0.17	10.2	89.7	0.18	10.8	95.0	0.21	12.6	110.9
Industrial use	0.03	0.7	6.2	0.10	2.4	21.1	0.10	2.4	21.1	0.11	2.6	22.9	0.11	2.6	22.9	0.14	3.4	29.6
Total	0.08	3.7	32.6	0.77	31.4	276.5	0.93	38.4	338.3	1.08	44.6	392.6	1.29	53.1	467.9	3.35	135.3	1,190.5
Transmitting and special-purpose tubes																		
Military use	1.2	36.8	200.7	2.8	85.7	467.9	3.4	104.0	567.8	3.8	116.3	635.0	4.0	122.4	668.3	4.8	146.9	802.1
Industrial use	3.1	13.6	74.5	7.5	33.0	180.2	8.9	39.2	214.0	9.9	43.6	238.1	10.6	46.6	254.4	12.6	55.4	302.5
Total	4.3	50.4	275.2	10.3	118.7	648.1	12.3	143.2	781.8	13.7	159.9	873.1	14.6	169.0	922.7	17.4	202.3	1,104.6
Grand total d/	25.2	92.5	665.9	76.6	260.1	1,954.1	89.6	311.1	2,337.4	98.0	347.5	2,621.1	110.0	381.3	2,902.8	153.0	552.9	4,372.4

a. Values are given in 1955 prices.
b. Because of the heavy price weight of cathode ray tubes, unit computations are expressed to one additional decimal place.
c. Negligible.
d. Totals are derived from unrounded data and may not equal the sums of the rounded components.

estimate excludes production at the plants in Tashkent and L'vov and at a few relatively minor additional plants for which recent information is not available. Information on these plants had indicated production of a total of 20 million tubes per year by 1956. 33/ The grand total of approximately 105 million tubes per year is consistent with Soviet announcements of production in 1957 and 1958. Details on the production schedules for individual classes of tubes are extremely fragmentary, and only for television picture tubes is there sufficient information to permit an estimate of production by this means. Reported production of cathode ray tubes for television receivers in the two plants which produce the greatest proportion of this type of tube reached a level of 790,000 tubes by 1957, with an additional number of such tubes reportedly produced in at least three other minor plants.* The estimated Soviet requirement for this type of tube for 1957 was approximately 1 million tubes. Although checks on other categories of production of electron tubes are not available at this time, future possibilities for such analysis may exist through the scientific and technical exchange program.

D. Check of Estimated Value

Information published in the Soviet press criticizing the rate of rejection in production of electron tubes contains figures which point to the great emphasis on production for military purposes in the electronics industry. A ministerial document of May 1957 showed that, in 1956, losses from rejection in the manufacture of "electrovacuum components" (electron tubes) at the final testing stage alone amounted to 260 million rubles, or 80 percent of the total loss from rejection in the whole electronics industry. 34/ The losses reportedly increased during the first quarter of 1957, amounting in some cases to 13 to 15 percent of production. It was implied that the rate of rejection in the industry for 1956 was about 10 to 12 percent. This rate of rejection would suggest that the total value of production in the industry in that year was between 2.15 billion and 2.60 billion rubles. The estimated value of electron tubes derived in this report lies at approximately the midpoint in this range and is considered to be reasonably well confirmed by the document cited.

E. Comparison of Levels of Production of Electron Tubes in the US and the USSR

The value series for production of Soviet electron tubes shown in Table 8** was calculated in terms of constant 1955 rubles and constant 1955 dollars as indicated in the text. Comparative data on the

* For details of this discussion, see Appendix A.
** P. 32, above.

value of US production during these years are available only in terms of current US prices. In order to establish comparability between these two sets of data, it was necessary to adjust the Soviet time series, where appropriate. Of the 4 years selected for comparison of value of estimated Soviet production, 1950 was the only year which was adjusted to reflect price levels different from those of 1955. No significant changes in the prices of Soviet electron tubes are known to have occurred during 1955-58. The estimate for 1960 was unchanged, as there is at present no information which would indicate that a price change is contemplated or is likely to occur by 1960. Changes in price, which occurred between 1950 and 1955, affected electron tubes as well as other electronic products. Prices of electron tubes were reduced 20 percent in 1950 and 15 percent in 1954. 35/ Because the change in prices in 1950 occurred in the early part of the year, probably in January, only the 15-percent reduction of 1954 was used to adjust the estimate for 1950 so as to reflect prices in 1950.

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