MACHLETT

CATHODE PRESS

FALL • 1952

NOW AVAILABLE... A COMPLETE LINE OF

Interchangeable

DIAGNOSTIC X-RAY TUBES

Machlett Laboratories are privileged to announce to all users of diagnostic x-ray equipment the availability of a complete line of diagnostic x-ray tubes in revised light weight shockproof housings incorporating standard federal cable terminals and mounting brackets. These optional models of proven and reliable Machlett x-ray tubes provide the civilian user with the utmost in tube interchangeability and the maximum in flexibility of operation.

Realizing the needs of large institutions with multiple installations and those of the user whose one tube stand must serve for all diagnostic techniques, Machlett Laboratories have made available a complete line of diagnostic x-ray tubes which are designed to provide for complete interchangeability of specialized tubes regardless of application. The tubes illustrated here are available in models incorporating the standard federal cable terminals.

The addition of these four tube types to Machlett's extensive line of diagnostic x-ray tubes provides for the user not only the choice of a tube specifically designed to meet a particular application, but the added advantage at his option of complete tube interchangeability.

Write for complete tube data and an article, "New Federal Standard Cable Terminals," Cathode Press, Winter 51-52 issue.

THE DYNAMAX "30"
a high capacity, all purpose rotating anode tube incorporating the world famous Dynamax "25" insert Ideal for all general radiographic applications. Operating voltages to 100 PKV, tube currents to 100 MA self-rectified, 500 MA rectified.

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a rotating anode tube designed specifically for under-the-table spot film radiography and fluoroscopy. Operating voltages and tube currents similar to those of the Dynamax "30".

THE SUPER DYNAMAX
heavy duty rotating anode tube for high speed photoroentgenography, angiocardiography, cineradiography and celebral angiography.

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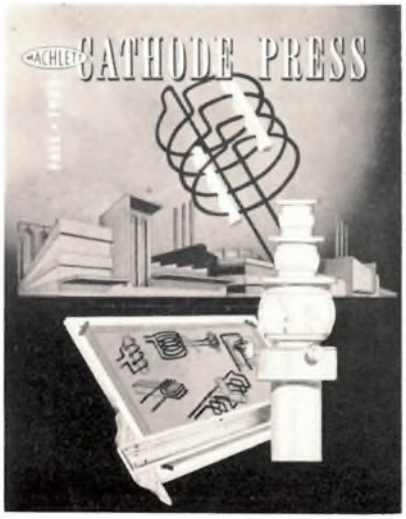
extremely light weight stationary anode tube designed for under-the-table spot film work and fluoroscopy. Voltages to 110 PKV, tube currents to 500 MA.

MACHLETT — X-RAY TUBES SINCE 1897 — TODAY THEIR LARGEST MAKER

MACHLETT LABORATORIES, INC., SPRINGDALE, CONNECTICUT



COVER

The newly developed ML-6256, illustrated on the cover of this issue and described in an article on page 2, is the most recent of Machlett designed and developed industrial electron tubes. It fulfills the recognized demand for a tube capable of providing long trouble-free service in 2-3 kilowatt electronic heating applications.

Two other versions of this tube: ML-6257, integral anode water jacket model and ML-6258, forced-air-cooled version, will be discussed in an article which will appear in the next issue of Cathode Press.

Cathode Press reports developments of interest to the Electronic Industry at large through its coverage of the latest advances in the design, manufacture and use of electron tubes — with specific reference to their use for x-ray, communication and industrial purposes. Particular emphasis is placed on the role of Machlett Laboratories in the development of new electron tube products, improvement in current types and in their application.

Cathode Press welcomes suggestions from its readers directed to the more effective presentation of such information to the rapidly expanding Electronics field.

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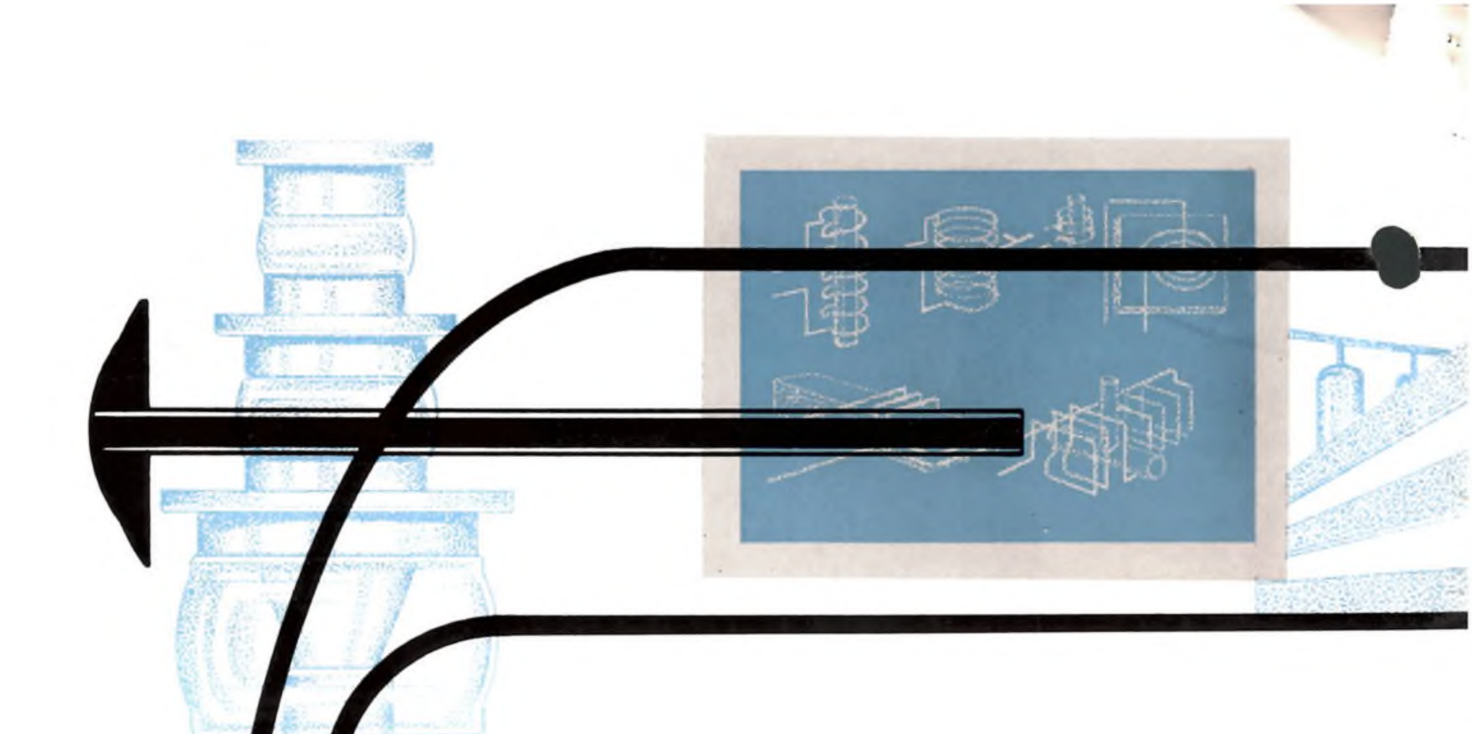
The Dynamax "40"—A High Voltage Rotating Anode Tube

The ML-5682—Its Use in a Super-Power Broadcast Transmitter



ML-6256 A WATER FOR 2-3 KILOWATT

by
C. V. WEDEN, Design Engineer
Machlett Laboratories, Incorporated

C. V. WEDEN

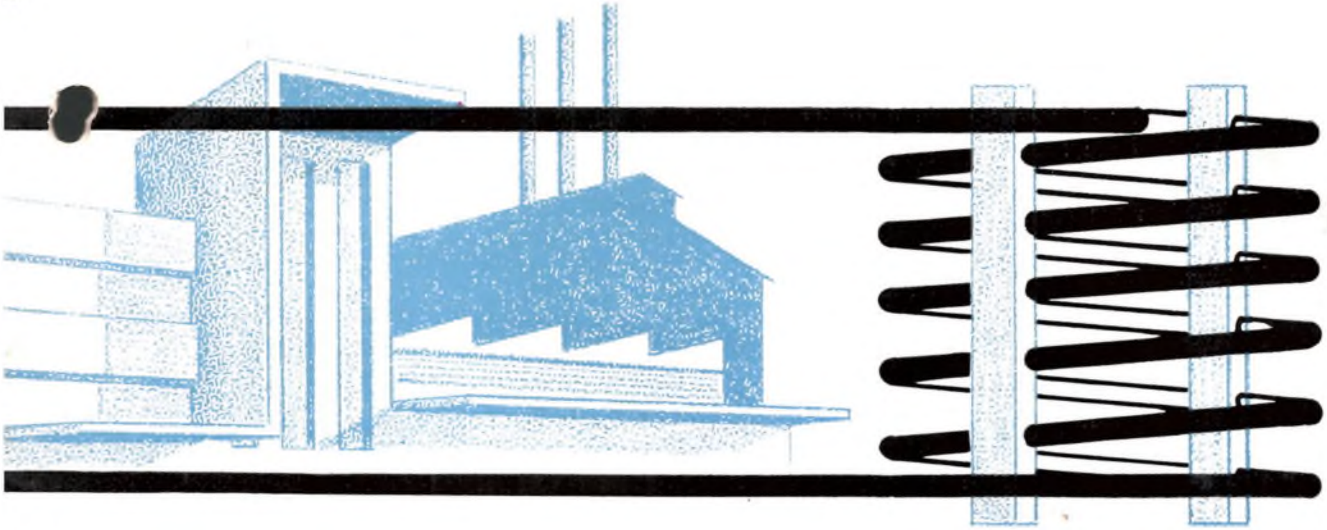
Mr. Weden joined Machlett Laboratories in 1948 after having received AB degree in Physics from Cornell University, Ithaca, New York. Engaged in the development of VHF Ceramic Tetrode, of UHF Ceramic Triode and of Thoriated-tungsten power tubes for communications, industry and research.

The ML-6256 is the most recent development in Machlett Laboratories' continuing program to make available electron tubes designed specifically for industrial applications. It meets the need for a reliable, economical oscillator tube for induction and dielectric heating equipments rated at 2 to 3 kilowatts output.

Both equipment manufacturers and users have long recognized the gap at the 2-3 kilowatt output level in the industrial power tube spectrum because of their less-than satisfactory experience with various radiation, water, and forced-air-cooled "radio" transmitting tubes, the only ones available for industrial service at this particular power level. The ML-6256, like the other Machlett power tubes previously developed for industrial heaters in the range from 5 to 150 kilowatts output, fulfills another demand for a specific industrial tube—one capable of providing reliable performance and low operating costs in 2-3 kilowatt electronic heating applications.

Description

The ML-6256 is a water-cooled triode capable of operation at 5.5 kVdc plate voltage and 7 kW plate input as an oscillator or unmodulated class C amplifier at frequencies up to 110 megacycles per second. It incorporates a heavy duty



-COOLED INDUSTRIAL TRIODE OUTPUT ELECTRONIC HEATERS

anode capable of dissipating 5 kilowatts, and is used with a quick-change automatic-seal water jacket similar in design to those developed for other widely used higher power Machlett industrial tubes. The ML-6256 will also be made available with an integral-anode water jacket complete with inlet and outlet fittings, and as a forced-air-cooled tube with a high-efficiency radiator. The cathode of these tubes is a thoriated-tungsten filament designed to operate at 12.6 volts, 27 amperes. Constant current characteristics and outline dimensions are given in Figures 2 and 3, respectively.

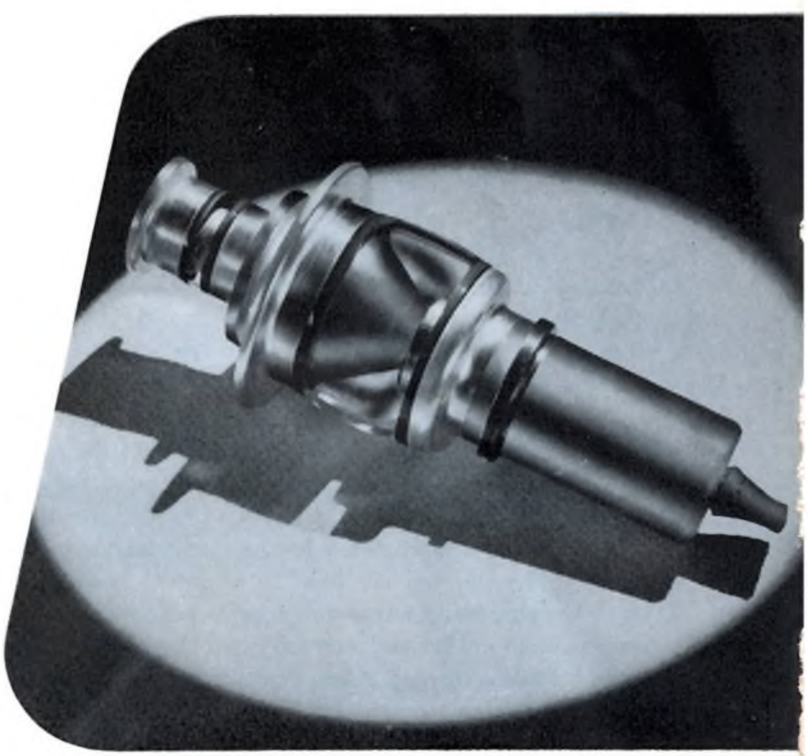
Design and Construction Features

The ML-6256 embodies the best mechanical and electrical features characteristic of Machlett-developed industrial tubes. Outstanding among these are:

- ***Sturdy Glass-to-Kovar Seals.***

  Experience has shown that thin feather-edge copper seals are an inherent weakness of many electron tubes. Kovar, an iron-nickel-cobalt-manganese alloy which closely matches the thermal expansion characteristics of glass, permits stress-free seals to be made with relatively heavy metal sections. With a strength more than five times that of annealed copper, the mechanical superiority of glass-to-kovar seals has been demonstrated clearly in comparative torsion and bending tests.

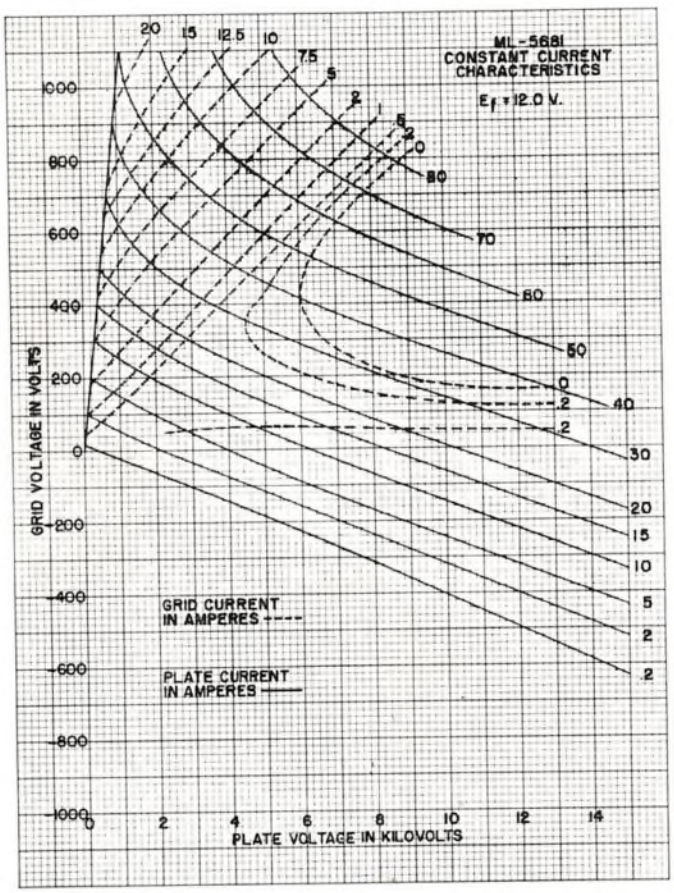
Figure 1—The ML-6256 power triode, newest of Machlett developed industrial electron tubes.



• ***Coaxial Terminals.***

The all-ring seal coaxial terminal construction permits excellent alignment of internal elements. The resulting large-diameter seals are capable of greater heat dissipation, and the coaxial terminal design adapts the tube naturally to resonant cavity circuitry. Both of these points are important in higher frequency applications, such as dielectric heating and FM broadcasting.

Figure 2—ML-6256 constant current characteristics.



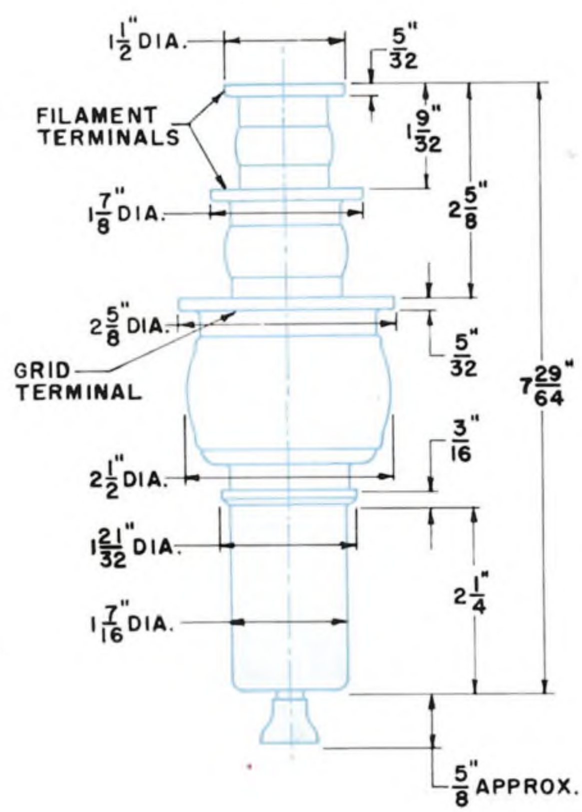
• ***Self-Supporting Thoriated-Tungsten Filament.***

Stress-free, self-supporting filaments have been found to be a great improvement over the spring-loaded type. With fewer and sturdier parts, the structure can be fabricated more uniformly, minimizing any tendency toward bowing and maintaining stability throughout life. In contrast, conventional spring-loaded filaments require potentially-troublesome guides and are subject to bowing, since the loading spring relaxes in time due to the high operating temperature. The ML-6256 filament is a bifilar helix of large-diameter thoriated-tungsten wire supported by heavy rods connected to mounting cylinders. The use of thoriated-tungsten in lieu of pure-tungsten means, of course, lower filament power, which is important for operating economy in any type of service. It also permits space economy, through the smaller filament transformer required, which is important in the construction of compact industrial equipment. The filament is carburized to form a tungsten-carbide shell of approximately 20% in cross-sectional area. Through the use of heavy wire, the filament may be carburized commensurate with high emission and long life, and still retain a relatively large-diameter uncarburized core having the toughness of pure tungsten. A centermast is brought through the vacuum envelope for applications requiring a center-tap return.

• ***Sturdy, High Heat-Dissipation Grid.***

The grid is a sturdy bird-cage type connected directly by a conical support to the grid terminal flange. This construction is superior to that used in conventional tubes of this power level in both mechanical ruggedness and heat dissipation qualities. Careful jigging as each sub-assembly is added insures accurate electrode alignment.

Figure 3—ML-6256 outline drawing.



- ***Heavy-Wall Copper Anode.***

The heavy-wall copper anode is now accepted as essential to industrial power tubes. Higher plate dissipation is permissible, and hot-spotting due to transient overloads is eliminated.

- ***Final Tube Seal-In By Induction Heating.***

Customary seal-in technique is to make a glass-to-glass seal by heating the parts with a gas flame, the operation requiring several minutes. By designing the tube for a metal-to-metal seal-in, the operation can be performed by induction heating within a few

Figure 4—ML-6256 final seal-in operation by induction heating.

seconds. This method eliminates the possibility of filament or grid contamination by the gas flame, which can occur even within a protective atmosphere, and confines the heat to the immediate area of the seal so that further annealing of the glass parts is unnecessary. Subsequent operations—Machlett high-temperature, high-voltage exhaust processing, radiography, initial and final testing—are carried out to the degree at which long, trouble-free tube performance is insured.

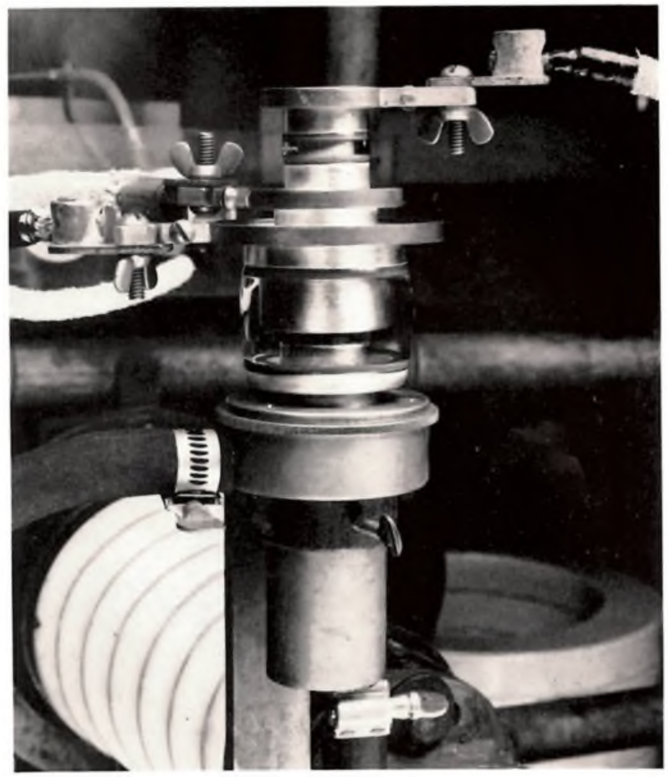


Figure 5—ML-6256 power triode under test.

As Machlett Laboratories developed its line of power tubes for industry, many equipment manufacturers and users formulated the properties they felt were necessary in electron tubes to be used in industrial heating equipment. These tube design objectives have now been collected as a "Suggested Standard for Future Design," proposed by the Induction and Dielectric Heating Section of NEMA. The more important performance characteristics are listed below and have been adhered to in the design of the ML-6256, as indicated in the tabulated Maximum Ratings and Typical Operating Conditions.

A ***Tube power output should be a minimum of 140% of the nominal equipment output rating.*** ML-6256 power outputs shown correspond to 140% of 2 kW and 3 kW, respectively. In normal operation the useful output will be considerably higher, and overall equipment efficiency well over 50% can be realized.

B ***Tube anode efficiency should be at least 65%.*** The suggested operating conditions indicate anode efficiencies at 65%.

C ***Maximum ratings of DC Grid Current and Voltage should be at least three times the values used in obtaining items (a) and (b) above.*** Values given in typical operation are approximately one-third the

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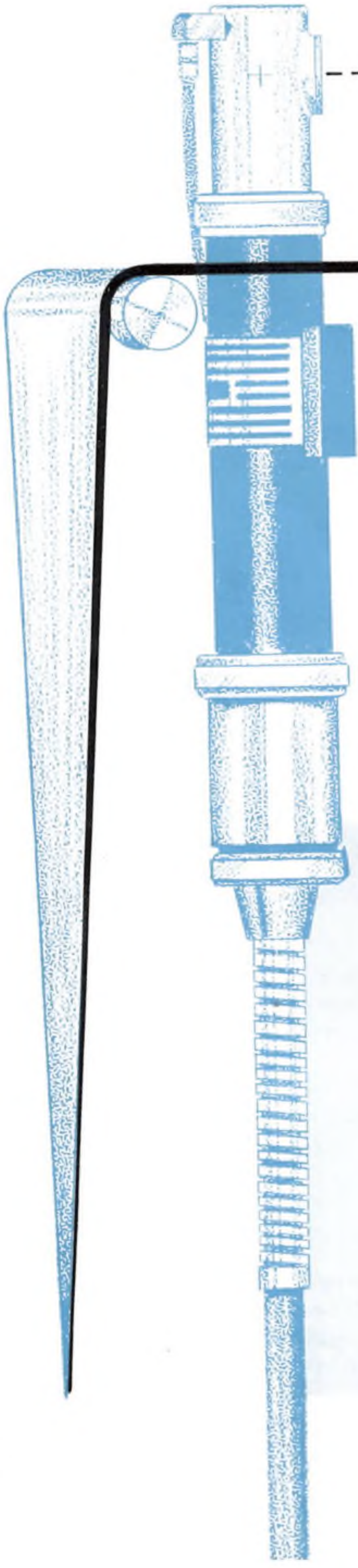
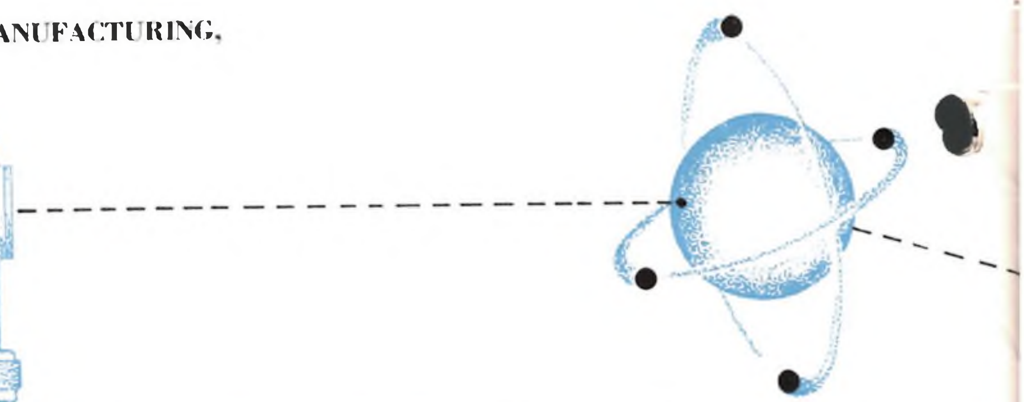
May 1952





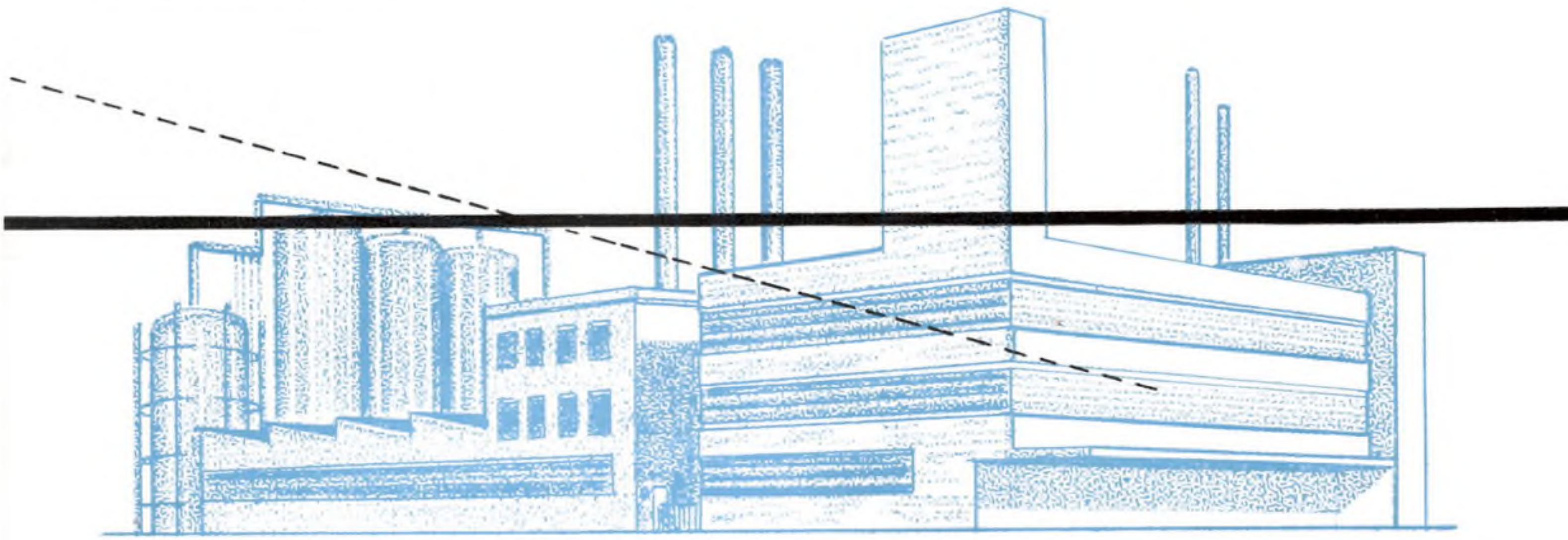
For some years, it has been felt by tin plate producers that a rapid, accurate and non-destructive measurement of tin coating weights would be helpful in the control of tin coating distribution on hot-dipped tin plate. Consequently, in 1946, extensive investigation was undertaken by the United States Steel Corporation to develop an x-ray method for the measurement of tin-coating thickness.

Prior to this development, tin-coating thickness measurements were based on chemical or electrochemical methods, wherein the tin coating was removed from a known area of the tin plate *(1, 2)** and the amount of tin was determined either by the loss of weight of the sample or by gravimetric or volumetric analysis of the stripping solution. These methods were quite accurate but were not as fast as desired and

* Italic numerals apply to cited references at end of article.

X-RAY TIN COATING GAGE

by G. E. PELLISSIER and E. E. WICKER
United States Steel Company



also involved destruction of the tin plate sheets. As a result, several hundred thousand sheets of tin plate were consumed each year in the determination of coating weight. Furthermore, the chemical methods became difficult and time-consuming if the coating weight on only a single side of the sheet is desired. X-ray coating thickness measurements had been proposed previously *(3, 4)*, but these were based upon x-ray diffraction phenomena and later were found to be subject to large deviations resulting from variations in grain size, in orientation and in other metallurgical characteristics of the coating and base metal.

The x-ray method developed by the United States Steel Company can best be described by reference to Fig. 1, which shows graphically the components of the system and their geometrical arrangement. A primary beam of x-rays from the x-ray tube in the upper left corner of the diagram is directed onto the tin-plate sheet through two collimating apertures. The wavelength of the x-rays in this primary beam is chosen so that the radiation will penetrate the tin coating with very little absorption and will cause secondary x-rays (iron K-alpha) to be emitted from the steel base. These secondary x-rays are emitted uniformly in all directions, and some of them emerge through the tin coatings where they are partially absorbed. Since the intensity of the secondary x-rays after passing through the tin is quantitatively related to the thickness of the tin coating, this intensity can be used as a measure of the coating thickness. It is evident from Fig. 1 that the actual thickness of tin through which the secondary x-rays pass depends upon the angle between the emergent rays and the surface of the tin plate. To insure that all radiation being measured will have traversed the same thickness of tin, it is necessary to place a collimating system in front of the radiation detector. The intensity of the secondary x-rays is measured by counting for a standard time interval (about 30 sec.) with a Geiger counter. From a graph or chart prepared with the aid of samples of known coating weight, it is then a simple matter to determine the coating weight of a test sheet from the count accumulated over the standard time interval.

At the outset of this development of an x-ray gage for tin-mill control use, it was determined that the principal application in the mills of the United States Steel Company would be in the measurement of coating thickness on hot-dipped sheets rather than on electrolytically coated strip. This decision meant that the measurement would be made intermittently on a prescribed area of the tin-plate sheet rather than continuously on a moving strip. Furthermore, on hot-dipped sheets, tin-plate producers and consumers customarily measure coating weight over a circular area of 4 sq. in. and report the average weight of the coating on both sides of the disk sample. This practice had the advantage of averaging out small-scale variations but posed a difficult problem in providing uniform irradiation and uniform detection.

Several other requirements had to be met. The measurement must be made without cutting, marking or defacing the tinplate sheet in any manner. The measuring time must not exceed 1 min. and the accuracy should be ±2 per cent as determined by the most reliable chemical methods. Furthermore, the test should give the total weight of tin present, including the amount combined as iron-tin alloy at the interface. Measurement should be unaffected by normal variations in the thickness of the steel base, or by thin tin-oxide films; measurements must be independent of grain size, orientation and commercial variations in composition. The gage should make simultaneous, but independent measurements on opposite sides of the area without mutual interference.

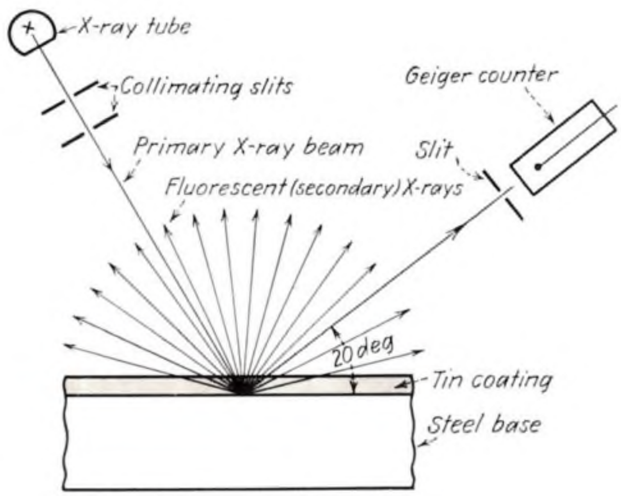


Figure 1—Secondary emission of fluorescence at the iron-tin boundary is measured from an acute angle; absorption by the tin coating reduces the intensity in proportion to the thickness of the tin coating.

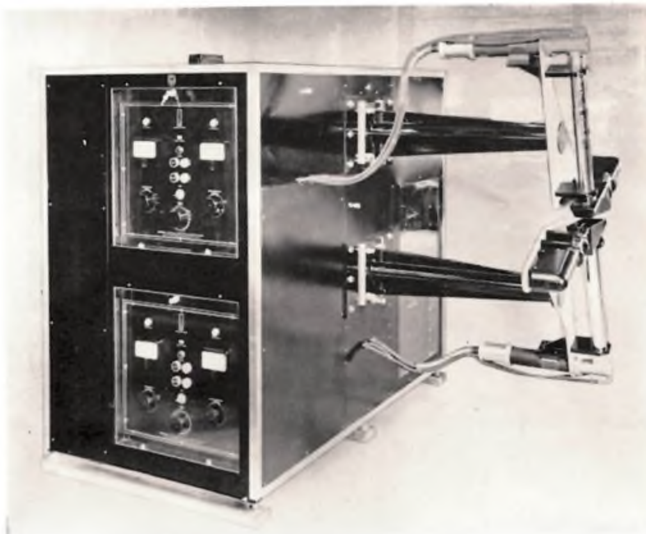
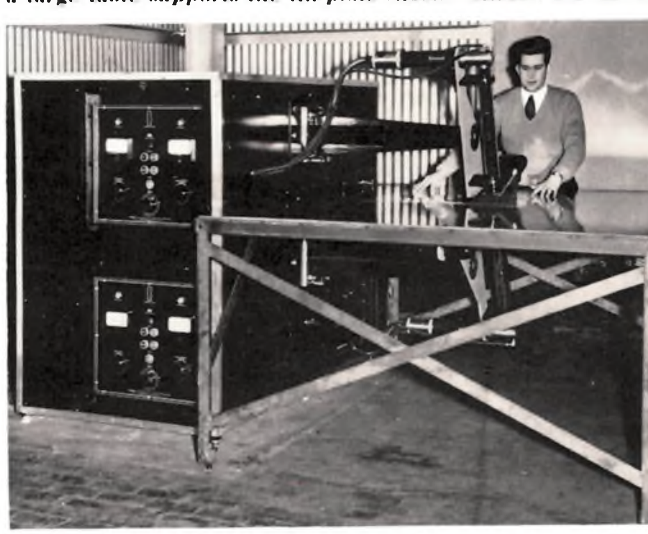


Figure 2 — Two x-ray measuring heads simultaneously indicate thickness of tin coating on both sides of a sheet. Radiation is maintained for 30 sec.; count from each Geiger tube is scaled down by a factor of 64 and registered on a counter.

An x-ray tin-coating thickness gage, Fig. 2, has been developed by the Research and Development Laboratory of the United States Steel Company to meet these requirements. Fig. 3 is a general view of this equipment in service at the Irvin Works of the United States Steel Company measuring the coating thickness of tin-plate sheets produced by the hot-dipping process. The major components of such a gage are (1) a large, floor-mounted cabinet housing the electrical and electronic components, (2) two x-ray measuring heads one above and one below the sheet being measured, supported at the ends of rigid, steel arms extending from the side of the cabinet, and (3) a large, flat table for positioning and supporting tin plate sheets so that any desired area may be placed between the measuring heads.

The x-ray measuring head, which embodies the novel and essential features of this gage, is shown in Fig. 4. The x-ray tube, located in the upper left corner of the photograph, is a Machlett Laboratories type OEG-50 with a large tungsten target. Immediately in front of the window of this tube is a slit 1 mm wide by 5 mm long, oriented with its length parallel to the long axis of the x-ray tube. Radiation emerging from the tube is confined in the long chromium-plated lead-lined brass tube that serves to support the lead collimating diaphragms and to protect operating personnel from any hazard of stray radiation. The collimating diaphragms are made of lead 1/16 in. thick and contain a 1-in. diameter aperture which is precisely centered on the axis of the brass tube. Two of these diaphragms, shown removed from their housing in Fig. 5, are used to limit the divergence of the x-ray beam while permitting the uniform irradiation of a circular area of 4 sq. in. on the tin-plate sheet. A second, shorter brass tube extends from the tin-plate sheet to the Geiger counter tube and houses the collimating system for

Figure 3 — Complete instrument incorporates two measuring heads mounted on the side of the x-ray equipment cabinet; a large table supports the tin-plate sheets between the heads.



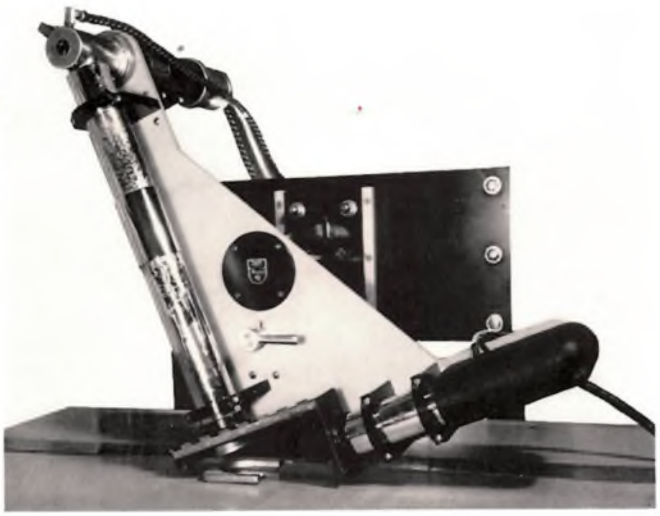
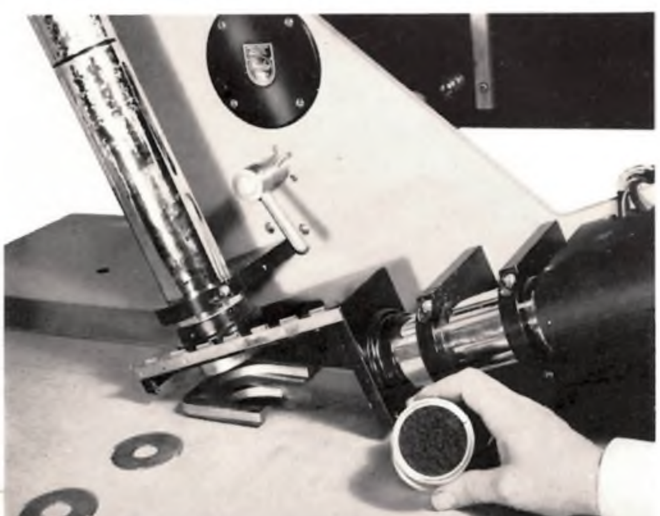


Figure 4 — Measuring head consists of the x-ray tube and a lead-lined brass collimating tube designed to produce uniform radiation over a circular area of 4 sq. in. Geiger tube at right measures the secondary emission after it has been reflected back through the tin coating at an oblique angle.

the secondary, or fluorescent, x-ray beam. This collimator, also shown in Fig. 5, consists of a 2-in. diameter bundle of nickel tubes each 1/16 in. in diameter by 1½ in. long. This collimator serves to limit the radiation entering the Geiger counter to those rays that emerge from the tin plate at an angle of 20 deg. from the surface of the sheet. The Geiger tube itself is mounted directly behind this collimator at a distance of 12 in. from the center of the area of tin plate being measured. In Fig. 6, two Geiger tubes with a single cathode follower circuit are shown mounted in the desired position. It is also possible to use one Geiger tube of larger diameter, and both arrangements have proved satisfactory. The type of Geiger tube used in this equipment is argon-

Figure 5 — Two collimating methods are employed. Lead diaphragms are spaced along the primary beam; secondary radiation passes through a bundle of thin-wall nickel tubes 1/16 in. diam. and 1½ in. long.



filled with a halogen quenching agent; it has a thin mica end-window, and the tube is sensitive to incident radiation over most of its cross-sectional area. Fig. 7 shows this x-ray optical system in ray-diagram form.

The electrical and electronic components used in a double measuring-head x-ray gage are shown in block diagram form in Fig. 8. As can be seen, duplicate and independent circuits are used for the two measuring heads. Each circuit consists of two basic parts, one for the generation of primary radiation in the x-ray tube, and the other for detection of the fluorescent radiation and measurement of its intensity. In this latter part of the circuit, a d-c power supply provides stable, high voltage to the Geiger counter tube, and plate voltage to the tubes of the scaling circuit. The scaling circuit itself is used to reduce the number of counts from the Geiger tube by some fixed factor before they are counted. The circuit consists of a series of binary scaling units, each of which effectively divides by two the number of counts reaching it from the previous binary unit. In normal operation of this gage, it has been found that scaling by a factor of 1/64 reduces the number of counts received in a 30-sec. counting interval to less than 500, a number which can be satisfactorily handled by recently developed counting equipment.

In the first gages of this type, the counts or electrical pulses were passed through the scaler to electromechanical counting and printing devices. For the simple counting operation, a relay closed by each pulse could be used to drive an indicating pointer around a calibrated dial; however, since a printed record is usually desired, it is necessary in electromechanical devices for the relay to drive printing wheels carrying embossed numbers, and for additional relays to actuate a printing mechanism. These relay-actuated devices proved to be unsatisfactory because it was necessary for the relays to respond to each of the counts accumulated in a 30-sec. time interval. Since the time separation between counts may be very short for random pulses at high counting rates, many pulses were not recorded due to the sluggish response of even very sensitive relays. Furthermore, the constant mechanical action of these devices caused severe wear and excessive maintenance. It therefore became essential to provide a faster counting system, and preferably one that could produce a permanent, printed record.

Such a printing counter has been developed for use with these tin-coating gages. In the new counter, Fig. 9, the pulses from the scaling circuit are accumulated electronically in three decade counting circuits until the conclusion of the counting cycle, at which time the three digit number thus determined is transferred through stepping switches to three printing wheels (units, tens, hundreds) and recorded on a paper tape. If only a visual indication of the total count is desired, the information from the decade counters can be transferred to three banks of neon glow tubes that provide

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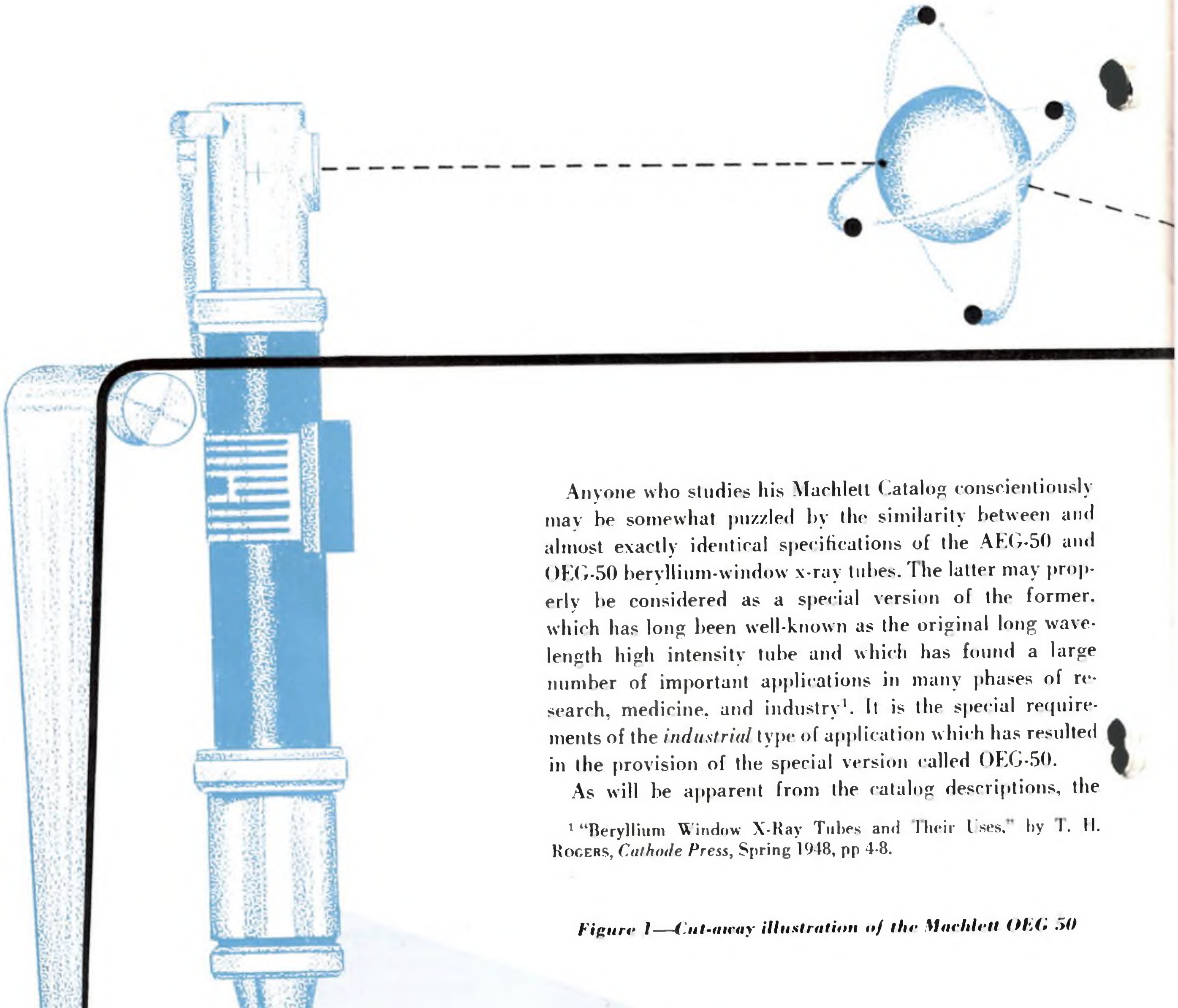


Anyone who studies his Machlett Catalog conscientiously may be somewhat puzzled by the similarity between and almost exactly identical specifications of the AEG-50 and OEG-50 beryllium-window x-ray tubes. The latter may properly be considered as a special version of the former, which has long been well-known as the original long wavelength high intensity tube and which has found a large number of important applications in many phases of research, medicine, and industry[1]. It is the special requirements of the *industrial* type of application which has resulted in the provision of the special version called OEG-50.

As will be apparent from the catalog descriptions, the

[1] "Beryllium Window X-Ray Tubes and Their Uses," by T. H. Rogers, *Cathode Press*, Spring 1948, pp 4-8.

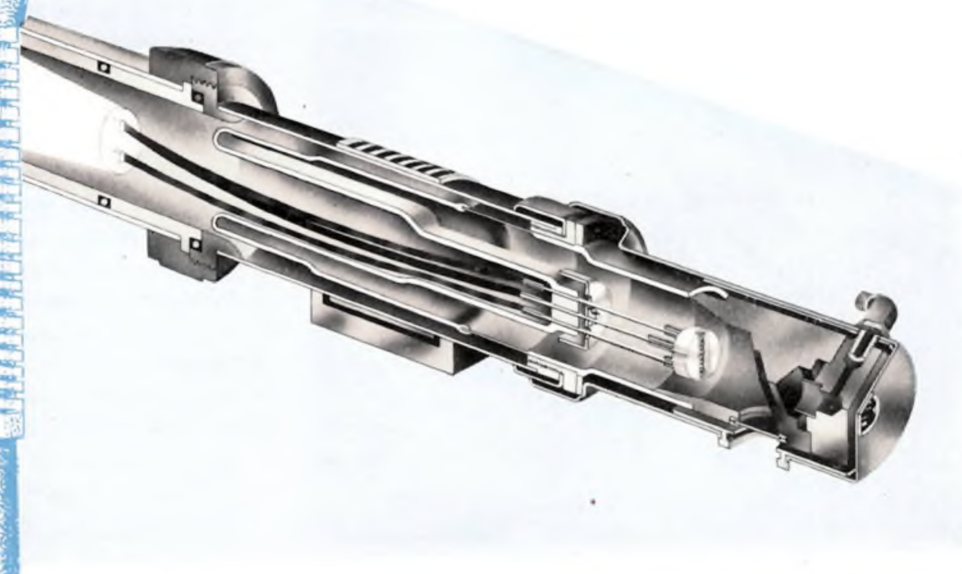
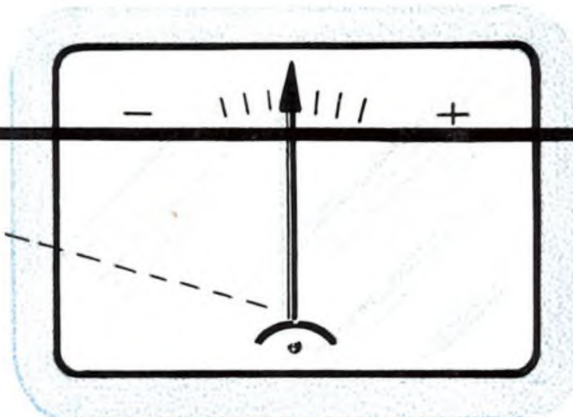


Figure 1—Cut-away illustration of the Machlett OEG 50

USE OF BE-WINDOW TUBES IN INDUSTRY POSES SPECIAL PROBLEMS — MET BY OEG-50

By T. H. ROGERS, Manager of Engineering
Machlett Laboratories, Incorporated



OEG-50 is an oil-insulated hermetically sealed unit as contrasted with the AEG-50 which, although it may be provided with a shockproof shield and cable, is not hermetically sealed and its external insulation medium is air. For most laboratory-type applications, the simple air-insulated shield is highly satisfactory and advantageous. However, many of the industrial applications for which radiation from AEG-50 tubes was desired involved atmospheric conditions under which air-insulation of high voltages became impractical. For these applications the OEG-50 was introduced.

One of the most interesting of these industrial applications is the gaging of the thickness of the tin coating on tin plate in the mills where this material is produced so as to maintain accurate control of the process as it is carried on. The preceding article, "X-Ray Tin Coating Gage," describes this application in complete detail. The equipment described employs the OEG-50 type of x-ray tube to excite the fluorescent radiation in the steel underlying the tin coating. This type of tube was selected because of the rather severe mechanical and atmospheric conditions that commonly occur in mills where the tin plate is made.

Another somewhat similar application is in the analysis of alloy steels at the mill[2], to maintain control of composition on a continuous basis. Here samples of the product are continually checked for composition by a method involving the excitation of characteristic fluorescent x-rays in the various elements entering into the alloy and measuring their respective intensities by means of a highly sensitive x-ray spectrometer employing a Geiger Counter. The tube for producing the exciting primary radiation, as employed in most such equipments, has been either the AEG-50 or OEG-50, the choice being guided by the degree to which adverse atmospheric conditions exist at the point of use.

Still another case in which the hermetically sealed unit provides outstanding advantages is in metal sheet thickness gaging[3], particularly in hot-rolling mills where the gaging is done as the hot strip steel passes through water-cooled rolls and the gaging head is actually subjected to the splash of cooling water directly. Such applications have made a hermetically sealed type of unit indeed mandatory.

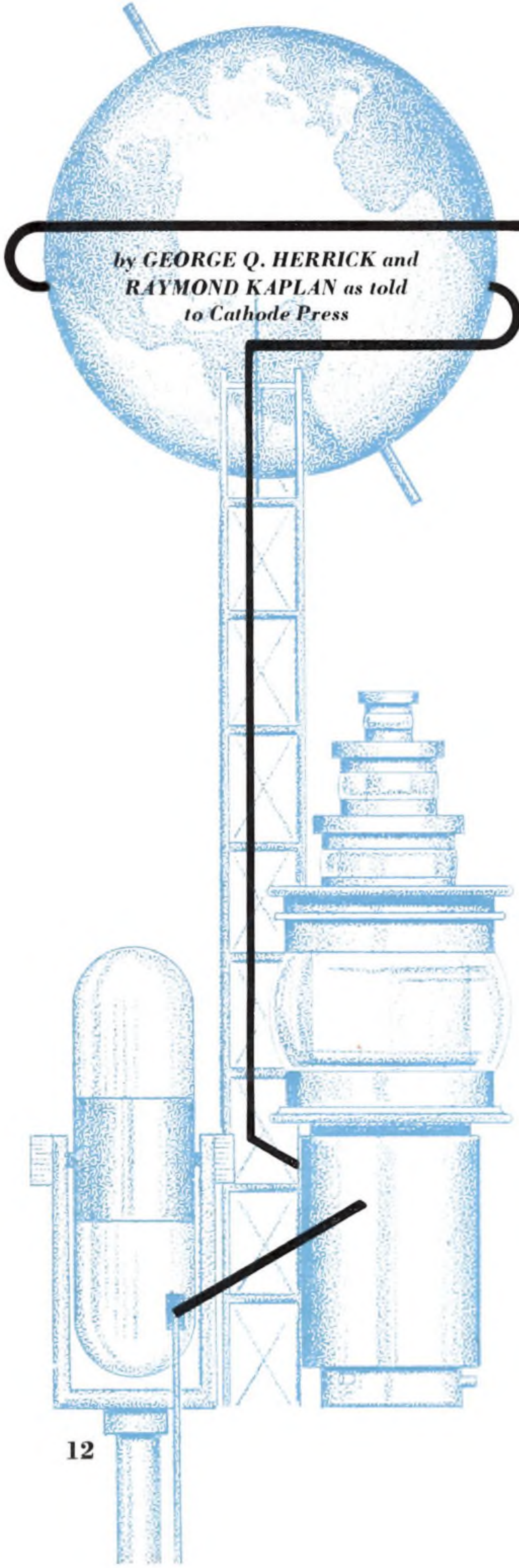
The physical arrangement of the hermetically-sealed OEG-50 unit is illustrated by the cut-away section view of Fig. 1. Note that the unobstructed beryllium window in the grounded water-cooled anode structure is not affected in any way by the oil insulation. Both high voltage and filament voltage are supplied at the cathode end of the tube through a standard shockproof cable, the terminal of which fits into a standard Machlett shockproof cable receptacle, which in turn is mounted in the oil-filled chamber surrounding the glass portion of the tube envelope. Thus the cable may be readily detached without breaking the seal to the tube unit itself.

The many advantages of the so-called "EG" design are more or less well known—short focal-spot to window distance, small space requirements for inserting tube into close proximity with the work, efficient tap water cooling for maximum loading capacity and reserve of power. All these factors have contributed to the wide adaptability of the "EG" tubes to so many applications.

[2] "X-Ray Fluorescence Analysis—Non Destructive Testing at Shop Level," by F. Behr, *Steel*, March 24, 1952, pp 70-1.

[3] "X-Ray Tubes for Thickness Gauging," by H. S. Cooke, *Cathode Press*, Summer 1950, pp 13-15.

THE VOICE OF AMERICA...



by GEORGE Q. HERRICK and RAYMOND KAPLAN as told to Cathode Press

This article further develops, within security limitations, the activities of the radio phase of the U. S. International Information Program. In the first of these articles, on this State Department sponsored work, the purposes, programs, facilities, general background and audience of the Voice of America were described (Cathode Press, Summer 1952). The current discussion enlarges on transmitting needs, equipment and methods.

GEORGE Q. HERRICK

George Q. Herrick, Chief, Facilities Branch, International Broadcasting Division, graduated from New York University as an electrical engineer. He became Assistant Chief Engineer of Radio Station WINS, New York City, in 1935. In 1937 he became Chief Engineer of WINS and, later, was Operations Chief. He has been Consulting Engineer to the Mutual Broadcasting System, to the Capitol Recording Company and to UN Radio. In May 1942 he was employed by the Department of State and became Chief of Facilities Branch, International Broadcasting Division, May 1948.

RAYMOND KAPLAN

Raymond Kaplan attended Capitol Radio Engineering Institute and American University, Washington, D. C. Amateur radio operator 1925-28, and a Marine Radio Operator 1930-36. Broadcast station engineer at Radio Stations WNBF, Binghamton, New York and WOL, Washington, D. C., 1936-42. Called to active duty in April 1942 and served as Radio Officer of the 12th Air Force. Upon return to the U. S. in 1944 he served as Radio Officer, Continental Air Force Command. Released from active duty as Major in February 1946 and rejoined the engineering staff at Radio Station WOL. Appointed Radio Engineer, Relay Base Section, Facilities Branch, Voice of America December 1948 and in June 1952, was appointed to his present position of Special Assistant to Chief, Division of Radio Facilities Plans and Development, International Broadcasting Service.

... *The development of a program of transmitting facilities and methods for reaching target areas around the world*

In Mr. Kohler's recent article[1], he described the broad policies which guide the Department of State's International Information Administration in presenting the United States to the peoples of other lands. The importance of radio as a major media in executing the Administration's responsibilities in the field of international mass communications and in the development of United States strategy to combat the psychological machinations of those whose basic aims and ideology are inimical to the United States was brought out in Mr. Kohler's discussion.

The radio phase of the U. S. International Information Program, commonly known as the "Voice of America," is the direct responsibility of the Administration's International Broadcasting Service, which provides the necessary mechanisms of facilities planning, development and operations and of program content and their transmission to the target areas in accordance with policies and priorities developed by the Administrator, other areas of the Department of State, and other agencies of the Government. Mr. Kohler also wrote of three basic technical problems confronting the organization in the development of an efficient Voice of America Program. These are:

- The vast distance between the U.S. and the target area.
- The geomagnetic disturbances encountered on the transmission paths from the U.S. to the important target areas of Europe and Asia.
- The electro-magnetic jamming activities of the Communist Bloc against the Voice of American program.

Mr. Kohler also described some of the methods and procedures by which his organization has, to a degree, overcome these obstacles. He described, in a general way, a facility expansion program aimed at an increasingly effective solution of the basic problems.

This article will, within the limits of security, describe the technical developments of these operating and planned facilities.

The development of the facility program can best be described as an evolutionary procedure with roots in the exigencies of World War II. The following is a discussion of the basic steps in this development.

[1] "This is the Voice of America," KOHLER, FOY D., *Cathode Press*, Summer 1952, p 8. Copies available upon request.

U.S. International Broadcasting Requirements of World War II

The requirements of U.S. international broadcasting operations of World War II resulted in the expansion of U.S. international broadcasting facilities from some 13 domestic short wave transmitters to 38 such transmitters, plus a short wave relay base at Honolulu, as well as the establishment of bases in Asia and Europe, most of which were turned over to occupational forces and civilian governments after the cessation of hostilities. The domestic transmitters still in operation are of various manufacture ranging in power from 50 to 200 kw. They are concentrated on the northeast coast of the United States, in the midwest around Cincinnati and on the west coast around San Francisco, Sacramento and Bakersfield.

Postwar Development of Overseas Relay Base Facilities

The operational experiences gained during the war years pointed to the need of efficient overseas relay bases to overcome the handicaps to direct broadcasting from the U.S. resulting from the disadvantageous geographical position of the United States with relation to the target areas in Europe and Asia. These handicaps were:

(a) The distances involved limit direct broadcasts to the high frequencies thus leaving untapped the vast audience potential in the more popular standard and low frequency broadcasting bands.

(b) The combined daylight/darkness paths during the best listening hours (evening in Europe and morning in the Orient) require a transmission frequency determined by the control point in the area of darkness, resulting in an operating frequency far below that which should be used to avoid high attenuation on the daylight portion of the path reducing the received fields in the target area.

(c) The effects of geomagnetic disturbances which are prevalent on the great circle transmission paths from the United States to major target areas in Europe and Asia and which decrease the reliability of program delivery.

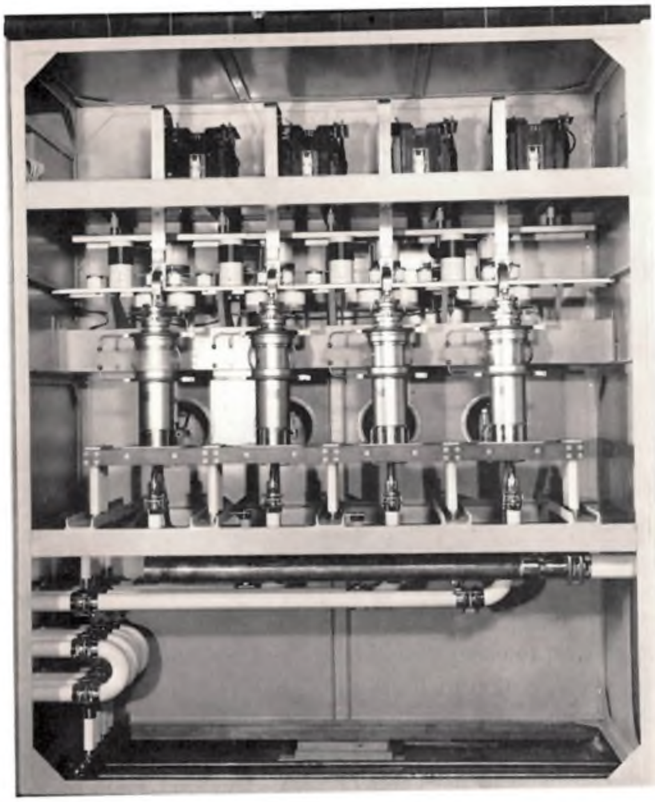


Figure 1—Right bank of Doherty 500 KW high efficiency amplifier showing four ML-5682's.

To provide a degree of relief to these problems, the Department of State, which was delegated operational responsibility for the Voice of America program upon the cessation of hostilities, was provided funds for the second step of VOA facilities development which, over a period of several years, made possible the following overseas relay base facilities:

I—MUNICH

(a) Repaired and made operable four high frequency transmitters of Czech manufacture used by the German Government during the war. Two of these transmitters are rated at 100 kw carrier power and the other two at 75 kw.

(b) Installed an antenna farm of 10 rhombics and 9 doublets to provide short wave coverage of all Europe, the Eurasian areas, of the Soviet Union, Near and Middle East, and Africa.

(c) Constructed a receiving plant, using triple diversity receiving systems[2] to receive program transmissions from the United States for rebroadcast over the Munich transmitters. The receiving plant also serves as master control and recording point.

[2] A system to reduce signal fading by using three antennas each spaced several wavelengths apart.

(d) Installed an RCA BTA-150 150 kw standard band broadcast transmitter to which was later added a duplicate unit paralleled through a combining network to obtain 300 kw of carrier power at the operating frequency 1196 kc. The antenna system uses a four element array and a switching system to provide three antenna patterns, each beamed towards a desired target area. The major lobe of Beam No. 1 provides a field of 600 MV/M/KW at one mile on a bearing of 60° true for sky wave service to Czechoslovakia, Poland and Eastern Russia.

Beam No. 2 is a modified figure 8, which provides a field of 348 MV/M/KW at one mile on a bearing of 5° true for sky wave service to the north, and a field of 348 MV/M/KW at one mile on a bearing of 105° true for sky wave service to Hungary and other Balkan countries.

Beam No. 3 is the reciprocal of Beam No. 1 laying down 600 MV/M/KW at a mile on a bearing of 240° true for sky wave service to Western Europe.

II—SALONIKA, GREECE:

(a) One WE 407A1 50 kw transmitter operating on 791 kc into directional antenna and switching arrangement to provide a reversible cardioid pattern. Beam No. 1 is directed towards the north to provide sky wave coverage of the Balkans. Beam No. 2 is directed south to cover Greece.

(b) A receiving plant, similar to the Munich installation.

(c) Two 35 kw Collins 207B-1 high frequency transmitters and rhombic antennas beamed to cover the Balkans, Central Europe and Western USSR.

III—TANGIER, MOROCCO:

This plant is designed primarily as the "Voice's" main gateway to Europe. Experience has shown that the transmission paths from the East Coast of the United States to Tangier are much more favorable than the more northerly direct paths to North and Central Europe. At the same time, the transmission paths from Tangier to the main target areas of Europe, the Near and Middle East and Western Asia, are excellent and provide reliable program feeds to other European relay bases and good direct short wave service to the target areas. The major facilities of the Tangier plant are:

(a) Four 100 kw General Electric Type 100-C high frequency transmitters; two 50 kw RCA 50 SW high frequency transmitters; four 35 kw Collins 207-B1 high frequency transmitters.

(b) An antenna farm of 24 rhombic antennas on appropriate beams to the desired target areas.

(c) A receiving plant employing triple diversity receiving systems, capable of exalted carrier[3] and single side band selection.

(d) Diesel electric power machinery at the transmitter and receiving plants, providing the necessary power for full operation of the entire relay base.

In the Pacific Area a relay base was constructed in the Philippines near Manila and this, together with the Honolulu relay base, provided a retransmission service to the Orient.

IV—MANILA

(a) A Western Electric 407A1 50 kw transmitter operating on 920 kc into a six element DA providing three beams, 335° for sky wave coverage toward China, 155° for Philippine service and 275° for sky wave service to Southeast Asia.

(b) Two RCA 50 SW 50 kw high frequency transmitters and a 7½ kw auxiliary high frequency unit.

(c) An antenna field of 10 rhombic antennas for short wave service to Japan and the Asiatic mainland.

(d) A receiving plant similar to the Munich and Salonika installations.

(e) Diesel electric plants to provide power for full operation of the relay base.

V—HONOLULU:

(a) Two GE 100-C 100 kw high frequency transmitters.

(b) An antenna field of nine rhombic antennas beamed to the Orient.

(c) A receiving station using triple diversity reception.

The overseas plants described above supplemented the 38 domestic high frequency transmitters and could be considered as the second step of the Voice of America's facilities expansion program.

Present Facilities Expansion Program

The present, or third step in the "Voice's" facilities expansion program which is still under way, was embarked upon by the Department of State when it became apparent that what might be termed pre-war "normalcy" would not recur, at least in the foreseeable future. Since the world appeared to be moving towards two distinct ideological poles with the United States assuming leadership of one and the Soviet Union the other, it became obvious that the United States must not only maintain, but augment, its most effective means of mass communications, its Voice of America's international broadcasting operations. Added impetus to the program was given by the Congress on January 27, 1948 when it passed Public Law 402, the U. S. International and Educational Exchange Act.

The inception of the Russian jamming effort late in 1948 and its progressive increase to its present intensity added further impetus to the program and at the same time dictated the need for adequate research and boldness in planning and development of facilities. Development proceeded along two primary lines:

(a) The improvement of the operating facilities.

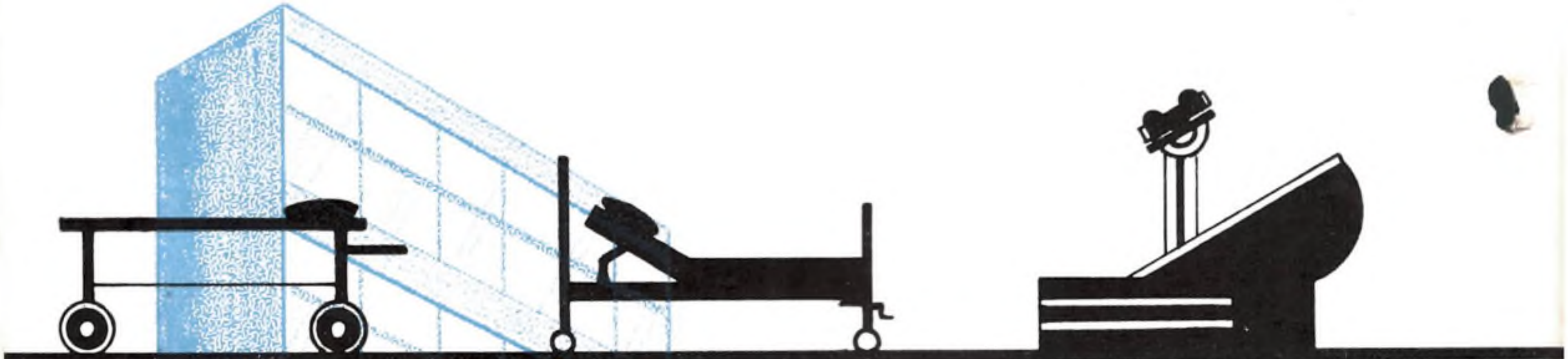
(b) The establishment of new facilities in a basic plan of action called the "Ring Plan" which, in itself, is broken down into three phases.

I—Basic "Ring" which provides for the establishment of extremely high powered relay base facilities which, consistent with security and political considerations, are sited at locations where it is possible to take maximum advantage of radio propagation conditions in the various broadcast bands utilized by receivers in selected target areas and, at the same time, provide the maximum strain to the jamming mechanisms. Each such facility is self-contained as to power source, is capable of program origination or of acting as a relay base performing instantaneous or delayed retransmission. It provides multiple antenna patterns which both complement and supplement patterns of other facilities

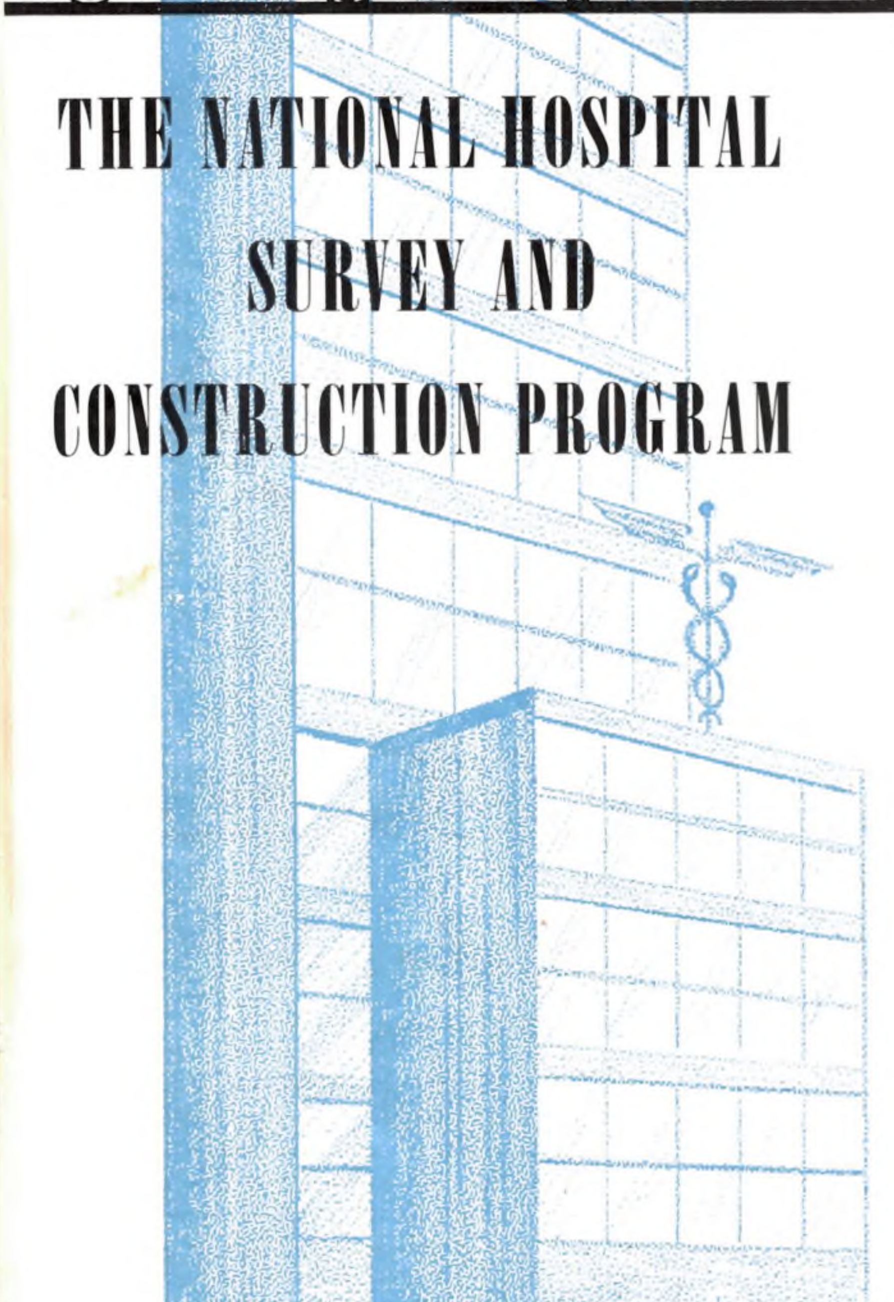
Continued on page 30

Figure 2—Three unit assembly associated with each 500 KW transmitter; (left) 15 KV rectifier tube assembly, (center) 3 bias rectifiers, (right) audio and RF driver.

[3] Exalted carrier operation is a process by which a receiver separates a carrier from its side bands, exalts or amplifies the carrier to constant and higher amplitudes then re-combines the carrier in proper phase with one or both side bands. This process reduces distortion due to selective fading of carrier and/or side bands which occur when side band to carrier signal ratios reach values greater than those required for 100% modulation. Exalted carrier reception, in effect, therefore, limits the value of modulation in the received signal to the same or lower value at the receiver to that developed in the transmitting system, minimizing the effect of ionospheric selective fading in the transmission path.



THE NATIONAL HOSPITAL SURVEY AND CONSTRUCTION PROGRAM



Due to world-wide instability, it is extremely difficult to forecast with a fair degree of accuracy the trend of any industry. Cathode Press, accordingly, makes no effort to prophesy for the x-ray industry, but does rather attempt, in the following article, to bring to its readers information for their own evaluation, which might be a basis for such a forecast.

It is felt that those industries serving the medical profession enjoy a rather enviable position when compared to industry as a whole. This optomistic opinion is based on the following factors:

Our country has reached a state of development where individuals and government alike recognize the importance of our national health. This makes it logical to assume that, in a nation as rich in natural resources and general wealth as ours, the government would sponsor national public health programs were private and state organizations unable to cope with matters during a possible period of depression.

The greater percentage of even present x-ray tube and equipment production is for direct civilian consumption, while that of many other industries goes into our national defense program.

While government buying of x-ray apparatus for defense is high, that of other governmental agencies is moderate and may be expected to increase as indicated by Dr. Cronin's report on "The National Hospital Survey and Construction Program."

Briefly, government buying can be broken down into four broad classifications and a reasonable estimate of the potential of each can be made. Government buying for defense, army field units, etc.,—which may be expected to decline as ample stock piles are amassed; U. S. Public Health,—which has not been as high as expected and should increase under the Hill-Burton Act; Veterans Administration,—which is not likely to decline and may even increase as Korean casualties continue; and Federal Aid to state and municipal health programs—which should also increase under the Hill-Burton Act.

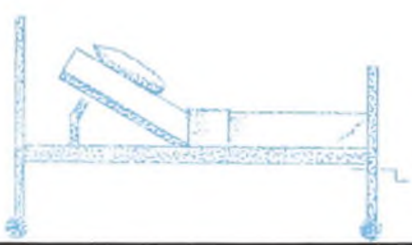
While the following article makes no direct reference to x-ray tubes and equipment, it must be assumed that as national health facilities expand so must the need for the goods and services of this industry. An indication of this may be had from an examination of the departmental equipment costs for general hospitals prepared in the Hospital Purchasing File 29th, 1952, printed by the Division of Hospital Facilities, United States Public Health Service. Again let us say that this is not a forecast of good times to come, but only an exposition of facts for your own interpretation.

JOHN W. CRONIN, M. D.

Dr. Cronin graduated from Miami University, Oxford, Ohio in 1928, University of Cincinnati, College of Medicine in 1932; and had post-graduate training at the University of Colorado. Entered U. S. Public Health Service in 1932; assignments included U. S. Marine Hospital, Seattle, Wash., U. S. Public Health Hospital, Lexington, Ky., U. S. Penitentiaries at Leavenworth and Fort Leavenworth, Kan., the Federal Reformatory, El Reno, Okla., and U. S. Public Health Hospital, Sheepshead Bay, Bklyn. Transferred in 1944 to Public Health Service Headquarters, Washington, D. C. as Ass't Chief, Division of Hospitals. Chief, Division of Federal Employee Health in 1946 and in 1949. Chief, Division of Hospital Facilities which administers the Hospital Survey and Construction (Hill-Burton) Program. Fellow of the Amer. Psychiatric Assn., Amer. College of Surgeons, Amer. Public Health Assn., Amer. Medical Assn. and a Diplomate of the Amer. Board of Preventive Medicine and Public Health.

by JOHN W. CRONIN, Chief, Division of Hospital Facilities, Public Health Service, Federal Security Agency

It is prudent, in times such as these, to take stock of our national resources. One of the important resources of our Nation is its hospitals and related health facilities. Their impact on our industrial welfare and other phases of our total economy is far-reaching.

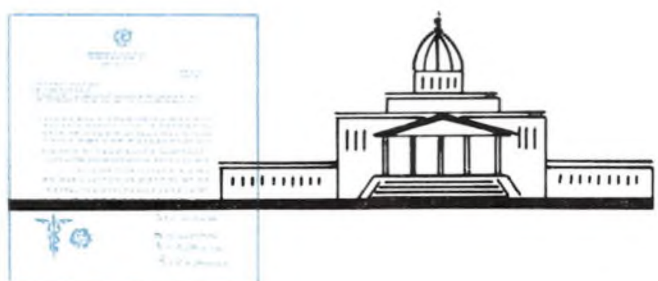


The Nation's Supply of Acceptable Hospital Beds

Under the provision of the Hospital Survey and Construction Act (Public Law 725, 79th Congress), popularly known as the Hill-Burton Program, each State prepares and submits for approval to the Surgeon General of the Public Health Service a State Plan for hospital and health facility construction. The Original survey made by the States indicated that the Nation had 868,000 existing acceptable hospital beds with a deficiency of over 900,000 beds. The current State Plan revisions indicate that our total needs today in hospital beds approach the 2 million mark.

There are available in this country approximately 1,018,000 beds acceptable for use; our deficiency is nearly 882,000 beds. Currently, therefore, approximately 54 percent of the Nation's estimated total bed needs are met by the present supply of acceptable hospital beds exclusive of those in Federal hospitals such as Veterans, Armed Forces, Public Health Service and Indian Service.

Since construction was begun five years ago under the Hill-Burton Program there has been considerable stimulus to hospital construction. A total net increase of about 150,000 acceptable hospital beds has occurred since 1947. The construction of new beds has proceeded only slightly ahead of needs due to population growth and rate of obsolescence. Furthermore, this net increase of 150,000 acceptable beds has reduced the bed deficiency only by something over 30,000 beds. Although essential progress in constructing hospital beds has been made during the last five years, the Nation is still confronted with a tremendous bed deficiency, especially in meeting the needs of patients with mental and chronic diseases.



Aims of the Hill-Burton Act

The major purpose of the Hospital Survey and Construction Act is to assist the States to provide "adequate hospital, clinic, and similar services to all their people." This was to be accomplished in two phases, namely, the survey and planning phase and the construction phase of assistance to the States in building hospitals, public health centers and related health facilities. Since it was recognized at the beginning that an inventory and survey of existing hospital facilities was a prerequisite to sound planning; the law made it mandatory that this be done prior to the allotment to any State of Federal funds for construction. The Nation would,

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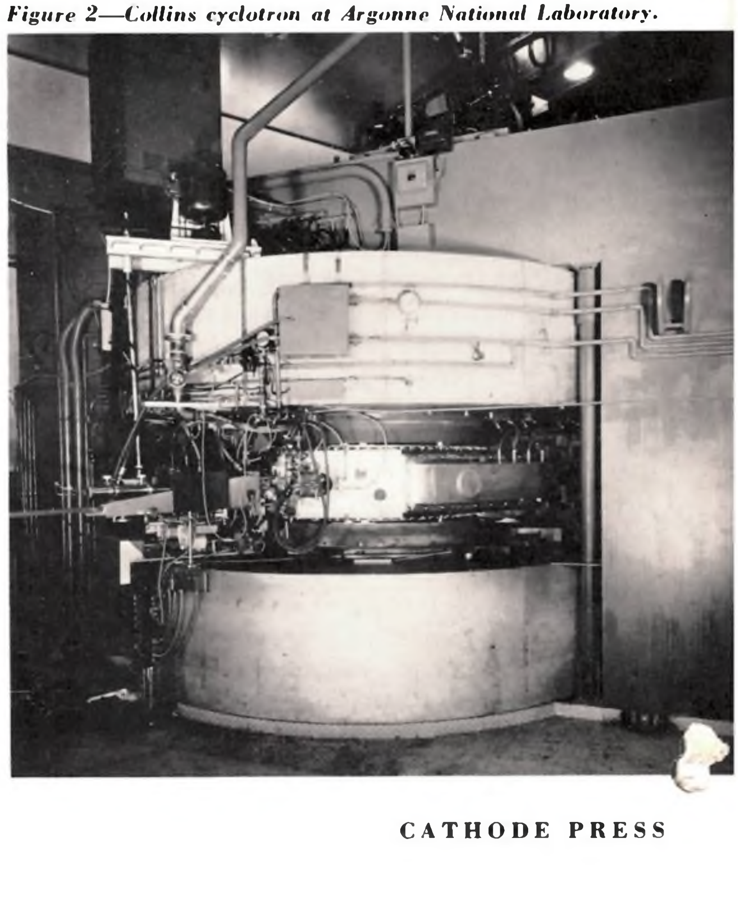
COLLINS CYCLOTRON

The highly publicized by-products of nuclear fission have made the names of such machines as cyclotrons almost as familiar to the uninitiated as their popular term: atom smashers. Since the war, these and other nuclear research machines—technically known as particle accelerators—have become a product of industry.

Most of the particle accelerators were the brainchildren of college and university staffs who custom-made the high energy machines, frequently by themselves, on the campus. It was not until the era of atomic research that climaxed at Alamogordo, however, that the apparatus became of mature age, and there began a transformation of the high energy machines from an academic luxury for university physicists to a useful tool for applied science and industry. Tracer experiments with induced radioactivities made by atomic bombardment with the cyclotron provide a method of labeling atoms by making them radioactive for detection, in much the same way a dentist uses an x-ray to detect cavities by the shadows they make on the x-ray film. Once a substance has been made radioactive, it can be traced

Figure 1—Placing of the 67-ton top member on the 250-ton magnet of the Collins cyclotron.

Figure 2—Collins cyclotron at Argonne National Laboratory.



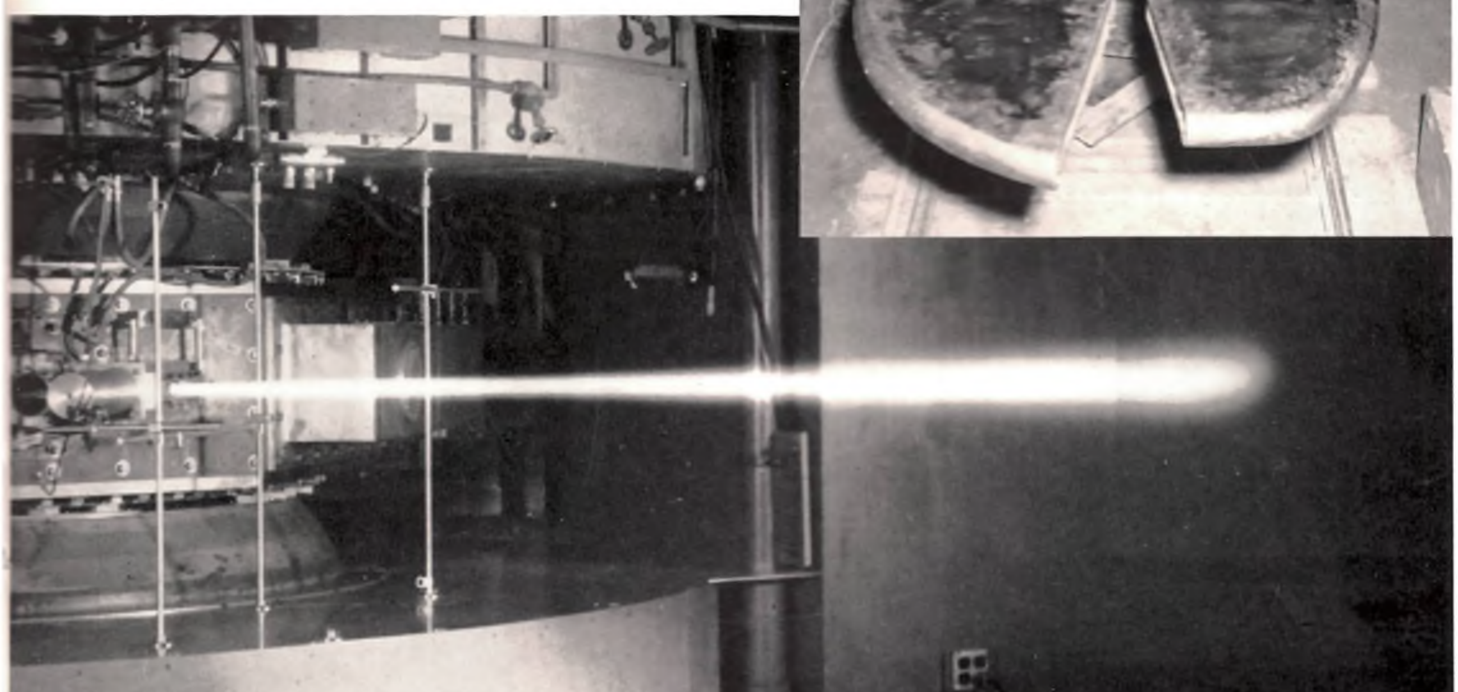
Reprinted from Collins Signal
Summer 1952

and identified with positive accuracy. All chemicals bombarded in the cyclotron become radioactive although some have too short a lifetime to be useful. Many, however, can be made into a cheap and plentiful substitute for the costly and scarce element radium. In the field of medicine, the high energy machines hold great prospects for cancer therapy. Like all living cells, cancer may be destroyed by radiation. In such treatment, the subject is placed before the particle accelerator or near to chemicals that have been exposed to it and given small doses of radiation that are hoped to cure even the most deep-seated cancer.

Development of one of the particle accelerators, the cyclotron, began in the early 1930's at the University of California under the inspirational direction of Prof. Ernest O. Lawrence. During the following years, other laboratories built such machines, at first largely designed by graduates

Figure 4 — The two semi-circular hollow electrodes called "dees" because of their shape. Radio-frequency voltage between the dees accelerates the ions into the interior of the dee which at that moment is negative.

Figure 3—200 microamperes of 21-million volt deuterons emerging from the cyclotron. The heat of the 4.5 KW of power being dissipated decreases the density of air, extending stream 10.5 ft. instead of the 7.5 ft. it would if air was not heated.



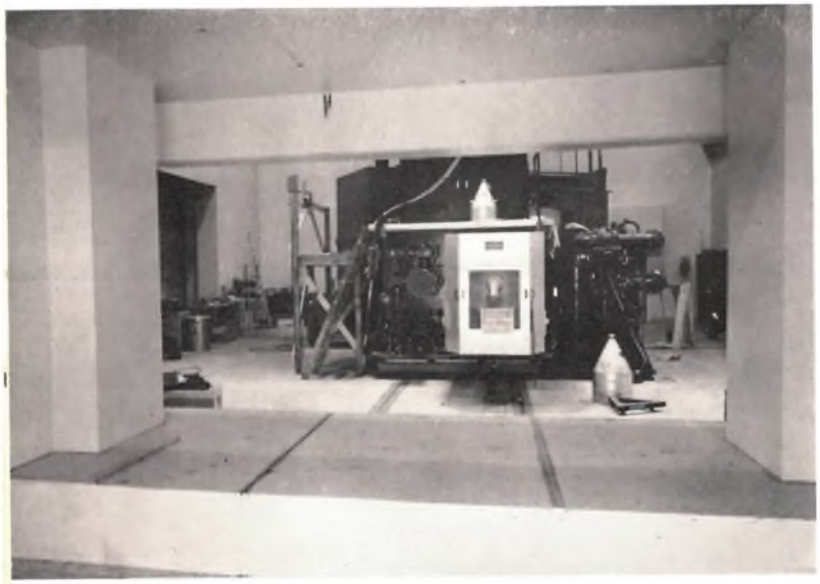
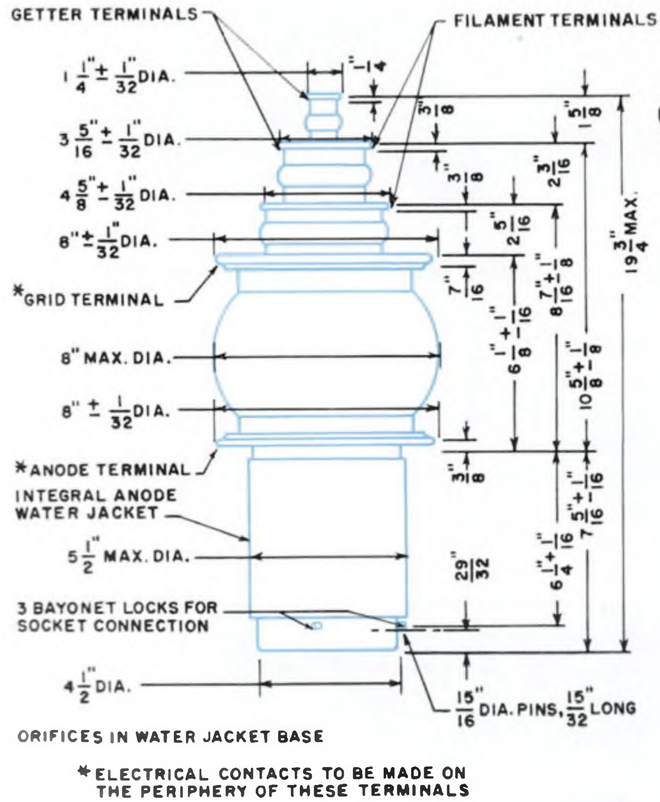


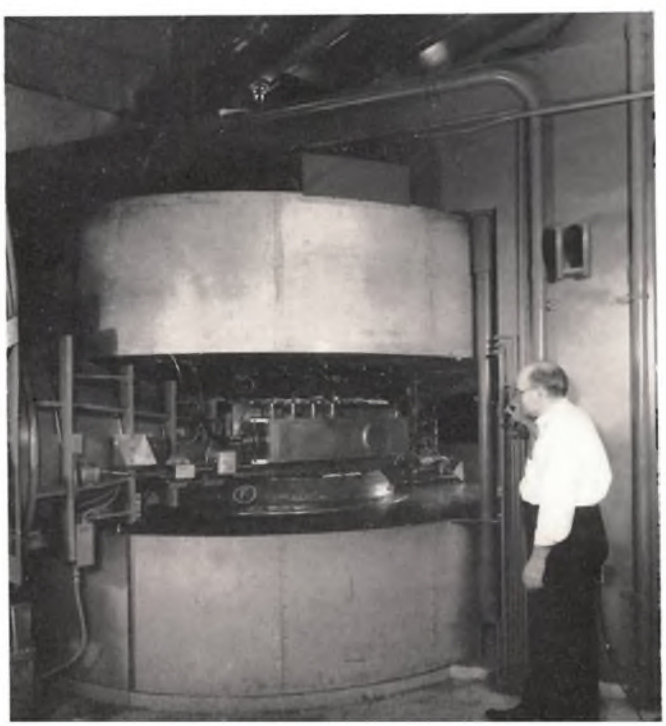
Figure 5—Concrete elevator door of the cyclotron vault which weighs 100 tons. Entire building which houses the particle accelerator was constructed around the machine after it was erected.



of the Berkeley school. A healthy exchange of ideas and designs accelerated the machine's progress and made the modern cyclotron a composite product of many laboratories and individuals.

In 1947, under contract with the Atomic Energy Commission, the first commercially-built cyclotron began as a Collins project. For the first time, construction of a cyclotron was put on a production budget and certain standards of performance were guaranteed. This accelerator was delivered to AEC's Brookhaven National Laboratory on Long Island, where it is now serving pure science. A second cyclotron, very similar to that made for Brookhaven, was

Figure 6—Another view of Collins cyclotron at Argonne National Laboratory.



An essential part of the cyclotron is the electron tube complement which delivers a radio-frequency voltage to the "dees" to accelerate the ions within them. In the Collins cyclotron at the Argonne National Laboratory, this is accomplished by a pair of ML-5681's in push-pull, driven by two ML-356's oscillating at 11 Mc.

The good high-frequency characteristics of the ML-5681, with its high perveance, high transconductance, and relatively low interelectrode capacitances, have been shown to be highly desirable for particle accelerator service. The heavy-wall anode, integral anode water jacket, and quick-change baynot-lock water coupling socket contribute to the usefulness of this compact, high-power tube. Its all-ring-seal construction and coaxial terminal design add to its ruggedness and adaptability to resonant cavity circuitry, used in some cyclotron applications.

ML-5681
GENERAL CHARACTERISTICS

Electrical

Filament Voltage	12.0 volts
Filament Current at 12.0 volts	220 amps
Filament Starting Current, maximum	550 amps
Filament Cold Resistance	0.0062 ohm
Amplification Factor	25
Direct Interelectrode Capacitances	
Grid-Plate	61 uuf
Grid-Filament	76 uuf
Plate-Filament	2.0 uuf

ML-5681 — ARGONNE CYCLOTRON

Mechanical

Mounting Position	Vertical, Anode Down
Type of Cooling	Water and Forced-Air
Maximum Water Pressure	75 psi
Maximum Outlet Water Temperature	70°C
Air Flow on Seals, approximate	250 cfm
Maximum Glass Temperature	165°C
Net Weight, approximate	43 lbs

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

R-F Power Amplifier and Oscillator— Class C Telegraphy

(Key-down conditions per tube without amplitude modulation.)*

Maximum Ratings, Absolute Values

D-C Plate Voltage	9000	15000 volts
D-C Grid Voltage	—3200	—3200 volts
D-C Plate Current	12	12 amps
D-C Grid Current	2.0	2.0 amps
Plate Input	100	150 kW
Plate Dissipation	75	75 kW
Frequency	110	30 Mc

Typical Operation

Power Amplifier and Oscillator, Cathode-Return Circuit—30 Mc

D-C Plate Voltage	8000	12000	14000 volts
D-C Grid Voltage	—800	—1200	—1500 volts
Peak R-F Grid Voltage	1500	1950	2330 volts
Peak R-F Plate Voltage	6500	10000	12000 volts
D-C Plate Current	9.0	9.9	10.5 amps
D-C Grid Current	1.4	1.2	1.3 amps
Driving Power, approx	2.0	2.2	3.0 kW
Power Output, approx	52	90	115 kW

Power Amplifier, Grid-Return Circuit—110 Mc

D-C Plate Voltage	6000	9000 volts
D-C Grid Voltage	—600	—750 volts
Peak R-F Driving Voltage	1150	1350 volts
Peak R-F Plate Voltage	4700	7500 volts
D-C Plate Current	6.7	8.0 amps
D-C Grid Current	1.0	1.0 amps
Driving Power, approx	8.0	10.2 kW
Power Output, approx.†	35	62 kW

*Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

†Includes power transferred from driver stage.

Figure 7—Control room from which the cyclotron is operated. The cyclotron is housed in a vault with concrete walls seven feet thick to protect the operators from lethal quantities of nuclear particles.

completed in July by Collins for the Argonne National Laboratory* near Chicago.

In principle, the cyclotron operation is not difficult to understand. Atomic particles are injected into the machine's center and are accelerated by electric forces and steered by a large magnet into a spiral path which brings them to the target area. The specimen target, being bombarded by particles, is made radioactive. In other words, the cyclotron gives high speeds to the particles and uses them as projectiles for nuclear distintegration. And it does this without the use of relatively high voltages.

*Operated for the AEC by the University of Chicago.

Figure 8—Seven foot thick concrete door between the control room and the vault.

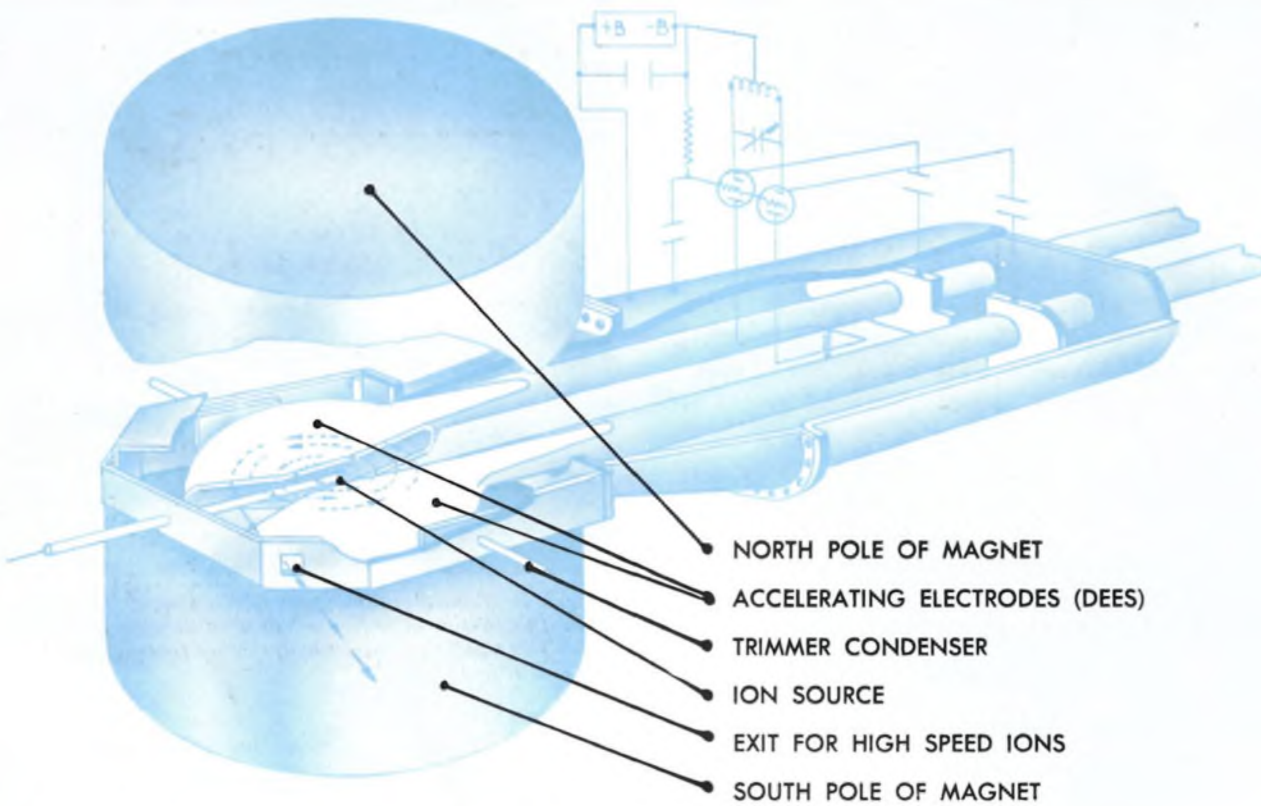
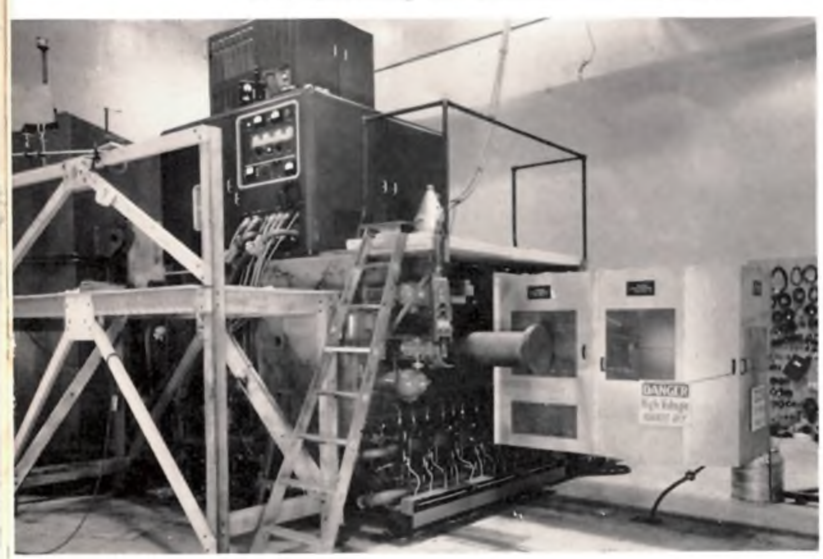


Figure 9—Cutaway drawing showing dees and schematic of the electrical system of the cyclotron.

Figure 10—Cubicle boxes on top of the cyclotron containing the oscillator and amplifier.



The Collins cyclotron has a 60-inch vacuum chamber mounted between the pole pieces of a 250-ton magnet. Inside the tank are two semicircular hollow electrodes called "dees" because of their shape. These form the capacitive elements of a resonant circuit driven by an oscillator so that the dees alternate in voltage at a frequency of 11 megacycles per second. The magnet is operated by direct current at 375 amperes producing a field of 15,000 gauss (a unit of magnetic field strength).

Acceleration begins by injecting a gas into an arc source located between the two dees. The gas contains particles called deuterons, which are the nuclei of heavy hydrogen atoms. The electrical arc ionizes the hydrogen nucleus so it can be accelerated by the radiofrequency electric field between the two dees. The magnet curves the path of the particles into a semi-circle.

If the magnetic field and the oscillator frequency are each adjusted to a critical value, the particle will return to the gap between the dees just one half cycle later, when the voltage between the dees has reversed, so that the particle receives a second acceleration. By a happy circumstance, the time for a half revolution is independent of the size of the circle, so that with a fixed frequency oscillator, the particle curves round and round, gaining energy every time it

Figure 11—Two of the first experimental cyclotron vacuum chambers. Dees were formed by silver plating insides of flattened glass flasks.

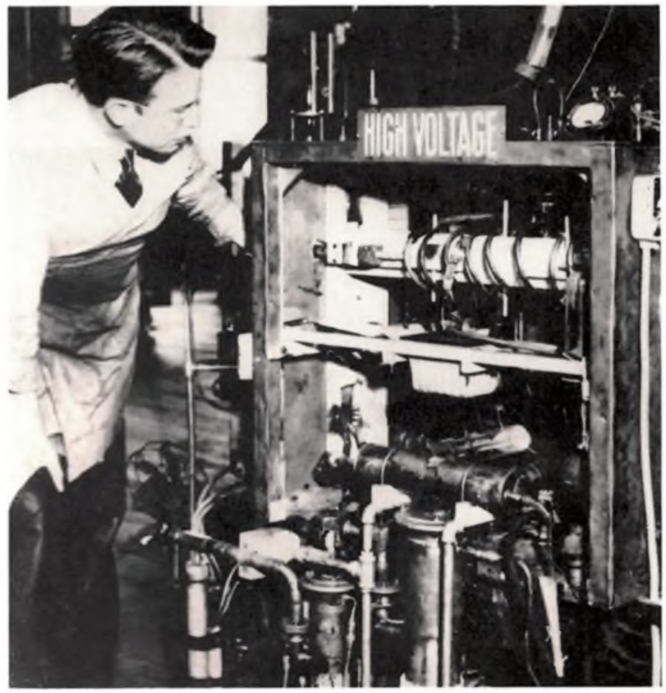


Figure 12—Development of the cyclotron began about 1930 under the direction of Prof. E. O. Lawrence of the Univ. of California physics dept. Prof. Lawrence is shown with the first 5-million volt cyclotron.

crosses the gap, making successively larger half circles at corresponding greater speeds. The particles gradually spiral outward, attaining a final energy equivalent to that gained in each crossing of the gap times the number of such crossings. For a final energy such as that which would be obtained if 21 million volts had been used once, the particles are going at a speed of 28,000 miles per second.

At such speeds, the positively charged projectile is able to overcome the repulsive force that exists between it and the positively charged nucleus of the target atom, and hence to get so close to the target atom that it is within the range of the attractive forces that exist at nuclear dimensions. In this way the target atom's structure is altered by the addition of the projectile, so that an alchemical transmutation has been effected. In many cases, the resulting new atom is energetically unstable, and achieves stability, at a later time, by ejecting from itself an electron and a gamma ray. These delayed radiations constitute artificial radioactivity, and it is one of the prime purposes of the cyclotron to produce radioactivity in any chemical that may be used as a target material.

One of the outstanding features of the Collins cyclotron is the large number of high speed particles that it produces—about a million billion per second. Expressed in terms of conventional current units (for each particle carries a charge of electricity) the output is 200 millionths of an ampere, which is a lot, as cyclotrons go. At 21 million volts, the power in the stream of projectiles is 4.2 kilowatts, so

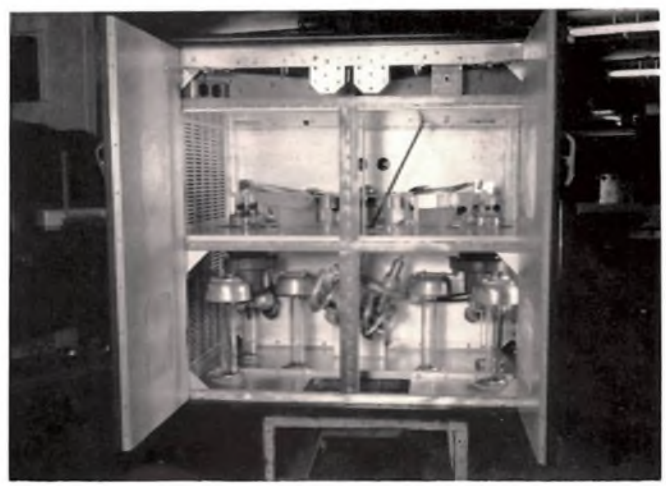


Figure 13—Oscillator section of the cyclotron showing two ML-356 tubes.

that it is necessary for the target chemicals to be water cooled or they will melt.

Incidental to the production of radioactive atoms, there is released, in almost every case, one or more nuclear particles called neutrons; these particles have become known to the man in the street in recent years. Since their effect in great quantities is lethal, the cyclotron is located in a vault with concrete walls seven feet thick that serve as protective shields to the operators who run the machine by remote control.

The ML-6256 . . .

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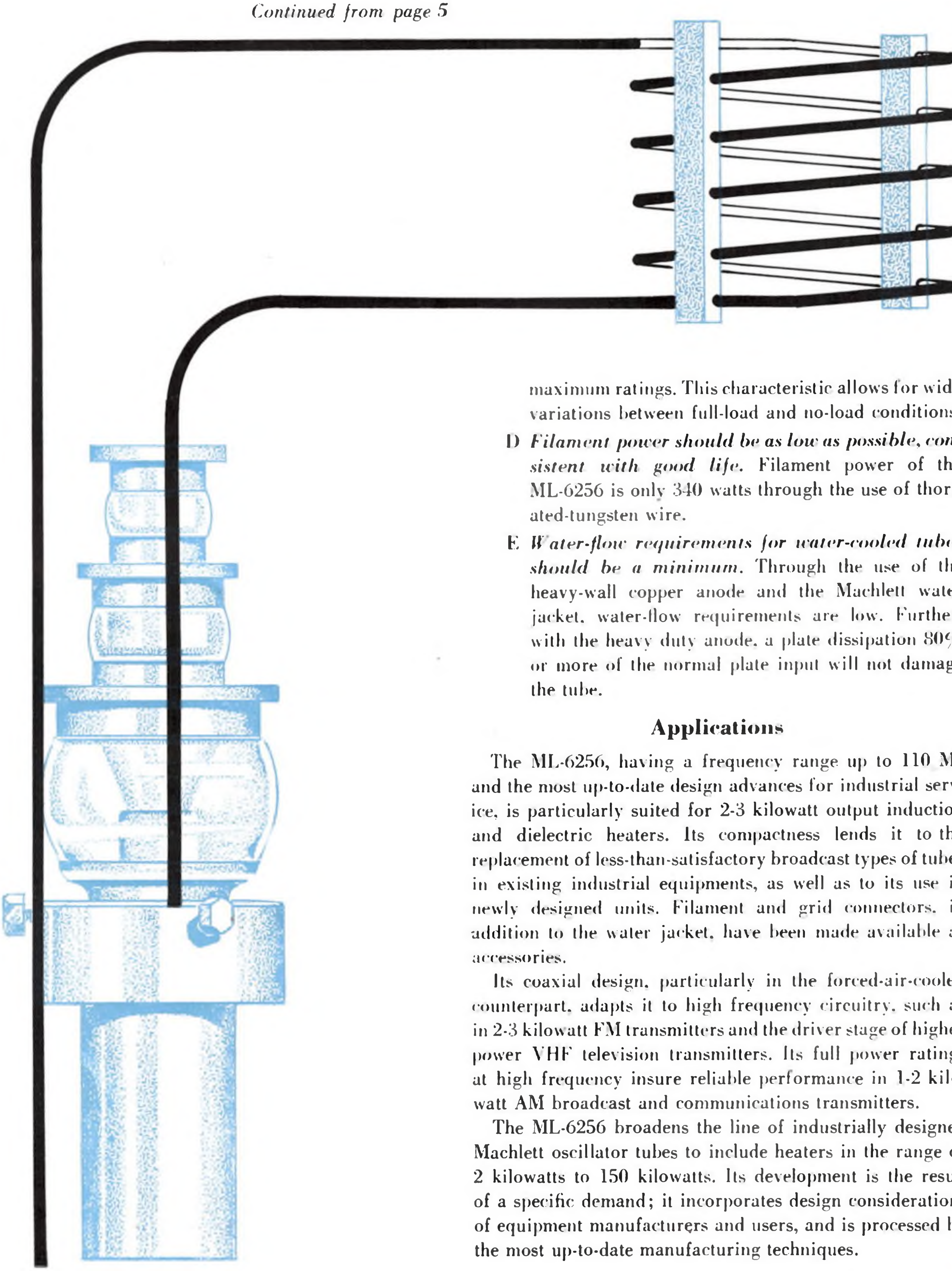


maximum ratings. This characteristic allows for wide variations between full-load and no-load conditions.

D *Filament power should be as low as possible, consistent with good life.* Filament power of the ML-6256 is only 340 watts through the use of thoriated-tungsten wire.

E *Water-flow requirements for water-cooled tubes should be a minimum.* Through the use of the heavy-wall copper anode and the Machlett water jacket, water-flow requirements are low. Further, with the heavy duty anode, a plate dissipation 80% or more of the normal plate input will not damage the tube.

Applications

The ML-6256, having a frequency range up to 110 Mc and the most up-to-date design advances for industrial service, is particularly suited for 2-3 kilowatt output induction and dielectric heaters. Its compactness lends it to the replacement of less-than-satisfactory broadcast types of tubes in existing industrial equipments, as well as to its use in newly designed units. Filament and grid connectors, in addition to the water jacket, have been made available as accessories.

Its coaxial design, particularly in the forced-air-cooled counterpart, adapts it to high frequency circuitry, such as in 2-3 kilowatt FM transmitters and the driver stage of higher power VHF television transmitters. Its full power ratings at high frequency insure reliable performance in 1-2 kilowatt AM broadcast and communications transmitters.

The ML-6256 broadens the line of industrially designed Machlett oscillator tubes to include heaters in the range of 2 kilowatts to 150 kilowatts. Its development is the result of a specific demand; it incorporates design considerations of equipment manufacturers and users, and is processed by the most up-to-date manufacturing techniques.

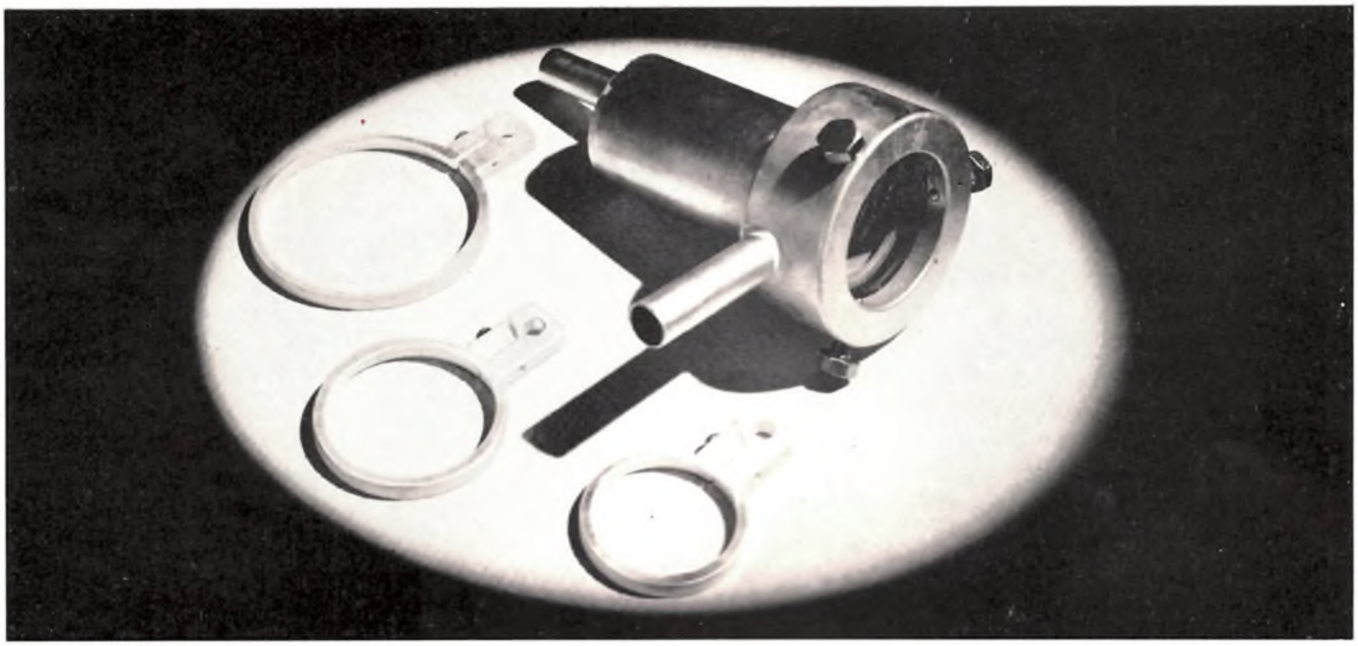


Figure 6—ML-6256 accessories.

- *water jacket*
- *filament connector (small)*
- *filament connector (large)*
- *grid connector*

ML-6256 Tentative General Characteristics

ELECTRICAL

Filament Voltage	12.6 volts
Filament Current	27 amps
Filament Starting Current, Maximum	65 amps
Filament Cold Resistance	.0053 ohm
Amplification Factor	21
Direct Interelectrode Capacitances	
Grid-Plate	20 uuf
Grid-Filament	22 uuf
Plate-Filament	0.7 uuf

MECHANICAL

Mounting Position—Vertical, anode down	
Type of Cooling	Water
Anode Water Flow Required	3 gpm
Water Pressure, maximum	80 psi
Outlet Water Temperature, maximum	70 °C
Glass Temperatures, maximum	160 °C
Net Weight, approximate	1.6 lb.

Maximum Ratings and Typical Operating Conditions

R-F Power Amplifier and Oscillator—Class C

Carrier conditions per tube without amplitude modulation

Maximum Ratings, Absolute Values

D-C Plate Voltage	5500 volts
D-C Grid Voltage	−1500 volts
D-C Plate Current	1.5 amps
D-C Grid Current	.22 amp
Plate Input	7 kW
Plate Dissipation	5 kW

Typical Operation, R-F Oscillator

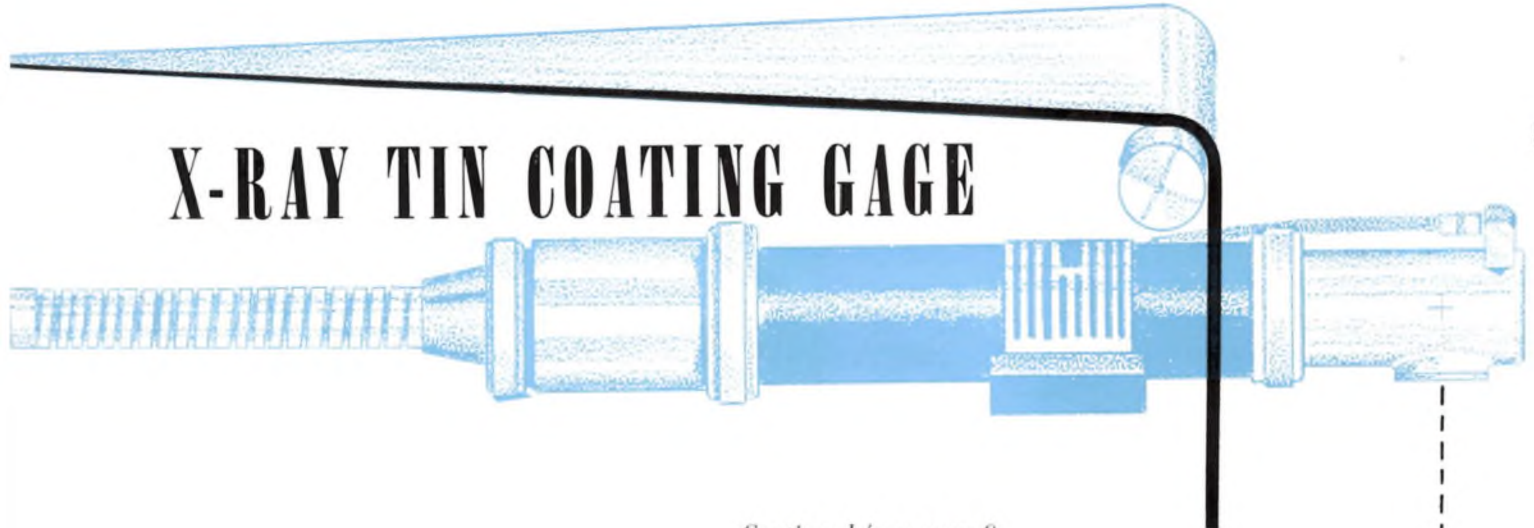
D-C Plate Voltage	4000	5000 volts
D-C Grid Voltage	−400	−500 volts
Peak R-F Grid Voltage	630	750 volts
Peak R-F Plate Voltage	2900	3600 volts
D-C Plate Current	1.1	1.3 amps
D-C Grid Current	75	75 mA
Power Output, approximate	2.8	4.2 kW

R-F Amplifier, Grid-Return Circuit

D-C Plate Voltage	4000 volts
D-C Grid Voltage	−500 volts
Peak R-F Driving Voltage	775 volts
Peak R-F Plate Voltage	3400 volts
D-C Plate Current	1.1 amps
D-C Grid Current	165 mA
Driving Power, approximate	800 watts
Power Output, approximate*	3.6 kW

*Includes power transferred from driver stage.

X-RAY TIN COATING GAGE



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an easily read indication of the count accumulated. This printing counter has the advantage that there are no relays or other mechanical parts required to move at high speeds. Since the counting is actually done electronically, the upper limit of counting speed is in fact the resolving time of the circuits, which in this case is 5 microsec. This means that two pulses spaced 5 microsec apart will actually be counted as two separate counts.

The third component of the tin-coating thickness gage is the large table used for supporting and positioning tin-plate sheets for measurement. It was originally thought that a table could be designed which would position the desired test area between the measuring heads automatically or semiautomatically, in order to simplify and speed up the measurement of a tin-plate sheet. This was believed to be feasible because there is only one area size and only two patterns of measurement employed in routine testing of tin-coating thickness. The first pattern consists of three areas located on a diagonal of the sheet, with one at the center of the sheet and the other two near the corners of the sheet. The second pattern consists of nine areas, arranged in rows of three across the width of the sheet at the two ends and the middle. In each of these patterns the exact locations are customarily prescribed with reference to the edges of the sheet. However, the large variety of sheet sizes produced commercially makes the design of such a table too complex to be economically practicable. Accordingly, the table currently being used consists of a simple angle-iron frame with a micarta or formica top upon which the sheets are positioned manually.

In any coating thickness gage based on the x-ray fluorescence principle, it is essential that the primary x-ray source be capable of exciting strong x-ray fluorescence in the base metal without exciting fluorescence, in the coating. It is obvious that if both the coating and the base metal were to fluoresce, the amount of radiation emerging from the sur-

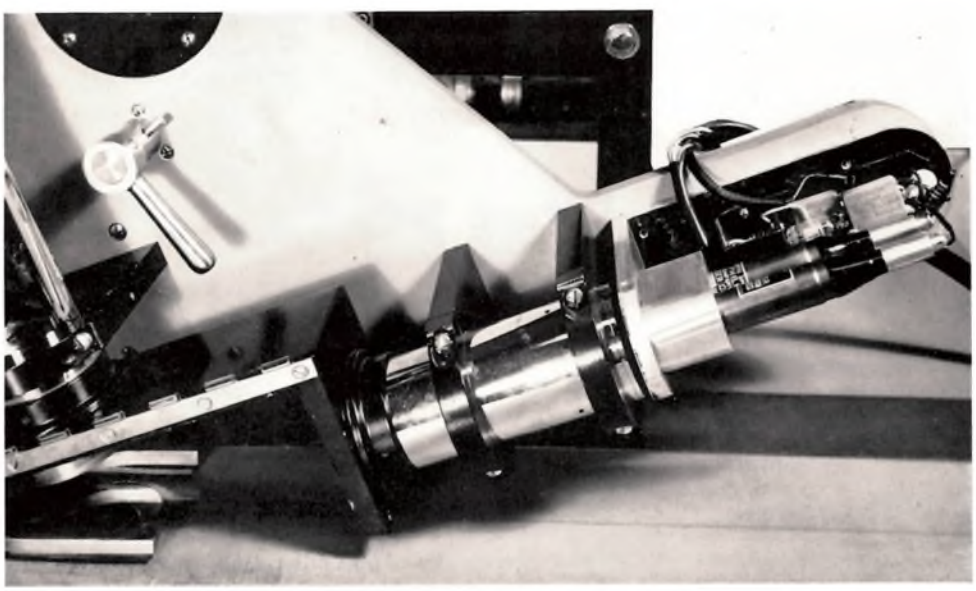

Figure 6—Shield is removed to show the pair of Geiger tubes mounted directly behind the collimator to measure intensity of secondary radiation.

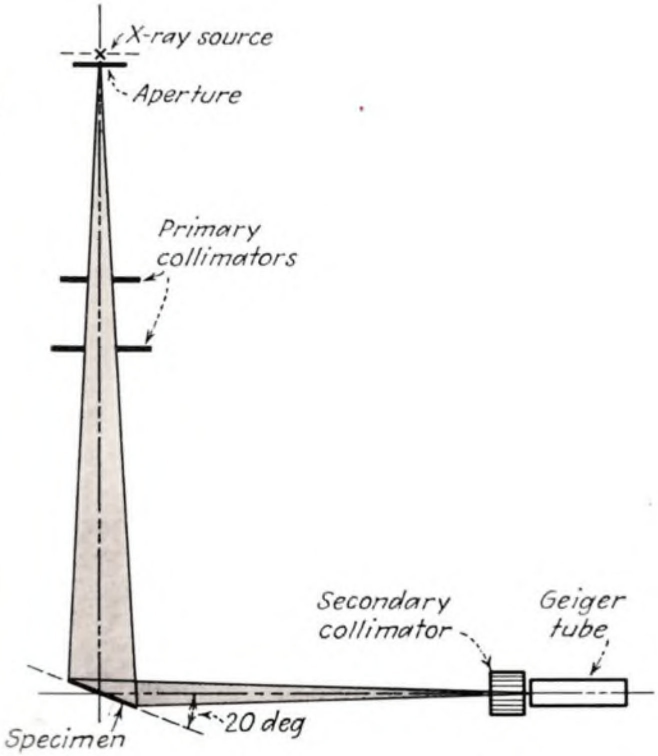

Figure 7—Ray diagram of the x-ray optical system.

face certainly would not be a unique function of the coating thickness. Therefore, the voltage applied to the x-ray tube, which determines the wave length distribution of the primary radiation, must lie between the excitation potential of the characteristic iron radiation and the higher excitation potential of tin characteristic x-rays. Since the K-series x-rays from tin will be excited by voltages in excess of 30 kv, and the iron K-series by 12 kv or more, these values define the range of operating voltages that can be used. Experimental work has shown that with the equipment described above, 20-kv x-rays excite sufficiently strong iron fluorescence to permit sensitive measurement of coating thickness over the coating range of 0.10 to 2.5 lb. per base box.* The x-ray tube current is varied depending on the sensitivity of the Geiger tube being used, but is usually maintained at some optimum value between 20 and 30 ma. These operating conditions are well below the maximum ratings of the OEG-50 x-ray tube, and to date some tubes have been in continuous service for more than 10,000 hr. with no indication of deterioration.

Calibrated Against Chemical Method

Since the x-ray fluorescence method measures coating thickness in terms of x-ray absorption, it is not an absolute method and must be calibrated against chemical or electrochemical measurements. This may be done by taking a

*One lb. per base box is the coating weight which results when 1 lb. of tin is distributed on both sides of 112 sheets, each 12 by 20 in.

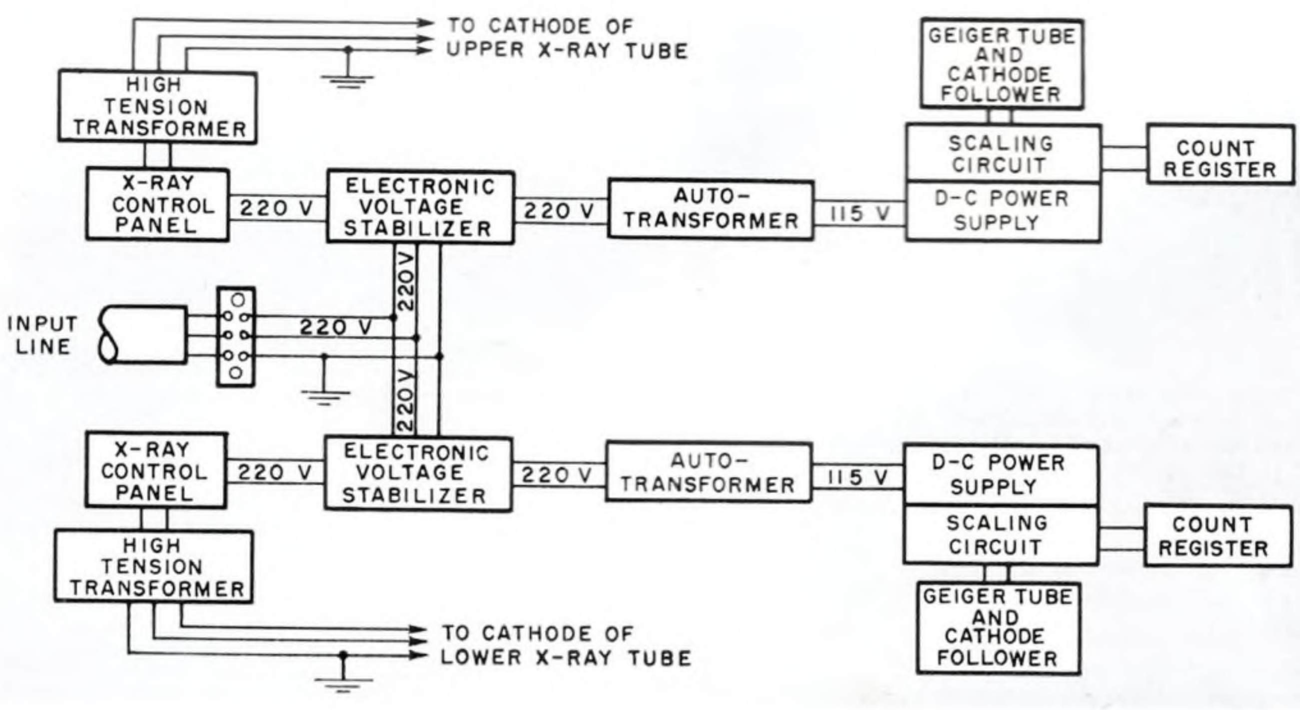

Figure 8 — Each of the two measuring heads (one for each side of the sheet) has its own power supply, scaling circuit and count register.

large number of tin-plate samples and measuring very carefully the intensity of x-ray fluorescence from them in terms of the number of counts detected by the Geiger counter in a 30-sec. time interval. The absolute coating weight of these samples is subsequently determined by one of the chemical methods; of course, the samples are destroyed during these determinations. If the logarithm of the number of counts is plotted as a function of the coating weight, the resulting curve will be a straight line. This calibration curve then permits the determination of the coating weight of any sample from the measured intensity of fluorescence, expressed as number of counts indicated by the Geiger counter tube. Such a calibration curve, plotted on semi-logarithmic graph paper, is shown in Fig. 10. In this graph, the intensity is indicated as the number of counts actually recorded, that is, 1/64 of the number of counts detected by the Geiger counter. It can be seen that the curve is essentially a straight line, as predicted by theory, with some slight curvature at 0.50 lb. and below. This curvature is caused by nonlinearity of response of the Geiger counting tube at the extremely high counting rates.

Figure 9 — Counts are accumulated for 30 sec. in three decade circuits and then transferred through stepping relays at the end of the count time to three printing wheels and recorded on tape.

In actual operation of a tin-coating gage of this type, the operator positions the tin plate sheet so that the desired area is between the measuring heads and initiates the count by a push-button switch. At the conclusion of the 30-sec. counting interval, the number of counts accumulated is automatically recorded on a paper tape, and the equipment is ready for the next determination. To convert the count to a coating weight value expressed in pounds per base box, the operator may use a curve similar to that shown in Fig. 10; however, most operators prefer to prepare a table of count versus coating weight values for more convenient conversion.

In any equipment of this nature, it is necessary to provide some means of standardization, to compensate for any deviation in results such as may arise from drift in electrical characteristics of certain components. Although all incoming electrical power to this gage is regulated by a saturable-core reactor type of voltage regulator, significant changes in the emission from the x-ray tube still may occur. To compensate for such drifts and to insure constant accuracy of results, the operator periodically measures one or more samples of known coating weight. If the count from such standard samples deviates from the proper values, the counting time is adjusted until the proper number of counts is attained for these samples. Since a variation in counting time will produce only vertical translation of the calibration curve, without rotation, this standardization procedure is entirely adequate.

As was stated earlier, the aim in this development was to design a gage that would measure tin-coating thickness with an accuracy of ± 2 per cent of the amount of tin present. The factor that ultimately limits the accuracy of any x-ray gage measurement is the statistical accuracy of counting random pulses, for certainly the coating weight value cannot be more accurate than the counting process. It is well known that in counting random events with a Geiger counter, the standard deviation of any counting operation is equal to the square root of the total number of counts (5). Thus if 1,000,000 pulses were counted, the standard deviation would be 1,000 or 0.1 per cent; whereas, if only 10,000 pulses were counted, the standard deviation would be 100, or 1.0 per

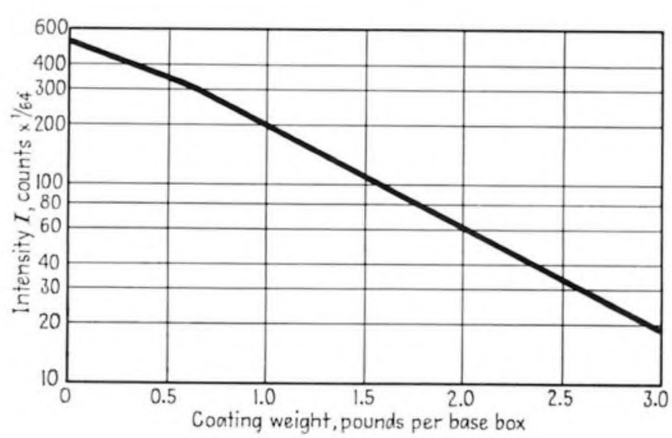

Figure 10 — Counter reading is converted to a coating weight value by reference to this curve based on comparative determinations on the same sample.

cent. From the calibration curve, Fig. 10, it is evident that the number of counts recorded by the gage in a 30-sec. time interval ranges from approximately 500 x 64 at coating weights near 0 lb. per base box to approximately 35 x 64 counts at 2.5 lb. per base box. By calculation, it is found that for these two extremes the standard deviations are ±2.8 counts and ±0.73 count, respectively, or 0.56 per cent and 1.1 per cent of the recorded counts. Since the accuracy of counting depends upon the total number of counts, the accuracy can of course be improved by accumulating more counts; this can be done most conveniently in this equipment by lengthening the counting interval. However, the accuracies quoted above for a 30-sec. counting interval are quite adequate; consequently, this interval has been chosen as a satisfactory measuring time.

Table I—Comparison of X-ray and Chemical Determinations of Tin-Coating Thickness

Determination*		Deviation	
X-ray	Chemical	Actual	Per Cent
0.23	0.23	0.00	0
0.24	0.25	—0.01	—4
0.46	0.46	0.00	0
0.46	0.47	—0.01	—2
0.72	0.71	+0.01	+1
0.72	0.72	0.00	0
1.02	1.01	—0.01	—1
1.02	1.03	+0.01	+1
1.22	1.24	+0.02	+2
1.23	1.24	+0.01	+1
1.54	1.56	—0.02	—1
1.54	1.50	+0.04	+3
1.81	1.78	+0.03	+2
1.86	1.88	—0.02	—1
2.13	2.19	—0.06	—3
2.17	2.20	—0.03	—1

*Values are in terms of total tin in lb. per base box.

Although the accuracy of the counting process has been shown above to be satisfactory, the accuracy in terms of pounds per base box must be determined by comparison between x-ray and chemical results on the same samples. Such comparisons have been made on several hundred samples as a continuing check on the performance of the x-ray gage, and some recent comparative results are shown in Table I. The criterion of accuracy established for the x-ray gage was that x-ray results should agree within ±2 per cent with determinations made by the most reliable chemical methods. It is evident from this table, which includes data for both electrolytic and hot-dipped samples, no result deviates more than 4 per cent from the chemical value; and only 9 of the 37 results (24 per cent) deviate more than ±2 per cent. Since errors are possible in both x-ray and chemical methods, this agreement is acceptable. In fact, a standard deviation of ±2 per cent would permit 32 per cent of the determinations to be outside these limits.

Since both x-ray fluorescence and absorption are essentially atomic phenomena, which depend upon the kinds of atoms present rather than upon the crystal structure or other properties of the metallic coating or base metal, the x-ray fluorescence method for measuring tin coating thickness is not affected by the metallurgical characteristics of either the steel base or the tin coating. This feature of the fluorescence method constitutes the principal difference between it and the x-ray diffraction method.

Before applying the x-ray fluorescence method to the measurement of any thin coating material on a metallic base, there are three factors to be considered. The first of these is the requirement that the coating material be of appreciably higher atomic number than the base metal. If this were not so, it would be virtually impossible to excite a large amount of fluorescence in the base metal without exciting fluorescence in the coating. The second factor to be considered is the thickness of the coating. As this thickness increases, the intensity of the radiation reaching the Geiger counter decreases exponentially to the point that it becomes indistinguishable from the normal background radiation. This sets an upper limit on the coating thickness that can be measured by the x-ray fluorescence method.

On the other hand, it is also necessary that the coating be sufficiently thick that the decrease in intensity of the fluorescent x-rays from the base metal be sufficiently large to be accurately measured by the detector. The third factor is that, for sensitive measurement of small differences in coating thickness, the coating material must have a sufficiently large x-ray absorption coefficient, for the wavelength of fluorescent x-rays emitted by the particular base metal used, to cause a measurable change in intensity of the emergent x-rays for a small change in coating thickness; that is, the sensitivity of measurement is to a large extent controlled by the fundamental nature of the coating material and of the base metal. The first requirement can be eliminated in some cases by the use of an analyzing crystal, which permits only the fluorescent radiation from the base metal to enter the counter; however, this makes the equipment too complex and unsuitable, in general, for mill applications with non-technical operators.

In conclusion, it can be said that the x-ray fluorescence method provides a new and useful tool for the nondestructive measurement of the thickness of thin coatings on a metallic base. In particular, the measurement of tin coating on a steel base can be performed in 30 sec. with an accuracy of ±2 per cent without defacing the sheet in any manner. Equipment for making this measurement in the mill on a routine basis has been developed and is in service at all tin-plate producing mills of the United States Steel Company.

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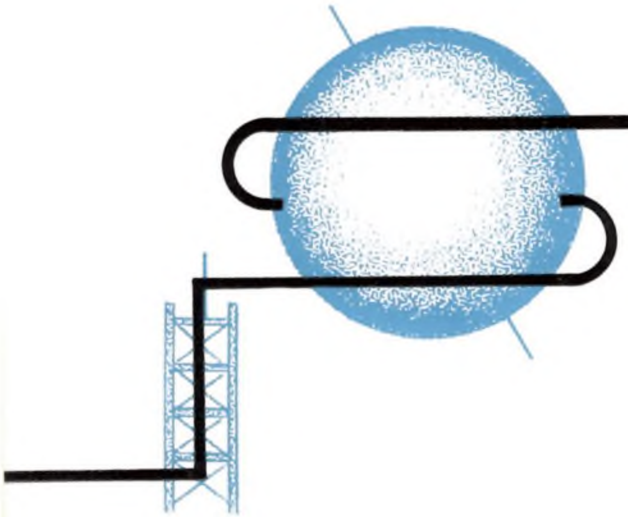


THE VOICE OF AMERICA...

Continued from page 15

to provide a prime service area pattern as well as to provide additional service in areas covered by other facilities. In general, these basic "Ring" plants have main transmitters capable of carrier powers of 1000 kw (1 megawatt).

II—Baker Installations provide reliable primary program channels from the United States to the overseas relay bases and secondary direct target area coverage as a security measure. These installations are designed for multiple high-frequency transmitter operation, with basic units of 500 kw carrier power operating into broad band curtain arrays having gains averaging about 20 DB referred isotropic radiators. With synchronized operation on a single frequency it is possible to obtain extremely effective radiated powers, something in the order of 200,000 kw with two 500 kw units operating into two phased arrays.

III—Vagabond facilities provide siteing flexibility in the over-all facility plan. The relay base installed aboard the USCG cutter "Courier" is one such facility, providing a self-contained relay base using a standard broadcast band transmitter of 150 kw and two 35 kw high frequency transmitters as well as a receiving station and radio teletype communications equipment. A discussion of the Vagabond operational plan as well as further details of the "Courier" installation will be described later in the text.

To adequately control and direct such a world-wide broadcast operation, the "Ring Plan" includes an integrated communications system.

The three basic steps in the development of the operating and planned installations through which the Voice of America now reaches and plans to augment its vast world-wide audiences have been described above, together with a brief description of the operating overseas relay bases. Unfortunately, security considerations do not permit detailed discussion of those facilities presently under construction or of those which are planned for future installation. It can be said, however, that research plays a vital part in the establishment of the "Voice's" facilities. It would not be prudent to overlook newly developed devices and engineering procedures that can be advantageously used in these broadcasting installations which have become a basic arm of the United States in combatting the psychological machinations of the Soviet Union, the major threat to world peace. It also would be extremely unfortunate not to subsidize basic research investigations which may develop these new devices or procedures. The Administration, through its International Broadcasting Service, has established a research program utilizing the services of such organizations as the Massachusetts Institute of Technology, Radio Corporation of America, the Research organizations of other Government Departments and Agencies, as well as many other commercial and institutional organizations having experience in research activities along lines most important to the "Voice's" technical development. In general, this research program explores the broad field of electronics and radio propagation.

The operations of the standard band transmitting plants used by the VOA differ in many ways from those of the commercial broadcasters in the United States. One of the fundamental differences is, with the exception of certain relatively short salt water paths, the dependence upon sky wave rather than ground wave to cover the primary service area. The reason for this, of course, is that the VOA audience is not concentrated in the vicinity of the transmitting plant as are the audiences of the United States commercial broadcaster, who, while in many cases does direct some of his attention to his secondary night time sky wave coverage, depends for his main source of revenue on his audience in his primary ground wave area. In the operation of the Voice of America plants, the ground wave service is in general a secondary service. In many cases the ground wave service is used by the sovereign government on whose soil a plant is located to serve indigenous populations during the time a facility is not useful for Voice of America programming, usually during the daylight hours.

So that adequate sky wave signals can be consistently developed to distances of over a 1000 miles, transmitter powers of 1000 kw are used. The antenna patterns are in the form of directed beams towards the target areas, although many of these beams must be modified and minor lobes suppressed so as not to provide serious interference to other co-channelled and adjacent channelled stations, much the same as the U. S. broadcaster affords protection to others.

The establishment of a 1000 kw standard band broadcasting station anywhere in the world, and the selection of an appropriate frequency, is not only a major engineering project but one with considerable international political ramifications. It requires delicate diplomatic negotiations with the sovereign government in whose territory a plant is to be located for permission to install an American radio station on its soil. Since, in general, no provisions have been made for American broadcasting operations in many areas, it requires further delicate negotiations with other governments operating co-channelled and adjacent channelled stations whose service areas must be protected. In many cases a frequency must be chosen which has been assigned on a clear channel basis by area agreements to a certain country. That country, which may be very friendly to the United States and her objectives, nevertheless invariably views with alarm even the slightest encroachment upon her right to operate an interference-free broadcast service. Obviously, it is necessary to reach a friendly understanding on the matter if our relationship with that country is not to suffer in many matters which may be far removed from the problems of broadcasting. The establishment of a Voice of America plant overseas, therefore, is a very lengthy, delicate procedure and at all times the United States must assure herself that the operation of such a plant would not cause difficulties with her friends even though the programming is designed to advance the well-being of the international community of nations.

"Vagabond"—Mobile Transmitters

One of the most interesting phases of the International Broadcasting Service's facilities development is project "Vagabond." This project provides sea-going mobile units necessary to assure a well rounded facility set up for Voice of America programming. "Vagabond" is not a cure-all. It has certain basic technical disadvantages relative to fixed facilities. Most of these are the result of antenna limitations and limitations on the size of the transmitter complements that are not inherent in fixed facilities. On the other hand, there are definite advantages to "Vagabond," some of these are immediately apparent, others are not.

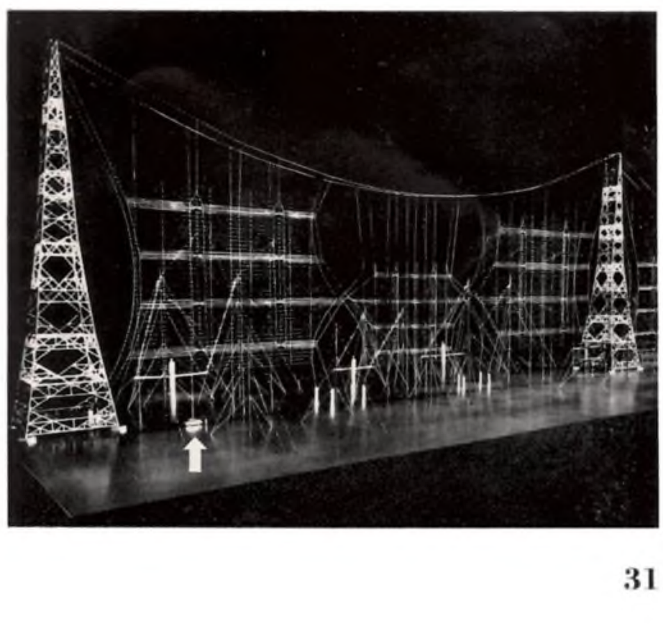
The ability to move into an operating location and commence broadcasting is an apparent advantage, as is the ability to leave an area when circumstances dictate.

There is one other advantage which is as important as the degree of mobility. That is the time necessary to construct one of these facilities. Use is made of available vessels suitable for this type of service. The time required for modification of a vessel to permit the installation of equipment and the installation itself is about nine months. Experience has shown that the construction time involved in an extensive fixed plant in an overseas area can exceed 18 months. Further, construction of a fixed plant cannot commence until such time as all the necessary diplomatic arrangements and negotiations for a site are completed. The important element of construction time is on the side of the "Vagabond" installations.

One important premise in the establishment of the "Vagabond" project is the possibility of using this type of facility as a temporary substitute for a fixed plant pending completion of construction of such a plant. By using "Vagabond" in the sovereign waters of a nation which has granted permission for the construction of a permanent base, effective operations can commence without awaiting completion of the fixed installation.

At present one of these "Vagabond" facilities is in operation. This is the United States Coast Guard cutter "Courier," now stationed at the Island of Rhodes, providing standard band and high frequency coverage of the Middle East and part of the Balkans with the short wave coverage extended over much wider areas.

Figure 3—Model of high-gain curtain-type directional antenna used with Voice of America transmitters. The scale-size automobile in the left foreground above arrow indicates the comparative size of a curtain antenna installation, which is as tall as a skyscraper building and about as long as two standard city blocks.



The announcement of the activation of the "Courier" caught the imagination of many people. Several articles appeared in popular, as well as technical, publications. Almost invariably the assumption was made that this ship was intended to operate on the high seas, or perhaps off enemy coasts, traveling back and forth broadcasting its messages. This is not the case.

The "Courier" is a completely self-contained broadcasting unit, from its independent diesel electric system to its transmitting antennas. It has a receiving system capable of simultaneous operation with all three of its broadcast transmitters operating at full power. It has recording and studio facilities. There is, therefore, no technical reason why this ship could not operate while under way, anywhere. The limitations are those of basic United States policy and of international law.

To operate such a facility while under way would be contrary to the provisions of the existing International Telecommunications Treaties to which the United States is signatory. Further, operation in other than the most friendly waters would make security questionable with attendant risk of embroilment in serious incidences.

The operational plan for this facility is quite similar to the operations of fixed overseas relay bases. The vessel is intended to operate at fixed locations in safe harbors in the sovereign territory of friendly nations which have granted permission for such operation. The frequencies used in the operation must also be authorized by the nation holding sovereignty over the site. The same fundamental precautions as to protection of the service areas of other stations that are adhered to by the fixed facilities of the Voice of America are also part and parcel of the "Vagabond" concept. This latter consideration is in a sense a limiting factor in mobility of "Vagabond" facilities.

Confining ourselves for the moment to the medium wave service, the vessel is equipped with a balloon-supported antenna that can be raised to optimum heights. Such an antenna, being omnidirectional, does not afford protection in any direction. In certain areas this is not an insurmountable problem, as perhaps the distances to the service areas of other stations are great enough, or the channel sharing pattern is such that the vessel's transmitters would have no appreciable effect to the services of co-channel or adjacent channel users. In some cases, certain hours of operation may require reduction in power of the ship's transmitter. In many cases, however, sites may be perfectly satisfactory in all respects except that it is not possible to use an omnidirectional antenna without causing serious interference to other broadcasters. Not only is it necessary in these cases to provide some degree of protection to stations, but it is highly desirable in all cases to transmit the maximum amount of effective radiated power towards a desired target area. Both these requirements can be met only by the use of multielement directional arrays which obviously cannot be installed on the vessel, even with the help of balloons. The use of the balloon-supported antenna is, therefore, considered a temporary measure at most locations.

Should it be desirable to operate an appreciable length of time from a given location, a secure anchorage is found close to shore, or a pier is constructed to which the ship is tied. A directional antenna is erected ashore which is then fed through a specially designed transmission line by the ship's transmitter. The mechanics of laying a transmission line from vessels that are subject to rise and fall of tides, is not as difficult as it appears at first glance. High power capacity flexible coaxial line is available from several sources. This cable can be laid on the harbor bed in the manner of a submarine cable or it can be brought ashore using a series of floats. Methods for using open wire lines when piers can be made available have been worked out by the use of a self adjusting system to compensate for changes in line tensions with the tides.

Figure 4—General view of the front panel of the megawatt transmitter and the centralized control console.

Not only can the medium wave antennas be erected ashore, but so can the receiving plant. By so doing, efficient directional receiving antennas of the rhombic type are erected to provide adequate space diversity reception and appreciable antenna gain. The receiving system aboard ship is a good one but, of course, does not reach the efficiency that can be achieved through shore based antennas. Incidentally, a program picked up by a shore based receiving facility is transmitted to the vessel via an SHF-STL[4] link which is part of the vessel's electronic complement.

Space is provided in the holds for the storage of medium wave antenna towers and a knocked-down "pre-fab" hut to house the shore based receiving station.

The short wave transmitting antennas are of rather novel design and are permanently located atop the ship's forecastle. These antennas were specially designed for this project and have extremely broad band characteristics, maintaining a relative constant input impedance and good radiation efficiency over a wide frequency range. Two of these antennas cover the entire high frequency broadcast spectrum lying between 6 and 26 megacycles.

In addition to the main broadcast transmitter, the standard band 150 kw, two 35 kw transmitters are installed on the "Courier." There is also a 5 kw transmitter installed which is used for radio teletype communications. A separate teletype communications room, independent of the ship's normal radio room is available for heavy traffic loads.

Three 500 kw synchronized diesel generators provide the power supply to the ship's broadcasting facilities. Two diesels provide power for full simultaneous operation of all transmitters. The third engine is a spare.

The United States Coast Guard operates the "Courier" for the Department of State, providing its complement of officers and crew and arranging for other services incidental to the vessel's operation. The International Broadcasting Service supplies three engineers to supervise the transmitter operations and the selection of relayed programs in accordance with instructions from their New York headquarters.

[4] Super-High-Frequency Studio-Transmitter Link.

It can be said from the foregoing discussion that the "Vagabond" facilities are used as though they were "transportable" units rather than fully "mobile" units, though the latter type of operation is entirely possible from a technical standpoint.

Super-Power Broadcasting—Megawatt Transmitters

Another development which may be of interest to the reader, is the 1000 kw standard band broadcast transmitters manufactured for the Department of State by the Continental Electronics Company of Dallas, Texas. The limits of security will not permit too detailed an examination but the major points of interest can be described. The transmitter, Continental Type 105B, is in reality two separate and complete 500 kw transmitters using one oscillator of either unit to drive the remaining stages of both 500 kw units, the output of each being fed into a phasing bridge device to develop 1000 kw at the input terminals of a transmission line.

The 500 kw amplifiers use the Doherty high efficiency linear amplifier, four Machlett Type ML-5682 electron tubes in the carrier position and four more in the peak position. Each 500 kw amplifier is driven by a grid bias modulated amplifier using one ML-5682. The RF chain is completed by an 807 followed by an 813 which drives the grids of two ML-357B tubes, providing an output of up to 2 kw to drive the modulated amplifier. The audio amplifier consists of two 807's followed by an 845 followed by four 845's in parallel as a cathode follower for grid bias modulating the ML-5682 modulated amplifier. Each 500 kw transmitter has its own filament, plate and bias power components, making it possible with some minor changes to split the two units for installation at two separate locations, if desired. A dummy load capable of dissipating 750 kw is supplied with each 105B transmitter. This permits the testing of each 500 kw unit under full modulating conditions.

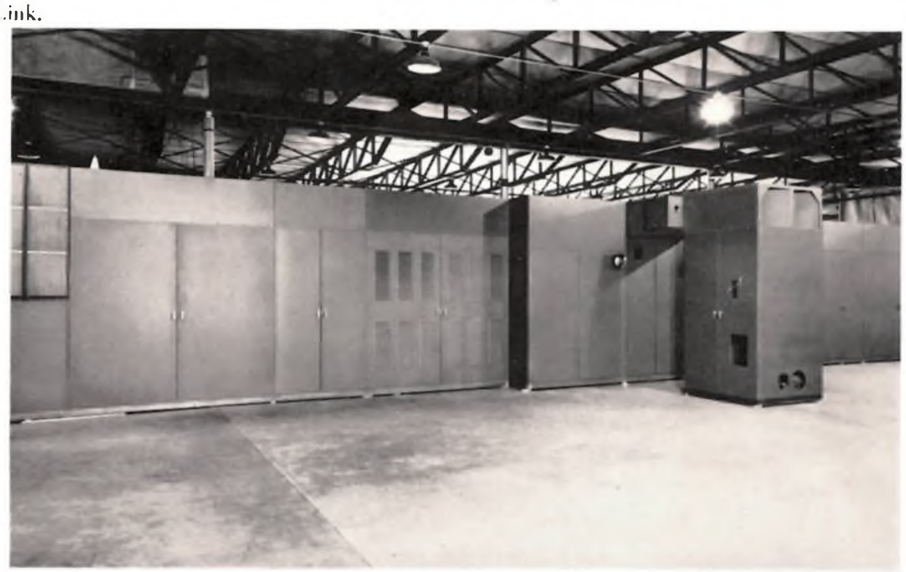


Figure 5—Rear view of the complete transmitter.

Some pertinent data relative to the characteristics of the 105B transmitter, which may be of particular interest, are enumerated below:

1. The high efficiency linear amplifier has a power gain of 33 using triode tubes. The tubes are newly developed, have thoriated tungsten filaments and high transconductance.
2. All metering, tuning controls and power controls are centralized on a console type of control and tuning unit.
3. Over-all conversion efficiency from power source to antenna is slightly better than 50% at carrier conditions, rising to approximately 54% with 100% tone modulation.

Performance characteristics are:

Residual Carrier Noise Level	60 DB below 100% modulation
Carrier Shift	Zero at any modulation to 100%.
Sustained Tone Modulation Capability	100% at any frequency 30 to 10.000 CPS.
Final Power Amplifier Efficiency	62%

Communist Bloc Countermeasures—Jamming

No discussion of the radio facility development which the International Information Administration is undertaking

Figure 6 — The Voice of America's floating radio station "Courier." Some of the special antennae can be seen in this view. From the raised platform amidships captive barrage balloons may be released to carry antennae hundreds of feet above the ship.

to increase the effectiveness of its Voice of America operations would be complete without some attention being given to the technique used by the Soviets and their satellites to blot out our programs.

The overloading of the medium and low frequency broadcasting bands, and the difficulty in obtaining an interference free service in these bands nearly everywhere in the world, have already been discussed. Additionally, the high frequency broadcasting bands also are overcrowded to the point where it is extremely difficult to deliver a service that is relatively free from interference. To describe the condition prevalent in these broadcasting bands, at an International Conference at Mexico City held in 1949, a total of 15,000 frequency hours were submitted as minimum broadcast requirements of the different nations. Using the most lenient standards, the spectrum can support a little in excess of 5,000 hours.

To these frequency difficulties, and to the difficulties inherent in the disadvantageous geographical position of the United States which have been previously discussed, has been added the jamming effort of the Soviet Bloc against the Voice of America operations of the United States as well as against similar operations of the BBC and other friendly broadcasters.

Evidence gathered over the years indicates that over a thousand jammers are being used in this destructive service. The observers of both the BBC and VOA have identified over 250 high-powered sky wave jammers by means of their call indicators. Further investigation has disclosed that, in addition to the sky wave jammers, there is a tremendous number of ground wave jammers serving heavily populated urban areas. Best estimates of both BBC and VOA are that there are nearly a thousand of these.

The operational procedure of these jammers would appear to make necessary complex control networks and centers. That they do not operate under a haphazard procedure is evidenced by the ability of a large number of jammers to "zero in" on a previously unannounced frequency within minutes after commencement of a program that the Soviets desire to jam.

Such a jamming mechanism is obviously expensive not only in material costs, but in the expenditures of trained man power and communications facilities—all of which, undoubtedly, are as important to the Russian economy as they are to ours. Based on comparisons with known equipment costs, the capital investment in the physical components of the jamming mechanism now operating against us is estimated to be in the neighborhood of $70,000,000. This figure is exclusive of the cost of such things as wire lines, radio links and other apparatus which are inherent in as complex a control network as must be established to control such a vast number of jamming transmitters. Included in the transmitting facilities involved in the jamming mechanism—and this further shows the degree of importance the Soviet Bloc places on their Electronic Curtain

Figure 7—Transmitter room aboard "Courier."

as a vital element of their Iron Curtain—are many of their high-powered broadcasting stations. Observers have noticed that when VOA programs are directed to certain areas behind the Iron Curtain, a noticeable decrease in the volume of internal broadcasting occurs followed by a great increase in jamming on VOA frequencies. Many of these jammers obviously are broadcast transmitters removed from their normal service for the purpose of jamming the "Voice's" programs.

The operating costs of the jamming operation, if based on rather conservative figures, are $2.00 per transmitter hour, exclusive of personnel. Most commercial companies average $3.00 per transmitter hour for small transmitters in the point-to-point service. Actual operating costs, using the two dollar figure would be in excess of $17,000,000.00 per year.

The cost in trained man power, if we were to be conservative and say that one technician operates two transmitters, which is doubtful since the Soviets have shown great facility in meeting changes in frequencies of a program transmitter, would be over 2,000 men. Not an inconsiderable number of trained technicians for any country to assign to one project.

To counteract the effects of jamming of our present operating facilities, we are undertaking many different techniques. For example, at certain times BBC and VOA join forces and mass all available transmitters to carry out a Russian operation. At other times we shift frequencies and engage in general diversionary tactics. An effective procedure also is to engage in round-the-clock repeat broadcasts over certain facilities, that is, repeating certain specific broadcast schedules so that a given program may be heard at several definite times during the day and night to permit a listener to tune in at other times if the original broadcast was unheard because of jamming. In passing we might mention that fifteen different types of jammers have been observed from the old and very familiar "German bagpipe" to highly sophisticated noise jammers of rather recent vintage.

We have described the basic problems facing the United States in the field of international broadcasting.

The question may be asked as to the extent these problems have been solved by the present day facilities of the Voice of America. Whether the "Voice," with its facilities now on the air, has been able to pierce the wall that has been placed around Soviet dominated areas, despite the natural and man-made obstacles in its path. The evidence is that it is getting through, and getting through to an appreciable degree. Monitoring reports indicate that, despite the concentration of jammers in the area, a good many of our programs are even getting through to Moscow. A much larger percentage are getting through to the rural areas of Russia which are not as efficiently covered by the jammers.

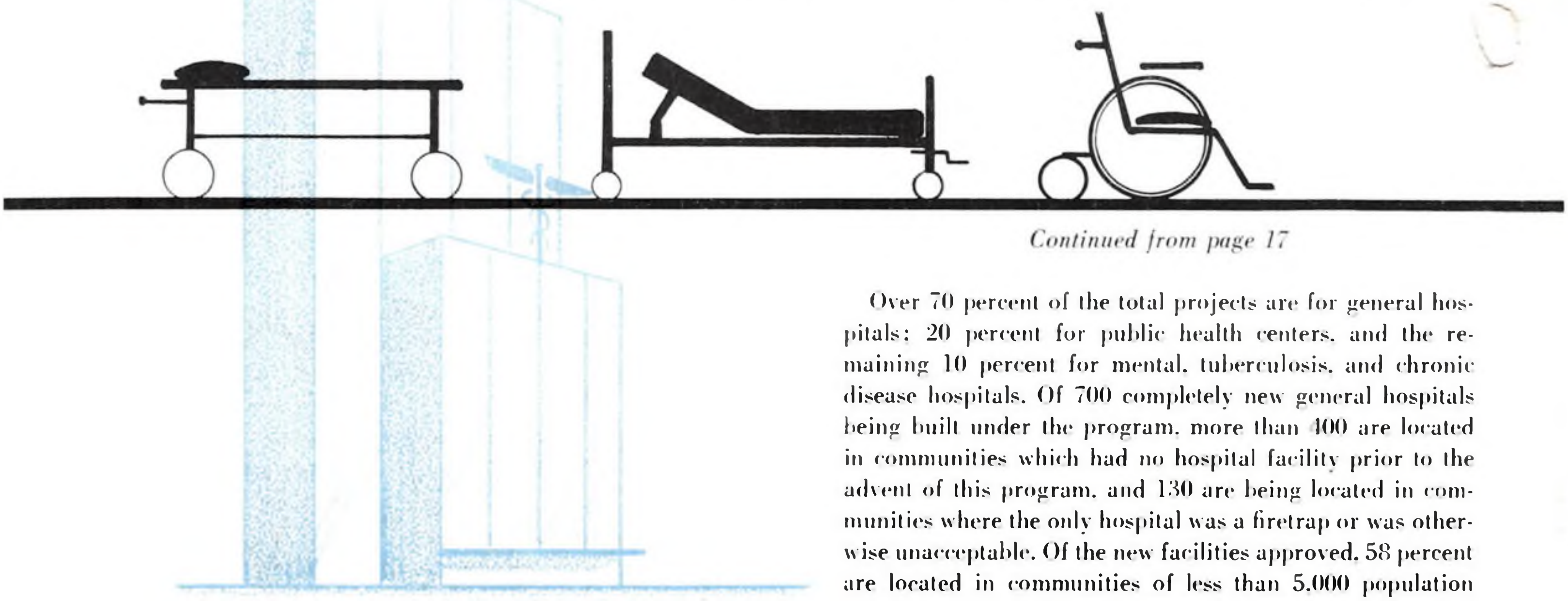
Despite these jammers, Radio Moscow felt obliged to attack the "Voice" 312 times during 1951 in an effort to discredit and refute the broadcasts, while TASS carried 23 separate attacks which were printed in 100 provincial newspapers. Even if it were assumed that the answer to the "$64" question is negative and we are not getting through, the Communist radio and press in their efforts to refute the Voice of America, repeat enough of it to make the effort very worth while indeed. Reports from other Iron Curtain countries, just as important if not more important targets than Russia herself, also prove that the "Voice" is heard with good effect.

Circumstances have placed upon the shoulders of the United States the heavy responsibilities of leadership of the free world. We are faced with a ruthless opponent determined to dominate the world, using whatever weapons she may find expedient, and the most effective weapon she has used to date has been the ideological approach—Communism itself—in the psychological war she is waging against the free world to achieve her major objective, imperialistic expansion and domination.

Do the strategists in the Kremlin fear the Voice of America? The existence of the jammers testifies to that! In a general way, the Voice of America can claim a considerable share of the credit for fostering the growing determination of the free world to resist encroachment upon their liberties and instill hope and equal determination in the peoples of Communist dominated lands to regain their lost liberties.

The stakes are much too high for the United States not to meet the constantly growing challenge to its best of all weapons of psychological warfare—truth. That is why the Department of State and its International Information Administration have embarked upon a bold, sound plan of radio facility expansion—to assure that the Voice of America is not drowned out in an electronic sea of noise and discord.

THE NATIONAL HOSPITAL SURVEY...



Continued from page 17

for the first time, undertake an orderly survey and appraisal of its existing hospital and public health center resources. This would permit, then, the development of a comprehensive program for furnishing hospital services to the people of the Nation.

The Congress made available limited funds to assist the States in this phase of the program. The plans developed by the States in accordance with the formula prescribed in the law, delineate also hospital service areas within a State and establish a priority structure. Priorities are essentially based on relative need to permit the construction of hospitals first, where the most need for them is demonstrated.

Progress to Date Under This Legislation

To date the Congress has authorized 542.5 million dollars for hospital construction of which over 500 million dollars, matched by an additional 900 million dollars in contributions by sponsors from the local community, have been allotted to projects approved for Federal aid.

At the end of July 1952, 1,839 hospitals, public health centers, and related facilities projects had been approved: 966 of these are completed, open and rendering hospital services to the community; 771 are under construction; the remaining 102 are in the planning and drawing board stages.

These 1,839 projects are adding 88,817 hospital beds and 350 public health centers to the Nation's health resources. The total cost of 1 billion 430 million dollars for these projects is being jointly met by over 500 million dollars in Federal funds and 900 million dollars in State and local funds.

Over 70 percent of the total projects are for general hospitals; 20 percent for public health centers, and the remaining 10 percent for mental, tuberculosis, and chronic disease hospitals. Of 700 completely new general hospitals being built under the program, more than 400 are located in communities which had no hospital facility prior to the advent of this program, and 130 are being located in communities where the only hospital was a firetrap or was otherwise unacceptable. Of the new facilities approved, 58 percent are located in communities of less than 5,000 population and only 10 percent in cities which exceed 50,000 population. Due emphasis has, indeed, been placed upon rural areas. Fifty-seven (57%) percent of the new hospitals have fewer than 50 beds and only 20 percent have 100 beds or more.

Future Needs

There is, as has been previously indicated, a hospital bed deficiency of 882,000. Population increases have been estimated at roughly 2 million persons annually. Since about 12 beds of all types are necessary to meet the needs of increasing population, about 24,000 beds are necessary to take care of our annual growth in population. Obsolescence has been calculated at roughly 2 percent of the existing annual beds, about 20,000 beds need to be built annually to replace obsolete hospital plants.

Cost estimates based on an average estimated cost per bed of $16,000 at current prices would mean an expenditure of over 700 million dollars annually just to keep up with population growth and obsolescence. Current forecasts indicate that about 840 million dollars will be expended on hospital construction put in place during 1952. To cut into the backlog of bed deficiency would necessitate a considerable increase in the rate of expenditure for hospital construction.

It is desirable to point out that better bed utilization, trends of medical practice, improved methods of hospital administration, all will affect the total bed need at present and in the future. However, there is little question that, if our Nation is to maintain its present place of leadership among Nations, the health of our people is an essential asset which must be maintained. Adequate health facilities combined with adequate skills of our health teams offer much to assure each citizen a high level of individual and public health.

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Providing this already well accepted tube with the advantages achieved by double focus design, has greatly widened its range of application without changing the basic "Dynamax Design". The Dynamax "20" still incorporates all the features which have made Dynamax rotating anode tubes world famous, including, of course, the solid tungsten disk target which has virtually made obsolete all other types of target construction. Experience has proved that a single focal spot of a size necessary to achieve the greater loading capacities, even in tube designs which have reverted to the use of the older, less durable copper-backed anode, is not significantly smaller than the larger focus of the new Dynamax "20", and is by no means small enough to insure maximum definition.

The addition of the double focus Dynamax "20" to the Machlett line of rotating anode tubes provides a dependable economical Dynamax tube for any diagnostic application regardless of power range. The Dynamax Series, the only complete line of rotating anode tubes available from a single manufacturer also includes: The Dynamax "25" for general radiography with tube currents up to 100 MA self-rectified or 500 MA rectified; The Dynamax "26" for under-the-table spot film work and fluoroscopy with ratings similar to those of the Dynamax "25"; The Super Dynamax for heavy duty radiography up to 900 MA; and the model designed for military uses, The Dynamax "30G".

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