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SUMMER • 1952

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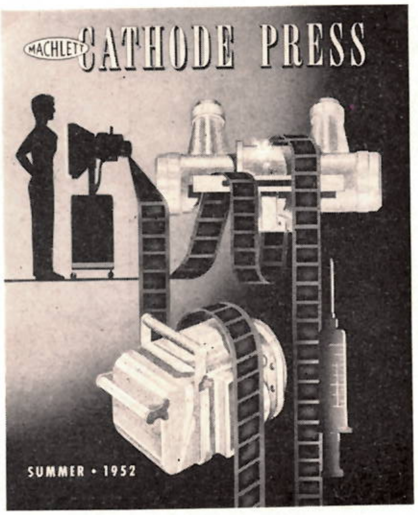

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COVER

Illustrated on the cover of this issue are two of the principle components of photofluorographic units used to make chest x-ray examinations of large numbers of people for the purpose of detecting tuberculosis and other chest abnormalities—the Fairchild roll film camera and the Machlett Dynamax rotating anode tube.

Indicated also is the use of the Super Dynamax in conjunction with the roll film cassette for techniques requiring multiple exposures in rapid succession.

Both of these are discussed in detail in articles on pages 2 and 6 of this issue.

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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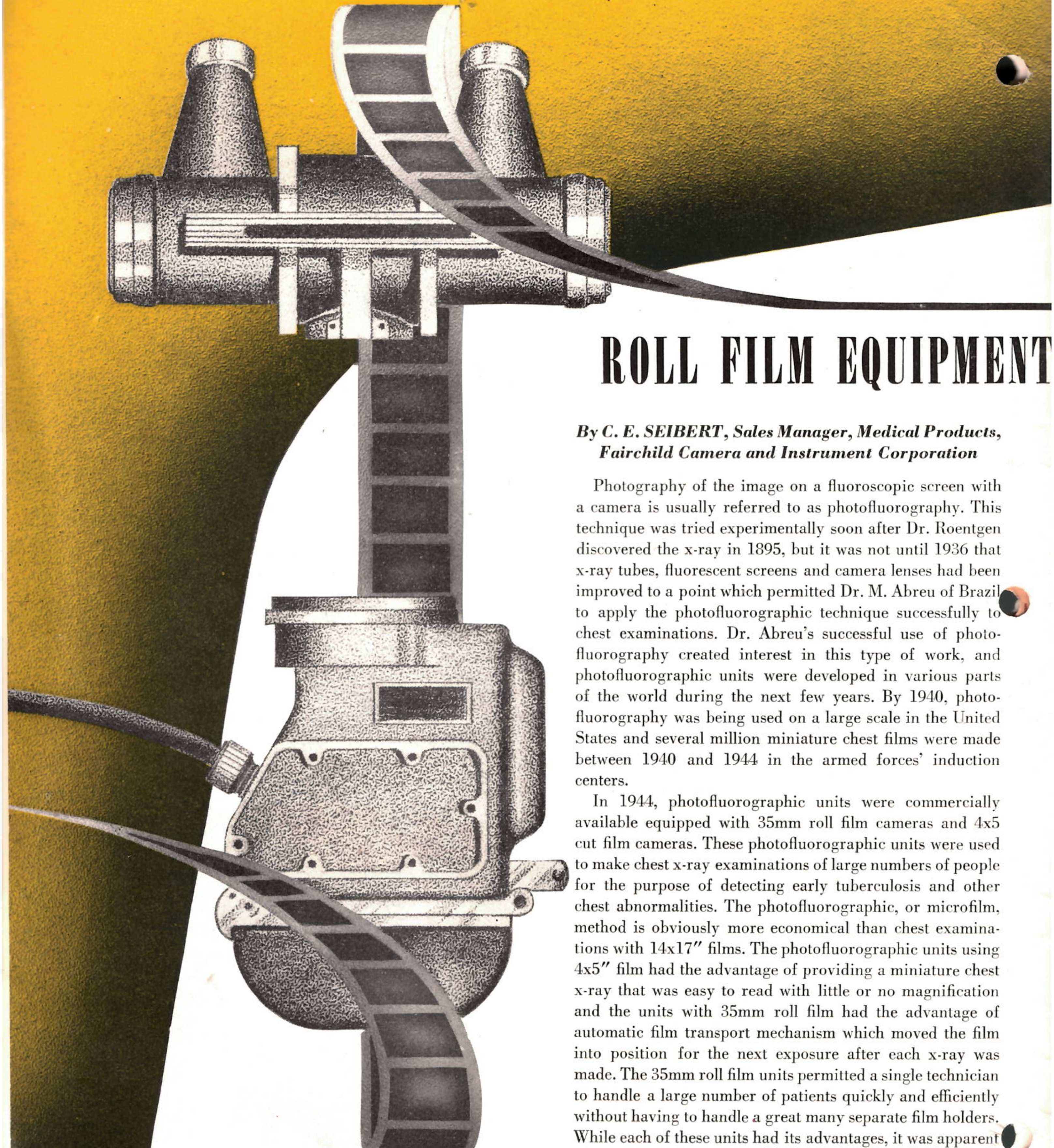
SCHEDULED FOR NEXT ISSUE

X-Ray Tin Coating Gage

An Intermediate Power Water and Forced Air Cooled Tube for Industrial Service

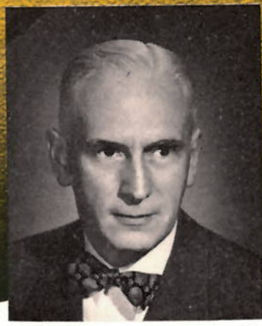


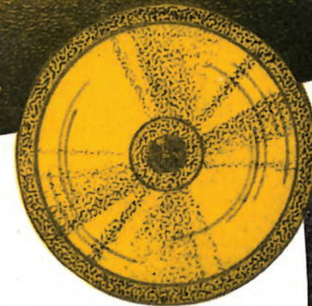
ROLL FILM EQUIPMENT

By C. E. SEIBERT, Sales Manager, Medical Products, Fairchild Camera and Instrument Corporation

Photography of the image on a fluoroscopic screen with a camera is usually referred to as photofluorography. This technique was tried experimentally soon after Dr. Roentgen discovered the x-ray in 1895, but it was not until 1936 that x-ray tubes, fluorescent screens and camera lenses had been improved to a point which permitted Dr. M. Abreu of Brazil to apply the photofluorographic technique successfully to chest examinations. Dr. Abreu's successful use of photofluorography created interest in this type of work, and photofluorographic units were developed in various parts of the world during the next few years. By 1940, photofluorography was being used on a large scale in the United States and several million miniature chest films were made between 1940 and 1944 in the armed forces' induction centers.

In 1944, photofluorographic units were commercially available equipped with 35mm roll film cameras and 4x5 cut film cameras. These photofluorographic units were used to make chest x-ray examinations of large numbers of people for the purpose of detecting early tuberculosis and other chest abnormalities. The photofluorographic, or microfilm, method is obviously more economical than chest examinations with 14x17″ films. The photofluorographic units using 4x5″ film had the advantage of providing a miniature chest x-ray that was easy to read with little or no magnification and the units with 35mm roll film had the advantage of automatic film transport mechanism which moved the film into position for the next exposure after each x-ray was made. The 35mm roll film units permitted a single technician to handle a large number of patients quickly and efficiently without having to handle a great many separate film holders. While each of these units had its advantages, it was apparent





C. E. SEIBERT

Mr. Seibert graduated from Amherst College in 1926. Engaged in miscellaneous sales work until 1936. Handled sales promotion and customer service for photographic studio doing advertising illustration December 1936 to August 1942. Served with Coast Guard until February 1943 when he joined Fairchild. Prepared technical instruction material for the Armed Forces covering Fairchild Aerial Cameras. In 1944 was given assignment coordinating development program of line of medical cameras for sale in post war market. Is at present sales manager for medical products.

IN PHOTOFLUOROGRAPHY AND RADIOGRAPHY

to radiologists and public health workers that it would be more desirable to use photofluorographic units which combined the good features of both of the units then available.

At this point, the Fairchild Camera and Instrument Corporation became interested in the problem of designing the camera for these new photofluorographic units. For over twenty years the Fairchild company had been supplying special aerial cameras to the U. S. Government for military purposes. Most of these cameras were equipped with automatic mechanisms for making exposures at pre-set intervals on long rolls of film. Officials of the U. S. Public Health Service were consulted and visits were made to prominent radiologists and manufacturers of x-ray equipment. As a result of information gained at these meetings, Fairchild worked out a set of specifications with each of the manufacturers of x-ray apparatus and began the design of the camera now known as the F-212 Fluoro-Record Camera.

While Fairchild was engaged in the development of the cameras, several of the large manufacturers of x-ray equipment were working on the 70mm units on which the cameras were to be used. Ultimately, Fairchild designed not one, but seven slightly different cameras. Some of the basic differences in the cameras resulted from the fact that there was no agreement on the proper size of the fluoroscopic screen. Photofluorographic units were designed by the manufacturers with screens measuring 14x17″, 15x17″, 15x18″ and 16x16″. This meant that the cameras had to be focussed in the Fairchild factory for each of the different camera-to-screen distances required to photograph the different screen sizes. All photofluorographic units were equipped with light tight metal hoods which held the fluoroscopic screen at one end and the camera at the other. These hoods were built to dimensions supplied by Fairchild in order to place the fluoroscopic screen at exactly the distance from the camera which would permit the lens to cover the dimensions of the screen used. The table given below shows some of the camera-to-screen distances provided by the hoods of the photofluorographic units:

Screen Size	*Camera-to-Screen*	*Picture Size*
14x17	**25.277**	**2½x3″**
15x16	**26.978**	**2½x2⅞″**
15x18	**26.978**	**2½x3″**
16x16	**28.686**	**2½x2½″**

These distances were figured to three decimal points so that the high speed lens operating wide open would be held

Figure 1 — Fairchild 70mm roll film fluorographic camera.

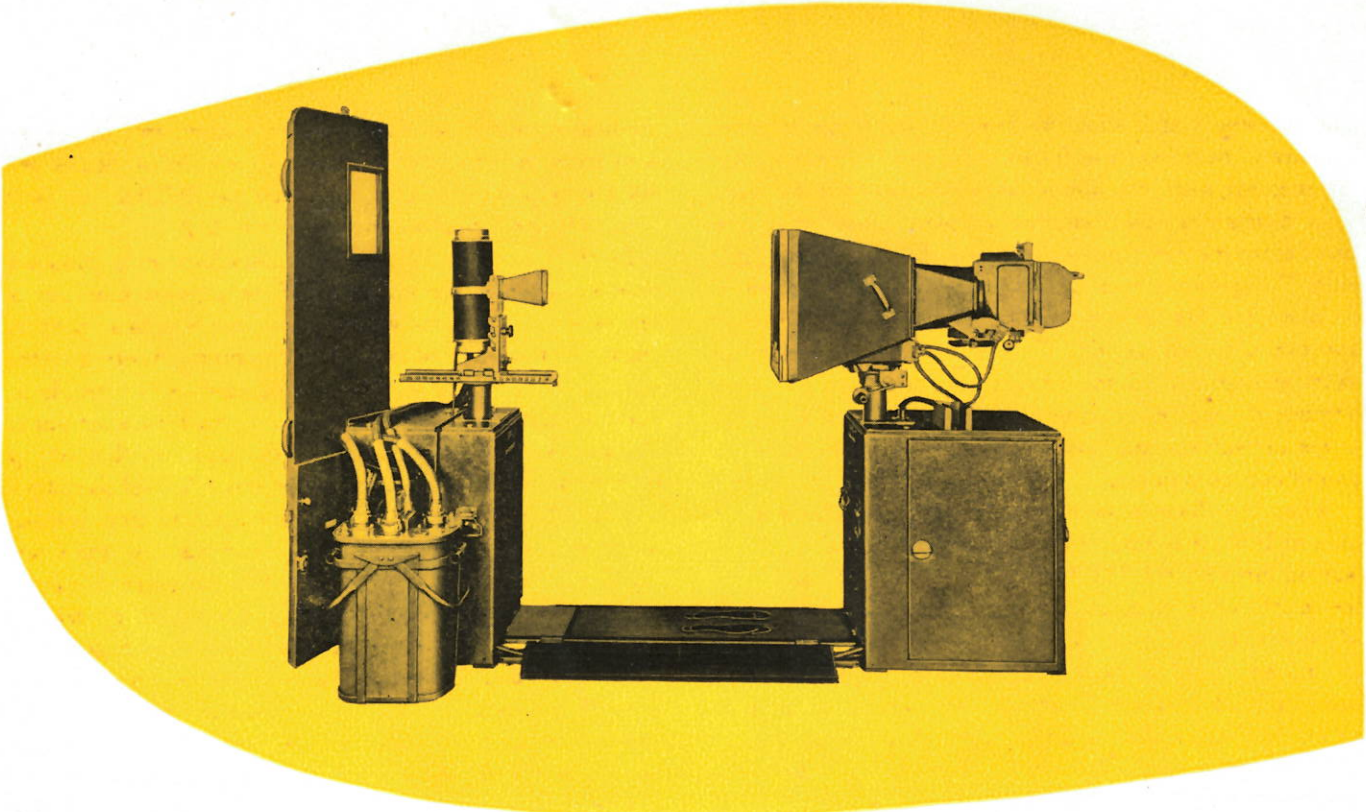


Figure 2—Typical chest survey unit using the Machlett Dynamax "25" and the Fairchild 70mm roll film camera.

at the exact distance from the screen needed to produce an image in sharp focus. The shape of the fluoroscopic screen determined the shape of the photographic image and the film magazines of the cameras were provided with openings to correspond with the different screens.

Some of the manufacturers equipped their 70mm photofluorographic units with fluoroscopic screens producing a greenish image and others used screens producing a bluish image. This fact did not complicate the camera design, but did make it necessary for the film manufacturers to produce two different types of roll film. The blue sensitive film used with the blue screens had the advantage of being slightly faster than the green and easier for the technician to handle in the dark room because it was suitable for handling under an ordinary x-ray darkroom safe light. The green film used with green screens produced a slightly more contrasty image which was preferred by some radiologists but had to be handled under a very dim red light in the darkroom.

Eastman Kodak developed a lens for the 70mm Fluoro-Record Cameras with an optical speed of f/1.5. This lens, known as the Kodak X-Ray Ektar Lens, was designed for use in photographing fluoroscopic screens in sizes ranging from 14x17″ to 16x16″. The lens had excellent color correction which was so accurate that it focussed equally well with either blue or green type screens. The lens proved to be an excellent solution to the special optical problem and combined high speed with good definition, color correction and flatness of field. These qualities would have been comparatively easy to obtain in a lens of lower optical speed. However, the high optical speed was necessary because of the dimness of the image on the fluoroscopic screen and the fact that the exposures had to be kept as short as possible to prevent loss of detail in the chest due to movement.

The Fairchild cameras, designed to use 100-ft. rolls of film, were equipped with a motor driven film advance mechanism which operated automatically after each x-ray exposure. In practice, the x-ray exposure determined the photographic exposure because the cameras were not equipped with shutters and the image on the fluoroscopic screen was recorded by the camera as long as it appeared on the screen. The x-ray exposure was measured by a photoelectric timer that cut off the x-ray tube as soon as the screen image had produced sufficient light to make a film of proper density in the camera. The photo-timer was built into the hood containing the screen by the manufacturer producing the complete 70mm photofluorographic unit. This development, along with improved screens, film and x-ray tubes, contributed greatly to the usefulness of the 70mm units.

To insure the operation of the camera as an integral part of the photofluorographic unit, a number of electrical interlocks are used. These circuits prevent an x-ray exposure being made unless the magazine cover and the magazine are seated properly and unless the camera contains film. A signal light on the camera indicates that film is in place and blinks when the end of the film is reached and the trailer is passing through the camera.

The film advance mechanism of the camera is operated by an electric motor which is turned on automatically at the completion of each x-ray exposure and turned off by a cam-operated switch when the film has moved the required distance to be in position for the next x-ray exposure. During each exposure, the film is pressed flat in the focal plane by a mechanical cam operated pressure plate which lifts just before the film begins to move at the end of the exposure. The operating cycle of the camera for the time required to move the film and get ready for the next exposure is approximatly two seconds. This interval has proved to be short enough for photofluorographic chest x-ray surveys, because it requires considerably longer than two seconds to get the subject into position in front of the hood of the photofluorographic unit.

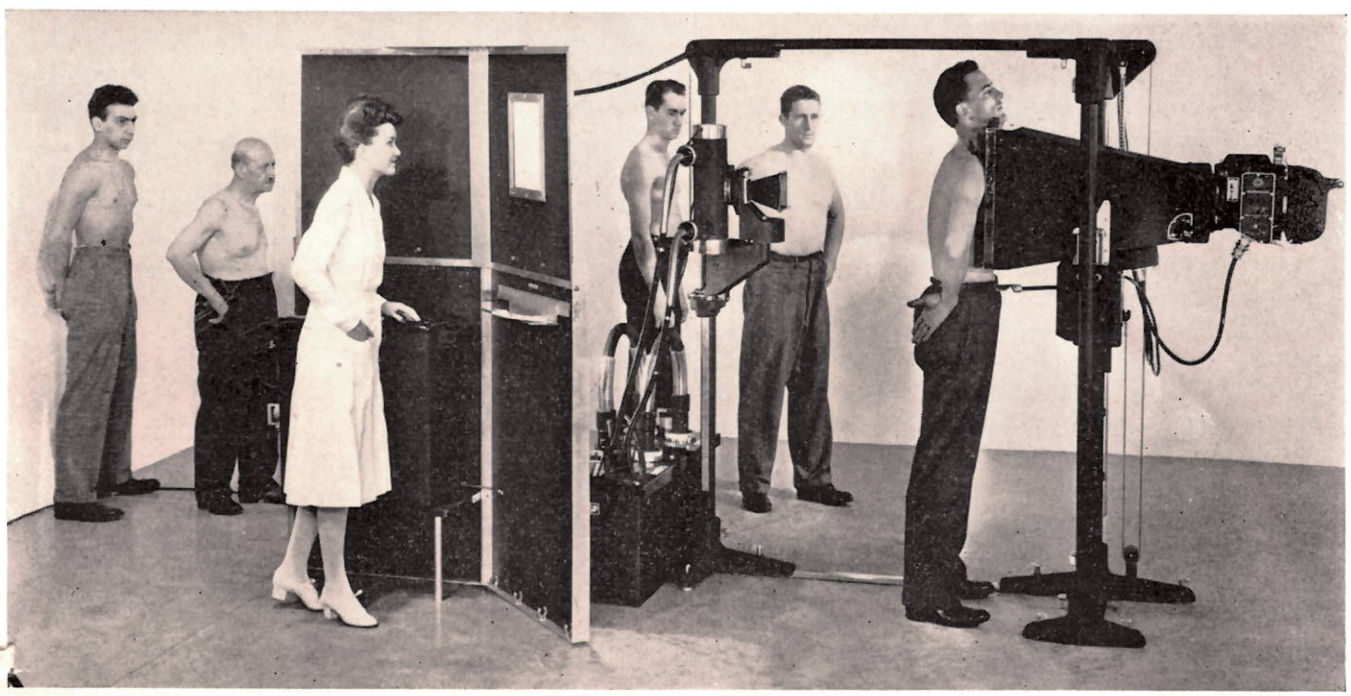
When the 70mm photofluorographic units became available in 1945, they immediately became a part of an all out war on tuberculosis. The United States Public Health Service conducted mass chest x-ray surveys in different sections of the country and encouraged the cities, counties and states to run their own anti-tuberculosis survey programs. At the same time, the National Tuberculosis Association was sponsoring similar programs and many tuberculosis societies used photofluorographic units in their survey work. The objective of this survey work is the complete eradication of tuberculosis, and the theory is that if enough cases can be detected and cured, the number of people spreading the disease will diminish and little by little the disease will die out. By the end of 1951 over 2000 photofluorographic units were in use by Federal, State, County and City Health Departments, tuberculosis associations, industrial plants, labor union health centers and commercial survey services working toward the same objective. Tuberculosis has not yet been eradicated, but it has been reduced considerably as can be seen from the tuberculosis deaths in the United States per 100,000 population: In 1945 the rate per 100,000 was 40.1—in 1950 the corresponding figure was 22.2.

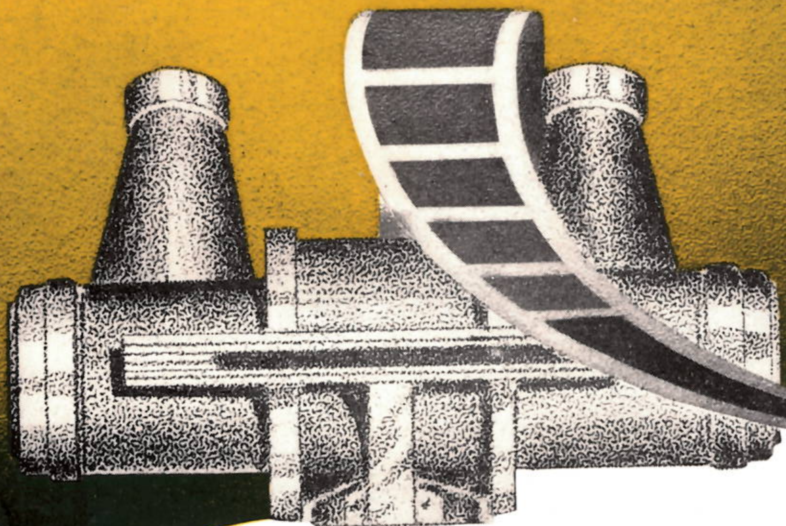
In chest surveys in large commmunities, it is common practice to install portable photofluorographic units for a few weeks in locations where many people gather, such as department stores and post office buildings. Another method is to bring the photofluorographic unit to the people in outlying districts by means of bus and tractor-trailer units. The photofluorographic units are the same whether set up in a building or used in a motor bus. The subject steps in front of the hood of the photofluorographic unit, presses his chest against it, holds his breath and waits for the x-ray exposure. One of these automatic photofluorographic units operated by only one technician can easily x-ray 800 to 1000 chests on an average day. Some days run higher and some lower than the above figures. One bus photofluorographic unit located in the town square of a moderate sized community operated from 10 A.M. until 10 P.M. and ran up a total of 2400 chest x-rays. This was averaging 200 exposures an hour, or 3½ per minute, for 12 hours. This work would not have been possible before the development of the modern automatic roll film photofluorographic units equipped with modern rotating anode x-ray tubes.

About two years after the new 70mm photofluorographic units became available for chest survey work, a new application for them was suggested. Radiologists at one of the large hospitals in New York City were interested in studying the heart and its associated blood vessels by angiocardio-

Continued on page 26

Figure 3—Chest survey unit in use in an industrial concern where time off the job must be kept to a minimum.





SERIAL RADIOGRAPHY

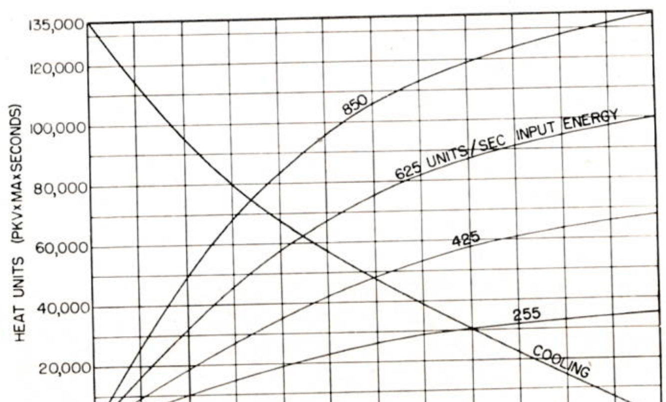
In the preceding article it has been shown that the roll film camera has been developed to the point where it is now possible to radiograph an entire group of individuals in a relatively short time. This has made possible the design of an x-ray installation that will meet the requirements of mass chest surveys where large numbers of the public are being checked for incipient tuberculosis. This type of installation places severe demands on the x-ray tube, because with the roll film camera it is now possible to make many exposures per hour. The Machlett Dynamax "25" has proven its ability to withstand the requirements of this type of service and indeed has established records for longevity, many tubes having been used in such applications for well over 100,000 exposures.

The roll film principle, as Mr. Seibert points out, has been incorporated into what may be called a roll film cassette which can be used to make radiographs directly on x-ray type film rather than by photographing a fluorescent screen using more conventional photographic methods. Accordingly, a roll film cassette may also be used to advantage in other radiographic applications. With this new cassette one or more radiographs can be made each second and a series of several seconds duration may be necessary to observe the passage of the opaque medium through the area being investigated. This means that the x-ray tube is subjected to a heat load that would be equivalent to several normal examinations crowded into a period of a few seconds. The amount of heat generated during such a series of exposures is far in excess of that which can be dissipated by conventional tubes including even the Dynamax "25."

The Machlett Super Dynamax was developed specifically to meet the requirements of techniques requiring high instantaneous loading and multiple exposures in rapid succession, and has an anode heat storage capacity of 135,000 heat units (PKV x MAS) and an overall, or housing, heat storage capacity of 1,250,000 heat units. This means that it can be used for a long series of angiographic type exposures without damage, i.e. 24 exposures at a rate of 2 per second, 100 PKV, 200 MA, 1/20 second each.

Along with its ability to absorb the heat developed during a series of exposures that comprise the examination of one patient, it is also important that the tube be capable of dissipating the heat at a rapid rate so that additional

Figure 1 — Super Dynamax anode thermal characteristics chart.



WITH THE SUPER DYNAMAX

by H. S. COOKE,
Assistant Manager of X-Ray Sales, Machlett Laboratories, Incorporated

Figure 2 — Radiographic rating chart for Super Dynamax 1.0 mm focal spot on full wave single phase rectification.

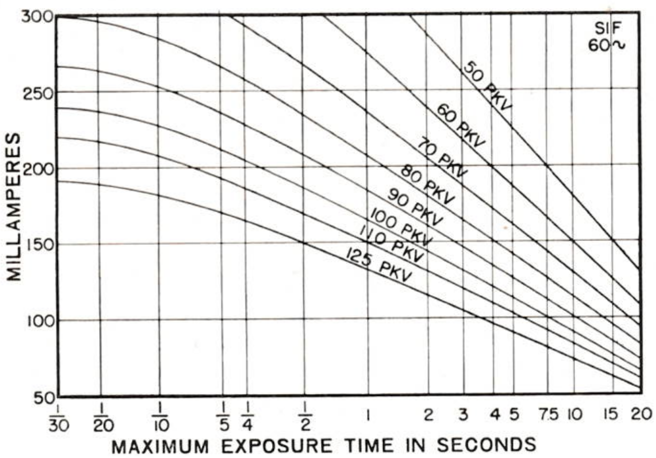
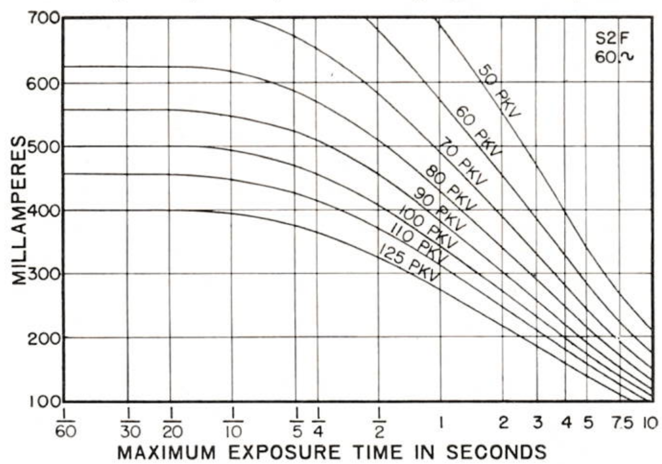


Figure 3 — Radiographic rating chart for Super Dynamax 2.0 mm focal spot on full wave single phase rectification.



examinations may be started without delay. Figure 1 shows the cooling characteristics of the anode of the Super Dynamax indicating that it dissipates all of its heat in a maximum of six minutes assuming that its full capacity of 135,000 heat units has been used. The usual type of angiographic series develops only 20,000 to 50,000 heat units. It can therefore readily be seen that this tube can be used for examination after examination without compromise when the time it takes to prepare a patient for this type of examination is taken into consideration.

Another important characteristic required by this type of application is the necessary use of high milliamperage, short duration exposures. Fractional second exposures are essential to eliminate blurring that would be present on the film as the result of the speed at which the opaque medium is carried by the blood through the organs being investigated. Figures 2 and 3 respectively give exposure ratings for the 1.0 mm and 2.0 mm focal spots of the Super Dynamax

Continued on page 30

by FOY D. KOHLER, Director, The Voice of America, as told to R. E. NELSON, Machlett Laboratories, Inc.

"THIS IS THE VOICE OF AMERICA . . .

. . . to promote a better understanding of the United States in other countries and to increase mutual understanding between the people of the United States and the people of other countries."

So reads the Smith-Mundt Act, known also as the United States International Information and Educational Exchange Act; it was passed on January 27, 1948. Under it the Department of State began to intensify its efforts to:

1. Strengthen the unity of those nations devoted to the cause of freedom and to show that their interests and those of the United States coincide.
2. Spread the conviction that the United States is an enlightened, strong, and determined power deserving the full support of other free nations.
3. Stimulate among free nations the building of the unified strength necessary to deter aggression and secure peace.
4. Develop and maintain psychological resistance to Soviet tyranny and imperialism.

Activities organized to accomplish the above objectives under the Information and Educational Exchange Program are carried on by the International Information Administration through media services:

- *The International Broadcasting Service (IBS)*
- *The International Press Service (IPS)*
- *The International Motion Pictures Service (IMS)*
- *The International Educational Exchange Service (IES)*
- *The International Information Center Service (ICS)*

Cathode Press is proud to present the first in a series of two articles prepared by State Department personnel to provide a more thorough understanding of the purposes, facilities and accomplishments of the Voice of America program. This first article by Mr. Kohler discusses the purposes to which this program is directed and the widespread operations necessary to achieve its aims.

The second article in this series, which will be published at a later date, will deal specifically with the technical aspects of Voice of America facilities, with particular emphasis on new developments.

FOY D. KOHLER

Foy D. Kohler, Chief, IBS, born Oakwood, Ohio, February 15, 1908. Graduated from Ohio State University in 1931 with B. S. degree. Appointed to U. S. Foreign Service in 1931, subsequently serving at Windsor, Bucharest, Belgrade, Athens, Cairo, London and Moscow. Served as Assistant Chief of Department's Division of Near Eastern Affairs, as Political and Liaison Officer at San Francisco Conference on the United Nations and as Secretary-General of the U. S. Mission to Observe Elections in Greece. Attended National War College. Served in Moscow successively as First Secretary, Minister-Counselor and Charge d'Affaires. Became Chief, IBS, November 1949.

There is also the Private Enterprise Cooperation Staff (ICO), which stimulates and guides cooperation from private enterprise to further the objectives of the Department of State's so-called "Campaign of Truth."

Major efforts have been concentrated on critical areas which are vital to world peace and to the security of the United States. These areas, comprising 31 countries, are divided into four main categories:

The first area is the hard core of the Soviet Union, which we must penetrate deeply.

The second area includes the satellite or captive countries, where millions of oppressed people still look with hope to the free world.

The third area is the crucial fringe of free peoples now living in the shadow of the Soviet threat but struggling desperately to maintain their independence.

The fourth area comprises those nations upon whose soil Communism has been planted and who are striving gallantly to weed it out.

The scope of activities of each major Service mentioned above is tremendous! Only a few aspects of the Voice of America (VOA) operation can be reviewed in this limited discussion.

The International Broadcasting Service (IBS)

"This Is The Voice of America"—with these words each broadcast, in any one of 46 different languages, goes "on-the-air," beamed to selected areas of the world—where there exists, outside North America, a total of 100 million radio receivers and a potential audience in excess of 300 million people.

About 125 separate programs, varying from 15 minutes to one hour and totaling nearly 50 hours, are prepared daily. Programs broadcast from the United States fall into three categories, balanced as follows:

News, 36 percent

Analyses and Features, 54 percent

(These include political commentaries, press reviews, roundtable discussions, and documentaries.)

Music, 10 percent

To the Iron Curtain areas, including China, the content is 48 percent news and 52 percent analyses and features. In addition, VOA sends regularly to missions abroad transcribed musical programs and special feature material for placement on overseas local radio stations.

Facilities

More than 365,000 words, which if printed and bound would make up the equivalent of five novels, go out daily over a vast network of about 75 domestic and overseas transmitters, both medium wave and short wave. There are 38 domestic transmitters, ranging in power from 50 to 200 kilowatts, located in the United States; 20 of these are located in the Boston-New York area for programs beamed toward Europe and South America, 8 in the Cincinnati area for broadcasts to Central and South America, and 10 in the San Francisco area for coverage of the Far East and also countries south of the United States. These facilities are licensed to private broadcasting companies and operated under contract with the Department of State. Additional stations are under construction in the States of Washington and North Carolina.

Relay stations at overseas bases, shown on the map of the "Voice's" global network, figure 1, pick up and simultaneously rebroadcast programs from the United States on medium and short-wave frequencies. Government-owned and controlled short-wave relay broadcast stations are located at Munich, Manila, Honolulu, and Tangier, and medium-wave stations at Munich, Salonika, and Manila. Other relay facilities are leased from Ceylon and from B.B.C. in Great

Britain. Selections of VOA programs are rebroadcast on medium-wave by 120 stations in Western Europe, over 100 stations in Latin America, and numerous stations in other parts of the world.

In addition to the direct broadcasts, the Voice of America repeats many of its programs from overseas relay bases. Programs to Russia are repeated around the clock in order to provide every possible means of getting through Soviet jamming. Counting both original broadcasts and repeats, about two-thirds of the Voice of America transmissions are directed to the Soviet orbit. The remainder of the broadcasts are beamed to friends in the free world in an effort to cement the friendship between their peoples and ours, to strengthen the elements favoring United States policies and democratic principles, and to enable them better to combat Communism and thus contribute to the mutual effort to maintain peace.

The question of effectiveness involves three main questions:

- **First, are we delivering a clear, strong signal?**
- **Second, are we getting an audience?**
- **Third, are we affecting the minds and influencing the actions of our audience in a sense favorable to the interests and aspirations of the free world?**

Development Of A Stronger, Clearer "Voice"

The importance of securing and maintaining effective radio penetration of the Iron Curtain cannot be overestimated. One obstacle to clear reception in the radio target areas includes electro-magnetic disturbances which circle the North Pole, interfering with the most direct and shortest transmissions to the prime audiences in Central Europe,

Figure 1 — "The Voice of America's global network of broadcasting facilities."

This Visualization of the world, on Mercator's Projection, aims to show at a glance how a vast array of transmitters and relay stations carries Voice of America programs in 46 languages to listeners everywhere.

For European countries, the programs are transmitted from stations in the United States located near New York City, Boston and Cincinnati, via directional antennas and with transmitters ranging in power from 20,000 to 200,000 watts.

The transmissions are beamed toward Europe, where a network of relay stations picks up and re-broadcasts the programs within dotted areas on the map. Short-wave relay stations are located at Tangier, North Africa, and Woofferton, England, while medium-wave transmitters are located in Munich, Germany, and Salonika, Greece.

Latin American programs are transmitted from short-wave stations located near New York City, Boston, Cincinnati and San Francisco to all countries south of the United States.

To Far Eastern countries the programs are broadcast from high-powered transmitters located near San Francisco, then relayed by shortwave transmitters at Honolulu, Manila and Colombo (Ceylon) and by a medium-wave transmitter at Manila.

The map indicates a considerable overlap of radio coverage from the various transmitters. Sometimes the overlapping areas indicate different language programs, and sometimes they indicate that a single language program is broadcast on several wavelengths, in order to give listeners a choice of the clearest signal in a locality. Vertical lines indicate Time Zones, with GMT at Noon and the International Date Line as a dotted line.

Figure 2 — View of typical VOA transmitter facilities at a short-wave station in the United States.

Russia, and a large portion of Asia.

In addition to this "electronic curtain," which results in a weakened signal, audio distortion, and static at the receiver end, is another which is Russian-made—jamming, referred to previously. This type of interference, heard as unpleasant noises and distractions, is transmitted at the same frequency as the Voice program which the Russians wish to make unintelligible. Soviet jamming of the Voice of America programs has been intensified to the extent that nearly 250 sky-wave jamming installations have been identified; in addition, it is estimated there are in operation at least 1000 ground-wave jammers in the heavily populated areas. The Voice, as well as other similar broadcast systems friendly to the West, can change transmitting frequencies in order to dodge jammers; however, such a procedure is temporary in effect and loses audience for portions of the program.

The most effective way of overcoming the jamming handicaps is with more power, and the Voice has a project directed to that end. With the collaboration of the best electronic engineering groups in the country, we are pioneering in advanced techniques and super-power in order not only to provide a more intelligible signal but to blast our way through the northern auroral interference zone directly to Europe and Asia and also overcome to some extent the effects of Soviet jamming.

Already under operation-tests is the first of several 1000 kilowatt medium and short-wave transmitters operating as relay stations as well as for direct transmissions.

Figure 3 — Short-wave station buildings and antennae at an overseas relay base.

Figure 4—Transmitter control room with master control console in an overseas relay station.

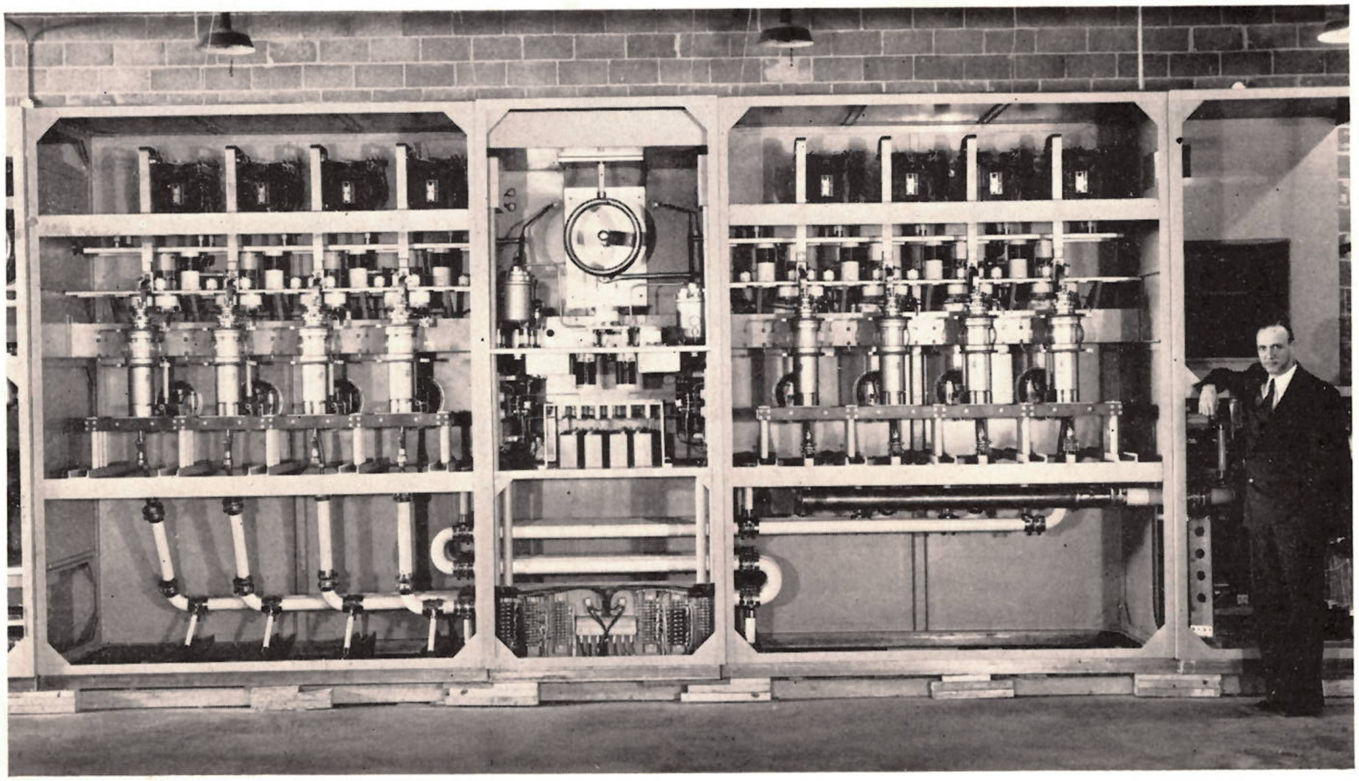


Figure 5 — View of 500 kilowatt section of mega-watt transmitter. Eight Machlett ML-5682 tubes are shown mounted in the Doherty high efficiency amplifier.

The effective radiated power of the super-power radio stations in the United States, called project "Baker," is further increased by their use of high-gain curtain-type directional antennae (Figure 6). The combination results in a radio signal, in the direction in which it is beamed, approximately 4000 times as strong as that of the most powerful commercial broadcast transmitters in the United States.

It is expected the super-power transmitters in the United States will give us direct transmissions to the oppressed peoples of Europe and Asia even though the relay bases be rendered inoperable by Communist action.

Another method of getting VOA broadcast transmissions through to the critical areas vital to world peace, in spite of auroral or sunspot activity and jamming, makes use of relay stations, indicated in figure 1. These relays serve to rebroadcast immediately, and sometimes on a repeat basis, programs originated in the United States around disturbing electro-magnetic conditions surrounding the North Pole and at multiple medium and short-wave frequencies to complicate as much as possible Russian jamming. To improve on the effectiveness of these facilities the Department of State is constructing five additional very-high-power relay stations.

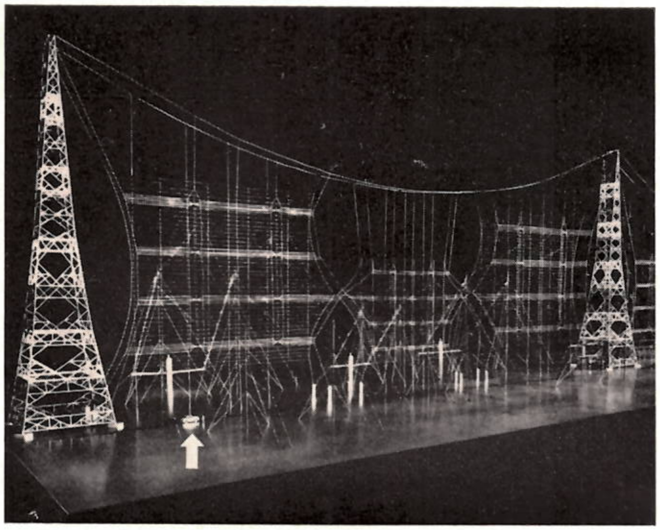
A typical overseas relay base includes: a transmitting plant with at least one very-high-power medium or short-wave transmitter; at least two high-power short-wave transmitters; communication transmitters, associated high gain antenna systems, and power generating equipment; and a receiving plant with a number of the most modern receiving units. The power requirements are comparable to those of a good size community, and the necessary power plant is a wholly separate and self-contained diesel operation.

In addition to "Baker" are two other facilities projects, named "Ring" and "Vagabond." "Ring" calls for fourteen short, medium, and long-wave relay broadcast stations around the Communist dominated domain. "Vagabond" calls for the use of fast sea-going vessels to carry powerful relay stations which are also capable of originating programs. Since the most ideal location for a jamming transmitter is close to a Voice of America transmitter, "Vagabond" complicates the Communist jamming system by transmitting from varied strategic waterways of the world.

The Audience

With respect to getting an audience, it is extremely fortunate that radio is an established and highly developed medium of communication even in relatively backward areas of the world. Either firm figures or informed estimates are available as to the number of radio receivers which can be reached throughout the world. Outside North America there are about 100,000,000 receiving sets, giving international broadcasters a potential audience of more than 300,000,000 people, not to mention secondary distribution, such

Figure 6 — 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.



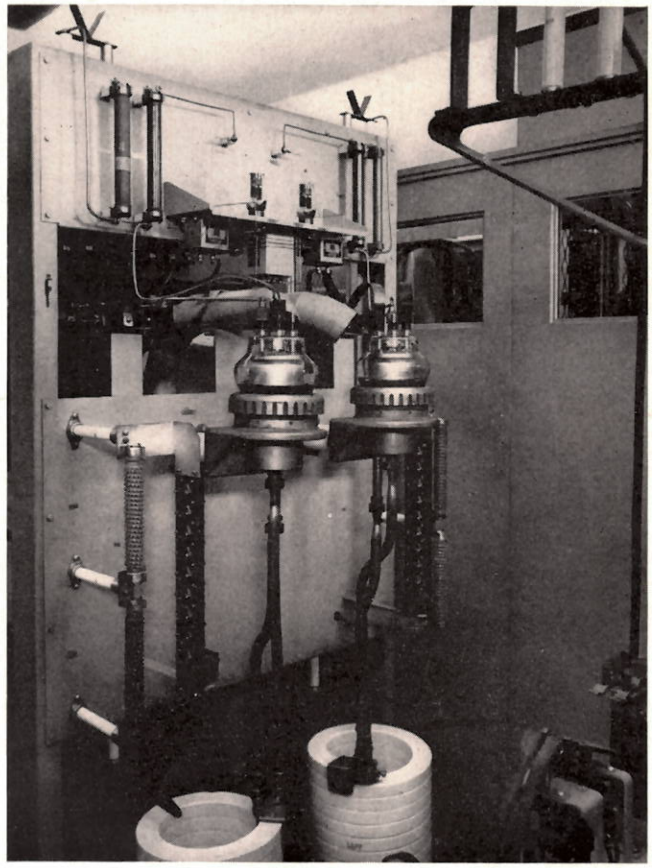


Figure 7 — View of Modulator Section using ML-5658 Electron Tubes in 50 Kilowatt Short-Wave Transmitter.

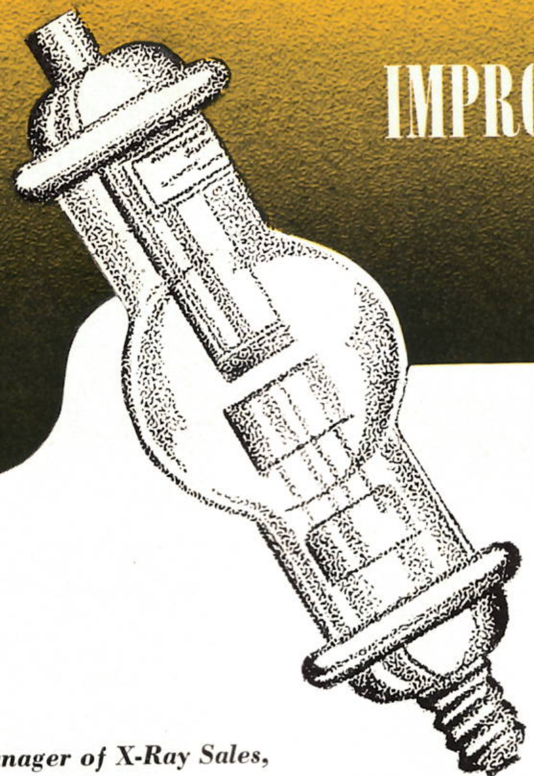
as newspapers and word-of-mouth, which is extremely high via the existing grapevines in every totalitarian country. In the free world it is possible to adapt and apply the techniques of quantitative audience surveys so highly developed in the United States. These provide an accurate measure of the size, composition, and characteristics of our audiences. For the most part such surveys are conducted by private contractors including such organizations as American Institute of Public Opinion (Gallup) and its overseas affiliates and the Bureau of Applied Social Research of Columbia University.

In addition to these surveys, letters from listeners, efforts by the Communist press and radio to discredit the broadcasts, interviews with Iron Curtain defectors, the reports from United States missions abroad, correspondents and travelers provide convincing evidence of a regular listening audience of many millions. Letters from listeners total as many as 40,000 in a month. Program schedules are published in twelve language editions, including English, and are available upon request to overseas listeners. These schedules are distributed to a mailing list of about 1,250,000.

In the Soviet Union in the early days of our Russian language broadcasts, which were inaugurated in February 1947, all the evidence which could be amassed at the Embassy in Moscow indicated that the Voice had a regular listening audience of at least 10,000,000 people. Since the Kremlin launched its colossal jamming campaign in April 1949, it is impossible to estimate the audience accurately although much favorable evidence is available from indirect sources. Monitoring reports show that the programs can be heard about 26% of the time even in Moscow, where the heaviest jamming is concentrated, and 60% to 80% of the time in other areas of Russia. Defectors continue to provide evidence of widespread listening and the Soviet press and radio contribute additional evidence. During 1951 Radio Moscow attacked the Voice 312 times in an effort to discredit and refute the broadcasts, and Tass press transmissions carried 23 attacks which were printed in hundreds of provincial newspapers. Similar attacks are made on a continuing basis in all of the satellite countries. Even if the broadcasts were not getting through the Communist press and radio, in their effort to refute the programs, repeat enough of the content to make the broadcasting worthwhile.

Continued on page 28

IMPROVING THE LIFE OF



by ***H. S. COOKE, Assistant Manager of X-Ray Sales, Machlett Laboratories, Incorporated***

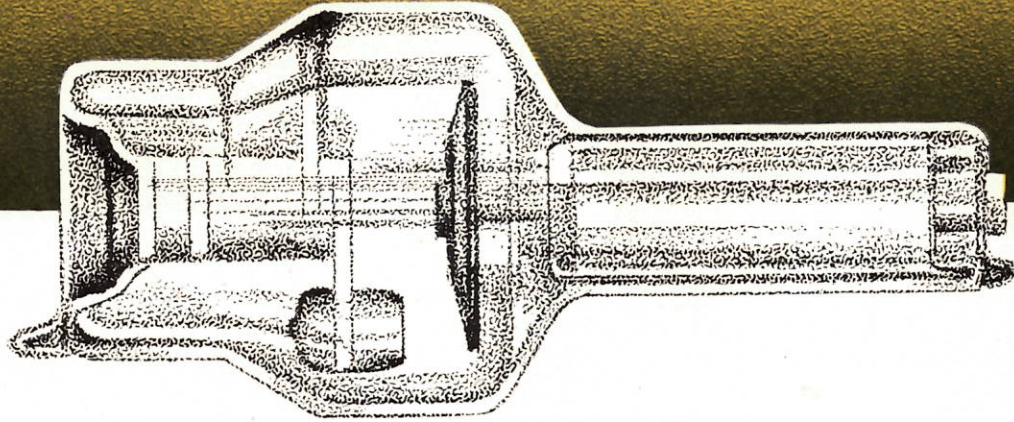
The average life of the x-ray and valve tubes that are used in x-ray machines can generally be increased if an understanding is gained of the natural laws that govern the life of an electron tube and if a few simple precautions are observed on the part of the user and the serviceman. It is also important that the ratings of the tubes and valves are understood and adhered to. Inspection of many x-ray and valve tubes over a period of years shows clearly that the life of a large portion of these tubes has been shortened by improper operation, by improper adjustment of the operating parameters, and by exceeding the ratings of the tubes with respect to either voltage, current, or heat storage capacity.

It is possible here at Machlett Laboratories to make a very accurate analysis of the factors that have contributed to the failure of the tube in the field because of the method by which replacements are handled. Machlett shockproof x-ray tubes are sold as a complete factory sealed unit so that when replacement is required, a complete new unit is installed in its place. The old tube in its complete form is then returned to the factory for credit allowance and inspection, this makes possible the examination of each shockproof tube that has failed regardless of reason and the determination of those factors which have contributed to its failure. In the case of valve tubes, those units which have not given satisfactory life are returned for inspection, and from time to time sample groups of all valves which have reached the end of life are returned from large users to give a broad picture as to which factors have contributed to ultimate failure. Analysis of the records of x-ray and valve tubes that have been returned from the field indicates that in a large percentage of these cases the life could have been improved by proper operation, a proper regard for the ratings of the tube, and correct adjustment.

It is hoped that by pointing out the reasons for premature failures and discussing conditions that govern the life of high vacuum pure tungsten filament tubes, the user and the x-ray serviceman will be able to reduce greatly the number of such failures, and thus gain the optimum in tube life, performance and reliability.

Damage to x-ray tubes and valve tubes, resulting in either shortened life or complete destruction, can be brought about by one or more of the following: (1) excessively high filament temperature for too long a period of time, (2) overheating or overloading the anode, (3) application of excess anode voltage, (4) gas accumulation, (5) mechanical damage. Inspection of x-ray and valve tubes that have been returned from the field which have not given satisfactory life proves that a large percentage of them have failed because of the first factor mentioned, "excessively high filament temperature for too long a period of time". X-ray tubes and most x-ray valve tubes have filaments which are made of pure tungsten wire. In order to liberate the quantity of electrons that are required for the production of x-rays in one case and to allow proper functioning of the valve in the other case, this tungsten wire is heated to a temperature of approximately 2500°K. At temperatures of this magnitude the tungsten wire gradually vaporizes or boils off the metallic tungsten to such an extent that the filament wire diameter is reduced to a point where the filament is no longer usable. With a properly designed filament operating at normal tempera-

X-RAY AND VALVE TUBES



tures, this vaporizing process can last for 1000 to 2000 hours before the tube becomes unusable. This boiling off of tungsten in the form of tungsten vapor follows a natural law that is directly related to time and temperature only and is not influenced by other considerations. In other words, the filament vaporizes away without regard to any other function of the tube, assuming, of course, that the tube has been properly processed and outgassed. When we consider that the average x-ray tube filament is approximately .0085″ in diameter and that it requires only a 10 per cent reduction in that diameter to cause destruction of the tube, it can be seen that extreme care is necessary in order to obtain maximum life.

Figure 1 — Life versus filament current for 2.0 mm focus of rotating anode tube.

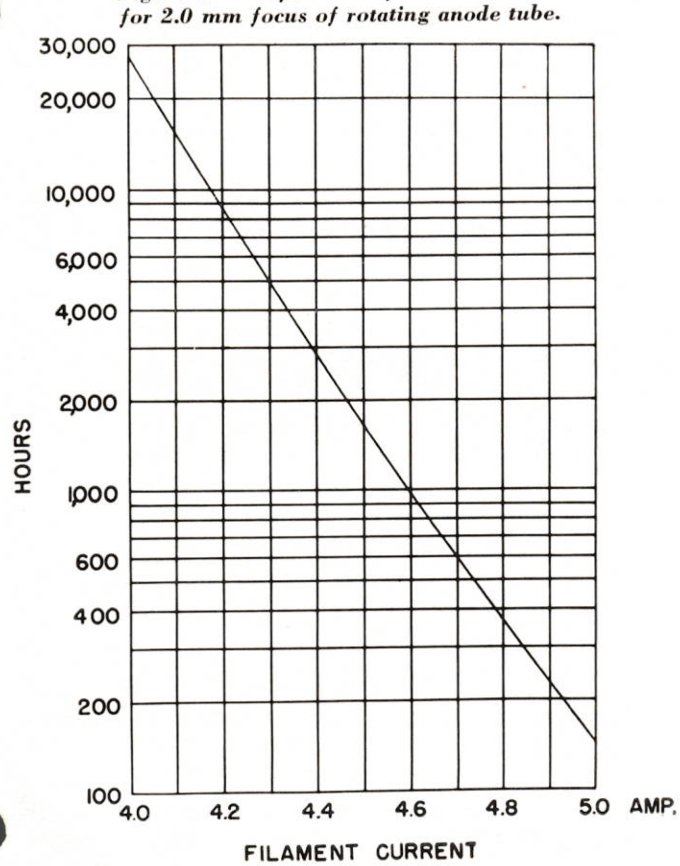


Figure 1 indicates what happens to the life of the large filament of a rotating anode tube as filament current is increased. Figure 2 indicates the life expectancy of the filament of a typical valve tube. These curves show clearly that as filament current and voltage are increased, filament life is reduced at a very rapid rate and that the rate of evaporation increases even more rapidly than the electron emission as the temperature is increased. On the curve shown in Figure 1, 4.0 amperes is equivalent to a current of approximately 50 milliamperes through the x-ray tube and at this temperature the filament will give approximately 27,000 hours of life. On the other hand, 4.8 amperes filament current (equivalent to 500 milliamperes through the x-ray tube) will give only 350 hours of life, so that a ten times increase in milliamperage through the tube reduces the life by approximately 99 per cent.

From Figure 2 it will be seen that at 10.0 volts on the filament, which represents a filament temperature that will permit loads of up to 50 MA to be passed without damaging the tube, 100 per cent of normal life (approximately 2000 hours) will be obtained, whereas with a filament setting of 12.0 volts, which represents the required filament setting to pass 500 milliamperes, only 10 per cent of normal life will be obtained. If the maximum continuous rating that an x-ray tube would be used for is in the order of from 3 MA to 5 MA, a standby setting of the valve filament may be used which is lower than that normally recommended. In the case of the Machlett ML-1 valve whose life characteristics are shown on Figure 2, the recommended standby filament setting is 10.0 volts. When this valve is used in a radiographic machine, which will require no more than 5 MA continuous output, a standby setting of 9.0 volts to 9.5 volts would be satisfactory. This range is indicated because a minimum of 9 volts would be necessary to insure emission and could be recommended if stabilized line voltage is available. If, however, there are line voltage fluctuations, valve filament settings in this case should be such that valve filament voltage will not fall below 9.0 volts during maximum line voltage swings. Considering that filament life of both the x-ray and valve tubes is so seriously shortened by the temperature that is required for high milliampere exposures, it becomes absolutely necessary to operate filaments at these high values for the shortest possible time. To assure the user that a maximum of possible life is obtained, the more modern x-ray machines use a filament boosting circuit to reduce the time to a minimum during which filaments are heated to the temperatures required by high milliampere exposures. Rotating anode tubes are being used for radiography at an ever increasing rate so that the filament boosting circuits on the newer x-ray machines are controlled by the same equipment which is used to start the anode of a rotating anode tube and allow a long enough time delay for the anode to achieve maximum speed before the exposure is made. This time is generally in the order of 1 second and is long enough for the filament temperature to rise from a standby value to that required for a high milliampere exposure. This same equipment then reduces the filament temperature immediately after the exposure is completed so that filaments are operated at elevated temperatures for the shortest possible time. Therefore, it becomes good economics to have a properly adjusted filament boosting circuit incorporated into the x-ray machine. Where the x-ray machine does not have boosting equipment, it is imperative that the filaments of the x-ray and valve tubes be operated for the shortest possible time at elevated temperatures, and that extra care be taken to see that the filament voltage is reduced to a standby value immediately after each exposure.

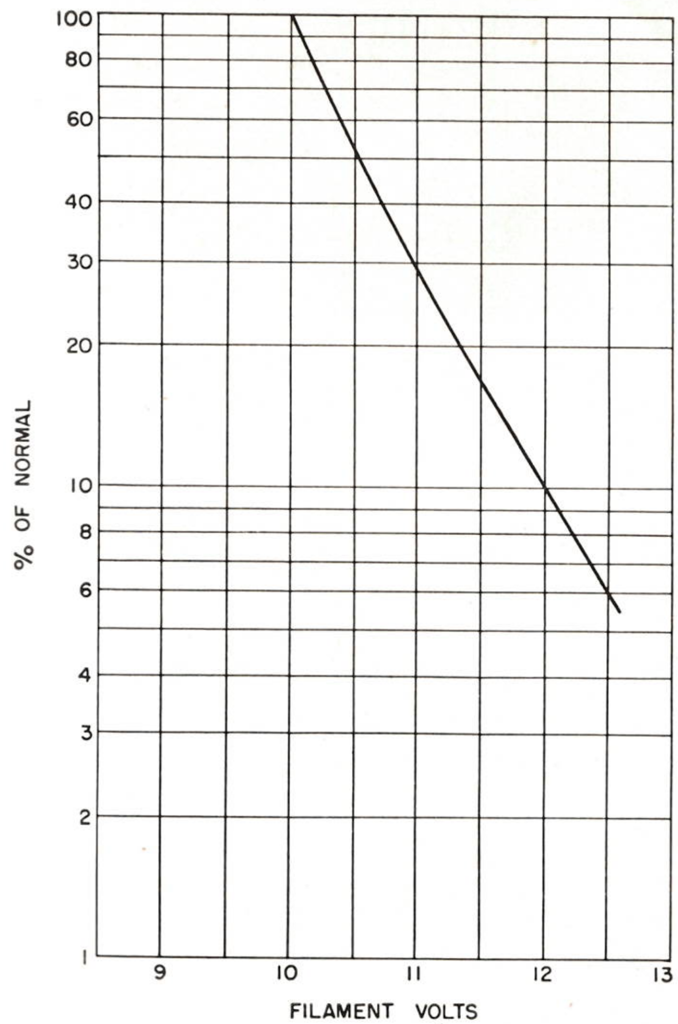


Figure 2 — Percentage of normal life of valve tube filament versus filament voltage.

Overheating or overloading the anode is responsible for shortening or ending the life of tubes and valves in a significant number of instances. In fact, approximately twenty per cent of the tubes returned have been damaged in this fashion. In an x-ray tube anode, overheating or overloading can be the result either of operation of the tube at excessive milliamperage for one exposure, or of a series of exposures which exceed the heat storage capacity of the anode. Maximum ratings for a single exposure and the maximum heat storage capacity are very carefully specified by the tube manufacturer so that such damage is the result of carelessness, lack of understanding of the ratings or malfunctioning of the equipment. Anode overheating or overloading can result in one or more of the following: liberation of gas from the anode which can result in puncture of the glass envelope or operational instability, mechanical destruction which could be in the form of the melting of the focal area; destroying the glass-to-metal seal by overheating; or damage to the bearing system in the case of a rotating anode tube. In many cases, this kind of damage may not be so severe as to cause complete failure, but the overheating will result in a general reduction in efficiency of the tube with respect to radiation output as a result of metallic deposition on the glass wall and subsequent electrical instability.

In a valve tube, anode overheating may be the result of insufficient filament voltage which tends to increase the losses within the tube which in turn overheats the anode and subsequently destroys the filament by electron emission from the overheated anode in a reverse direction. This kind of damage can be avoided by careful adjustment of the filament voltage considering line drop during the radiographic exposure and by operation of the valve within its published ratings.

An example of a situation where many tubes have been damaged by overheating has been brought about by the ever increasing tendency on the part of users to increase the number of spot films that are being taken in conjunction with a fluoroscopic examination. Figure 3 shows the anode thermal characteristics chart for a Machlett Dynamax "26"

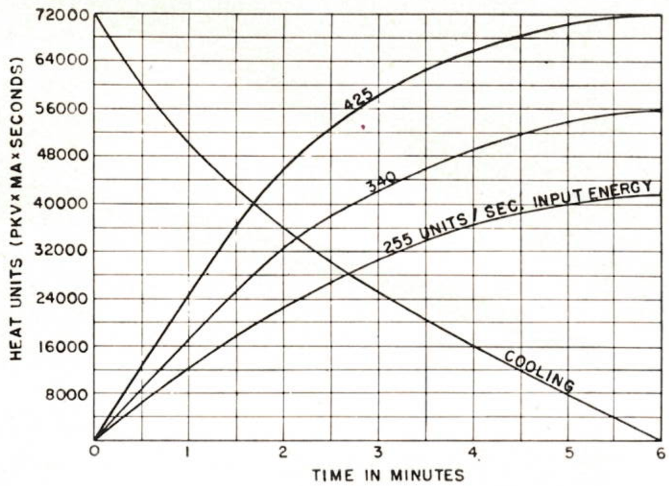


Figure 3 — Anode thermal characteristics chart for Dynamax "26."

rotating anode tube. This chart has three lines, one indicating the load that the anode is subjected to as a result of fluoroscopy at 85 PKV, 5 MA, which equals an input of 425 heat units per second (the heat unit being equal to kilovoltage times milliamperage) a 340 heat unit per second line indicating loading as a result of fluoroscopy at 85 PKV, 4 MA and a 255 heat unit per second line for fluoroscopy at 85 PKV, 3 MA. Even though the Dynamax "26" has a fluoroscopic rating of 85 PKV, 5 MA for 30 minutes continuously, spot film exposures can not be made after six minutes of fluoroscopic time has been used without damaging the anode. In other words, to make combination fluoroscopic and spot film examinations it is necessary that a fluoroscopic load of 85 PKV, 4MA be used or spot films be made at the end of two or three minutes of fluoroscopy. This example serves to illustrate the point that heat capacity of an x-ray tube can be exceeded quite easily if proper consideration is not given all of its ratings.

Another factor that quite often plays a part in reducing the life of both x-ray and valve tubes results from the application of excess anode voltage. Applying higher than rated anode voltage may be caused either by surges in the high voltage circuit as a result of unstable line voltage, or gassy tubes in the circuit, or by deliberate application arising from either misreading meters or experimental work which exceeds the rating of the tube. Quite often users of x-ray equipment will experiment with new techniques that are beyond the capacity of the tube. Even though x-ray tubes and valve tubes are designed to have a certain degree of "safety factor" with regard to the voltage rating, the tungsten vapor which is continually being given off by the filament, as explained previously, tends to deposit on the glass walls reducing the dielectric strength of the tube envelope. Thus, it is quite often the case that new tubes will withstand excess voltage to a greater extent than will tubes that have been operated for a period of time. If an x-ray machine gives indication of unstable operation, it is wise to discontinue use of the machine until the reasons for this condition can be found as almost inevitably either an x-ray tube or a valve will be damaged by the voltage surges that result from unstable operation.

The next factor mentioned in the list of basic causes for premature tube failure is "gas accumulation". Gas accumulation generally results from either overheating or overloading the elements of a tube, or is the result of a puncture caused by excess anode voltage or it may be the result of extended shelf life. While modern x-ray tube can be stored in an unused condition for long periods of time, it is generally desirable that they be operated at least every six months if it is at all possible. The gas that becomes apparent as a result of extended shelf life generally comes from those metallic parts of the tube which are not heated during the exhaust process and which have absorbed and adsorbed a certain amount of gas during processing. High voltage tubes, such as those used in therapy equipment, are more sensitive to small amounts of gas that might evolve during storage so it is necessary that these tubes be operated at low voltage until

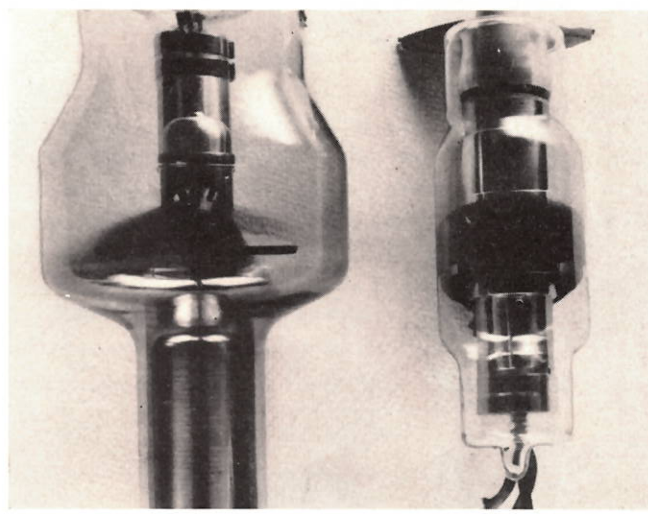


Figure 4 — Tungsten vapor deposit on glass envelope of x-ray tubes indicating excessive filament temperature.

this residual gas has been redistributed to areas where it can do no harm.

The last factor mentioned among those which contribute to shortened tube life is "mechanical damage". Mechanical damage can take many forms and it can affect either the tube insert or the tube housing and is generally the result of rough treatment during shipping, installation, or use. X-ray tubes and valves are relatively fragile objects and should, of course, be handled with great care at all times.

In most cases where tubes have failed, the physical evidence gives a concise indication as to the reason for failure. Due to the very large number of tubes that are manufactured by this organization and because of the unique method of

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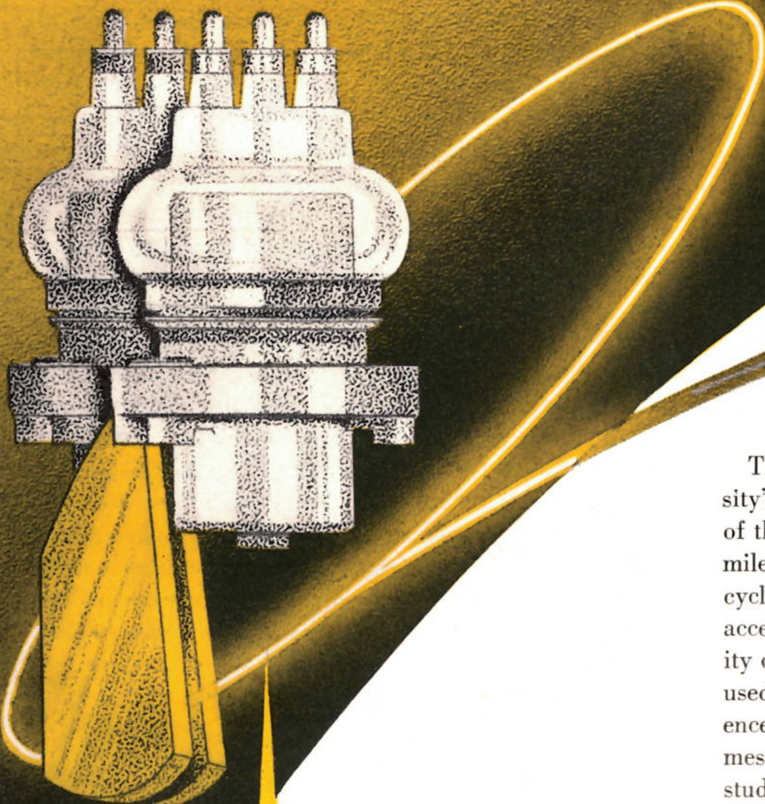


The Nevis Laboratories, which house Columbia University's large proton synchrocyclotron, are on the east bank of the Hudson River in Irvington, New York, about twenty miles north of New York City. This frequency-modulated cyclotron is one of the largest of its kind in the world, accelerating protons to an energy of 385 Mev., and a velocity of seven tenths that of light. The cyclotron is now being used as a source of pi mesons, particles whose very existence was not known before 1947. The properties of these mesons are being studied by faculty members and graduate students of the Department of Physics of Columbia University, under the joint sponsorship of the Office of Naval Research, the Atomic Energy Commission, and Columbia University.

The cyclotron accelerates protons by means of a series of electrical kicks, furnished by an oscillator. The protons are constrained to move in a series of semi-circles of gradually increasing diameter by a large electro-magnet. After approximately 100,000 revolutions, a distance of some 200 miles, and about 8 milliseconds, the protons strike a beryllium target and produce mesons. These mesons are subnuclear particles first observed in cosmic rays. Negative, positive, and neutral mesons are created in the collision from the kinetic energy of the protons. On a very small scale, this reverses the reaction of an atomic bomb, as matter is created out of pure energy. Streams of the charged mesons are focused by the magnetic field of the electromagnet, and emerge into the experimental area through slits in the lead and concrete shielding.

The major component of the cyclotron, at least by weight, is the magnet. This is a 2000 ton electromagnet, resting on reinforced concrete piers extending to bedrock. As the magnet is energized with direct current, it is made of solid steel, and is not laminated as in a synchrotron or betatron. A 600 kilowatt synchronous motor-generator set supplies 2000 amperes to give 1.2 times 10^6 ampere-turns, and an average magnetic field of 17 kilogauss over a diameter of 164 inches and an air gap of 18 inches. The magnet coils are cooled by transformer oil, which is in turn cooled by 1000 gallons of water per minute from the Hudson River.

WARREN F. GOODELL, JR.

Native of Illinois. B. S. University of Illinois 1944 in Engineering Physics. Radiation Laboratory at M.I.T. 1944 to 1946 doing development work in microwave radar, in particular timing and display circuits. A.M. in Physics at Columbia 1947, PhD in physics, Columbia 1951. Thesis on high energy neutron energy distributions. Assistant in Physics, Lecturer in Physics, Research Assistant in Physics, now Assistant to the Director, Nevis Cyclotron Laboratory since 1951. Tau Beta Pi, Phi Kappa Phi, Sigma Xi, American Physical Society.

THE NEVIS CYCLOTRON

The mass of the accelerated protons becomes appreciably greater than the rest mass as the velocity of the protons becomes comparable with that of light. Due to this relativistic effect, the length of time needed for the protons to traverse a given semi-circle of path becomes greater as the diameter of the semi-circle increases, although the velocity of the particles is also increasing. Since the protons are accelerated by the oscillator every half revolution, the increasing time of travel is reflected in a decreasing frequency of the oscillator. This requires that the oscillator be frequency modulated.

The oscillator consists of two Machlett type 5658 air and water cooled transmitting tubes operated as a multiple-tube grounded-grid oscillator. The triodes are coupled by transmission lines to the accelerating electrode, or dee, of the cyclotron. This dee may be considered as an end-loaded quarter-wave line, whose resonant frequency is determined by variable condensers. The dee serves as the tank circuit of the oscillator. To avoid unwanted modes of oscillation, one of the tubes drives the upper section of the dee and receives its cathode excitation from the lower section, while the other tube is connected in a reverse manner. The tubes operate in parallel.

The rotating condensers are located along a diameter of the magnet, rather than outside of the magnet, as in all other cyclotrons (Fig. 3). This allows a more complete separation of the oscillator tubes and components, and the resonant circuit. It also permits a smaller and more compact oscillator cabinet, and permits the tubes to be located farther from the magnet. The tubes are then shielded from the remaining magnetic field of a few hundred gauss by magnetic stainless steel water jackets. After a period of debugging, the oscillator and associated circuits are now very stable, and operate with an input power of approximately 10 kilowatts. Plate voltage is supplied by a half wave three phase rectifier using mercury vapor rectifiers.

The rotating condensers are 18 foot hollow water-cooled shafts $1\frac{1}{16}''$ in diameter, with each shaft carrying approximately 300 four-winged butterfly blades. These blades couple two sets of stators by varying amounts, and the rotation results in a frequency swing of from 29 to 17 megacycles. The modulation frequency is variable from 30 to 90 cycles per second, requiring a speed of rotation of the condenser of from 450 to 1350 rpm. The condenser bearings are bronze and stainless steel journal bearings, lubricated with a thin film of Teflon.

The region in which the protons are accelerated must be evacuated to reduce the probability of nuclear scattering of the protons during their 200 mile journey. This space between the pole tips is enclosed by a stainless steel vacuum chamber roughly 18 feet square, and is evacuated by two 32″ oil diffusion pumps to a pressure of a few times 10^{-6} millimeters of mercury. To reduce the time necessary to evacuate the chamber after it has been opened to air for any length of time, the vacuum chamber is thoroughly cleaned with a vacuum cleaner.

Sweeping grids are installed inside the resonant cavity of the dee to remove oscillating electrons and heavy ions. A high positive constant voltage sweeps these ions from the chamber, and prevents ion loading of the oscillator.

A tungsten filament provides electrons for a low voltage arc to ionize atomic hydrogen and furnish the protons to be accelerated. The filament is heated by a 180 kilocycle oscillator, employing a Machlett type 240B tube. Several probes and vacuum locks are provided to allow interchanging targets. One target is mounted on a trolley-cart which

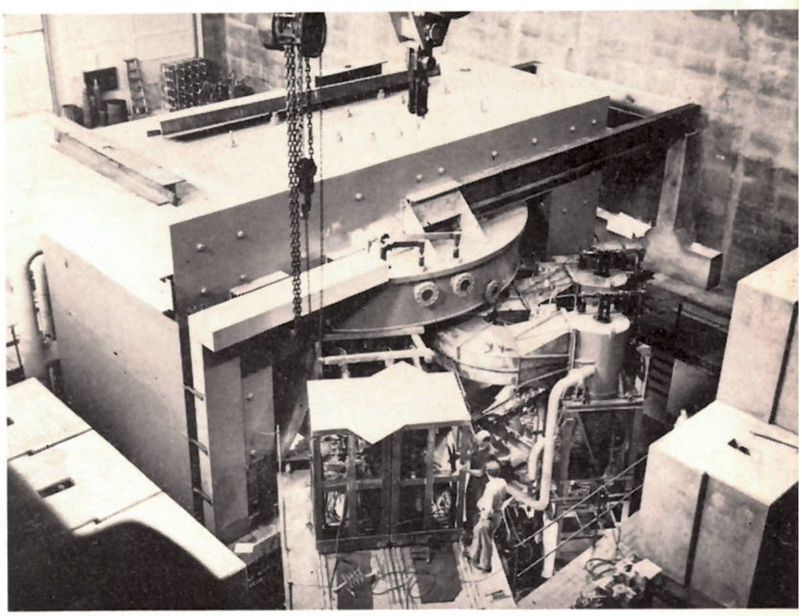


Figure 1 — General view of oscillator (left), vacuum pumps and condenser drive (right), magnet and shielding.

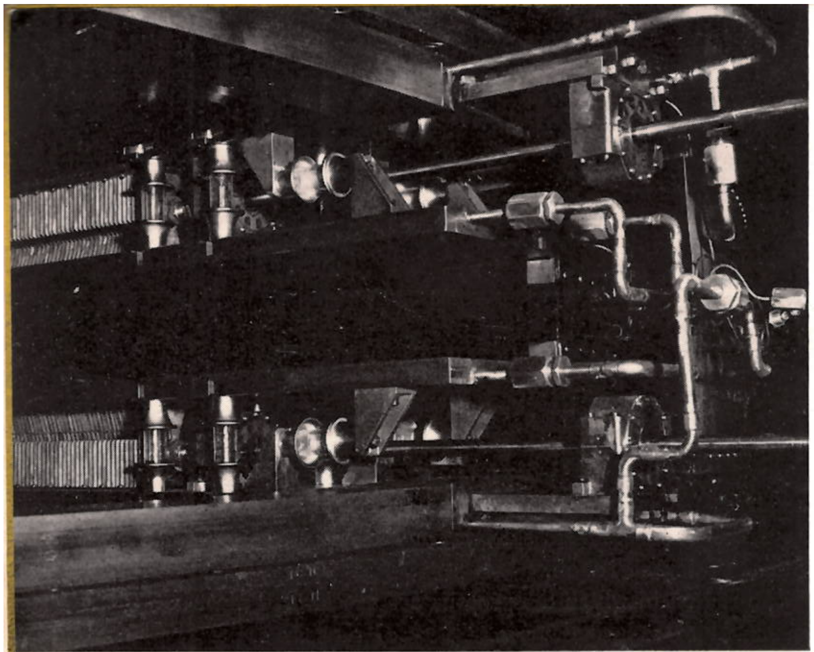


Figure 2 — Interior of the vacuum chamber and two rotating condensers.

is driven by the interaction of currents in coils mounted on the cart and the main magnetic field of the cyclotron. At present, beryllium targets are the most frequently used, although special targets have been used for chemical and nuclear emulsion research.

The cyclotron is surrounded by a six-foot wall of concrete shielding to reduce the intensity of background radiation in the experimental area and the remainder of the building. The blocks of shielding weigh up to 25 tons, and have a total weight of 2000 tons. They are moved about when necessary by a 40 ton crane spanning the building. This crane also is used to move experimental equipment such as a 30 ton cloud chamber magnet.

The beams of mesons previously mentioned emerge through slits in this shielding. These beams contain mesons of energies ranging from 70 to 150 Mev., and have an intensity between 100 and 1000 mesons per square centimeter per second. Neutron and scattered proton beams are also available, with an average of 10^4 to 10^5 particles per square centimeter per second. These particles are detected by various means, the most popular at present involving scintillation counters. These are organic crystals that emit a flash of light whenever a charged particle passes through them. The flashes of light are detected by photomultiplier tubes. By studying the coincidences between flashes from various crystals, the number of particles traversing the crystals in any given direction may be determined, as may the velocity of the particles. The mesons are allowed to fall on targets of various materials ranging from liquid hydrogen to lead, and the resulting scatterings and absorptions are studied. As pi mesons were discovered only five years

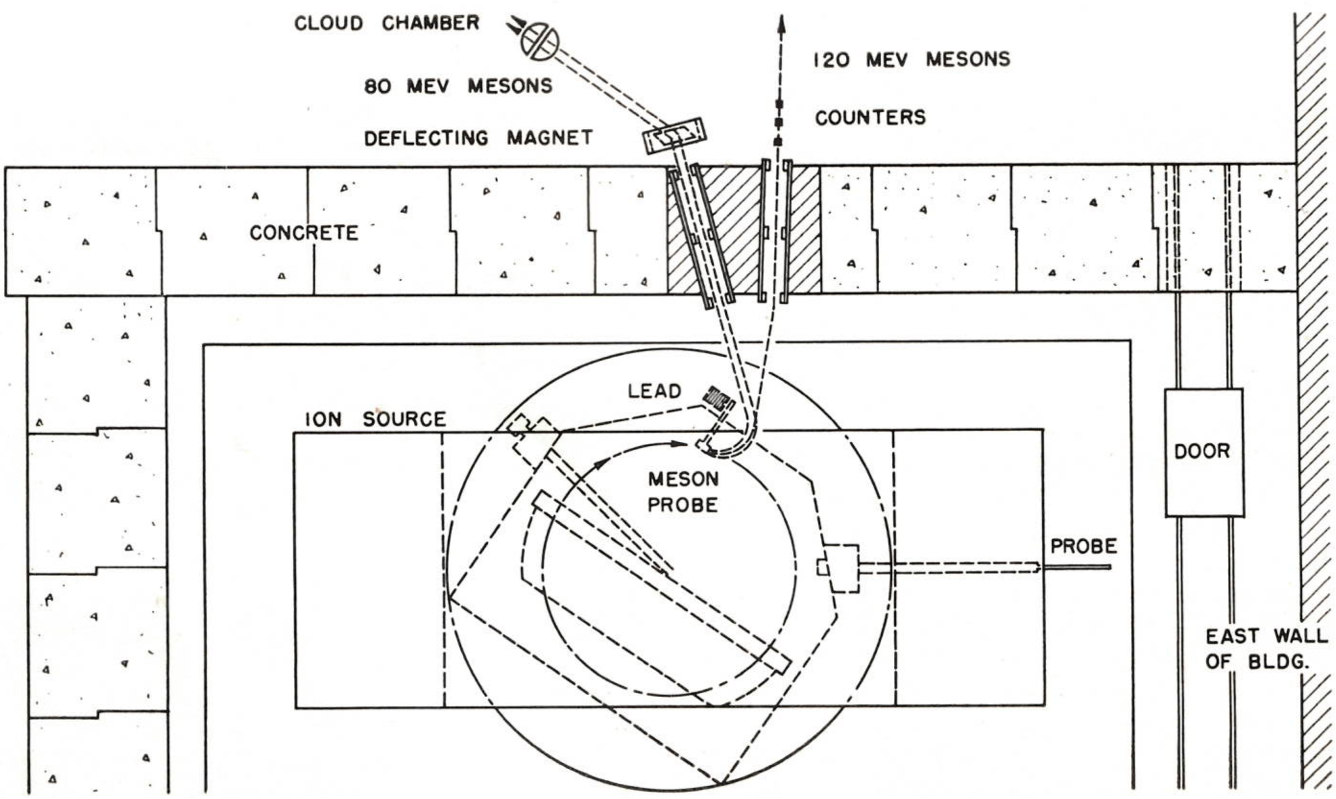


Figure 3 — Plan view of the cyclotron, showing proton and meson trajectories.

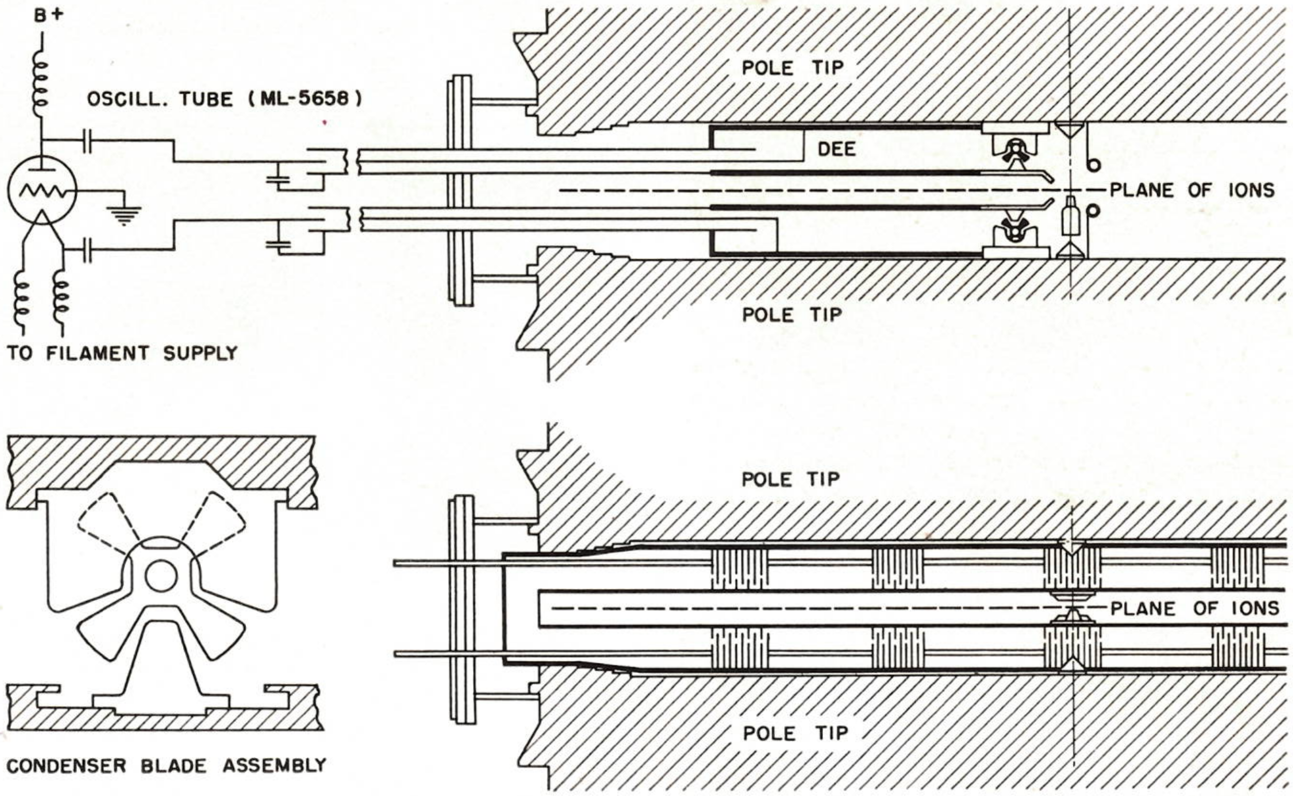


Figure 4 — RF system schematic.

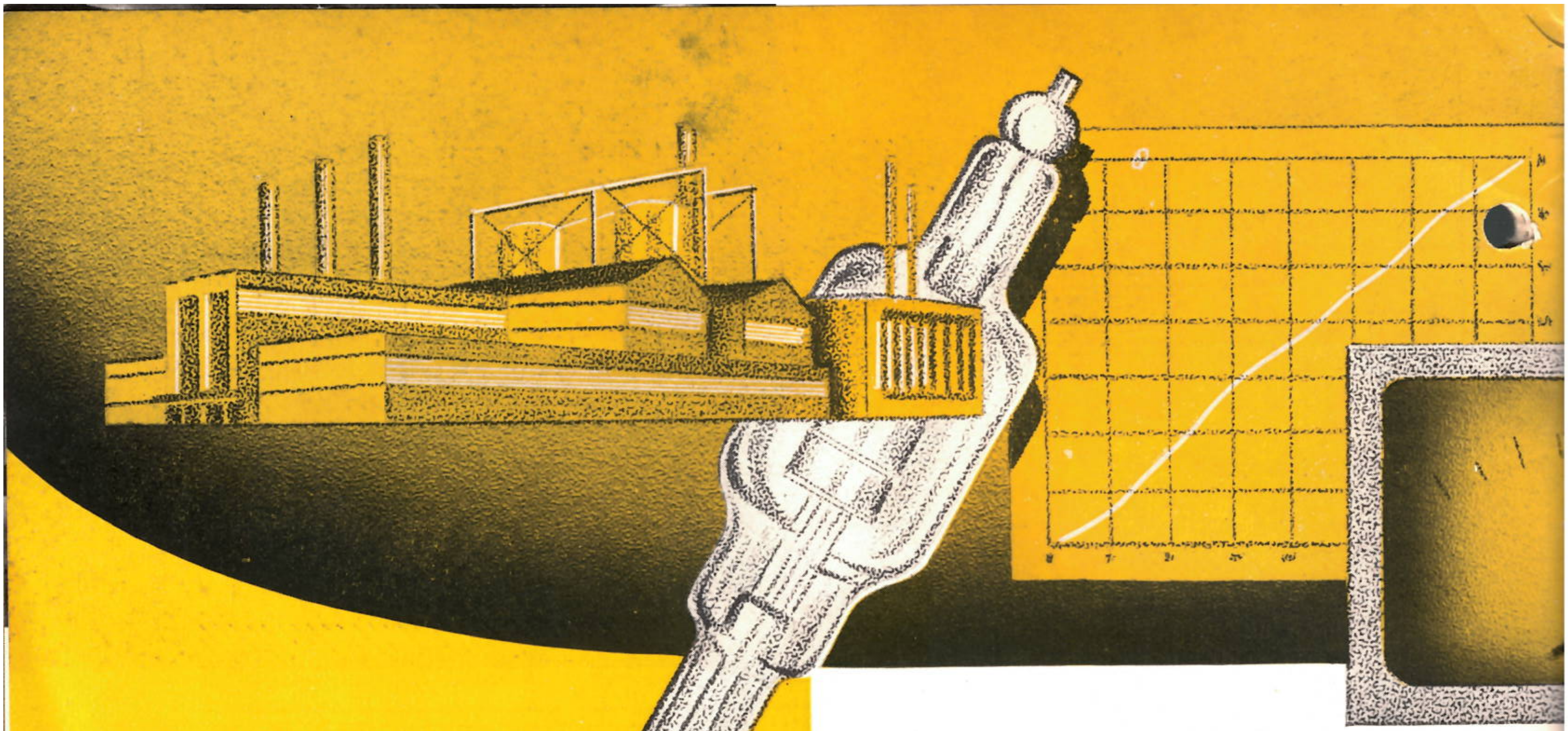
ago, and the number of machines that can produce them is limited to a very few, there is much to be learned about the characteristics of these particles. Some of the basic characteristics that have been determined at Nevis are the mass, lifetime, and spin of the pi mesons.

The Nevis cyclotron is fortunate in that several experiments may be run concurrently, using different energy beams of mesons at the same time. The focusing properties of the large cyclotron magnet for mesons were first utilized at Nevis.

Other detectors of mesons include cloud chambers and nuclear emulsions. At present, the laboratory has two expansion type cloud chambers, one of which is the largest in the world (36 inches in diameter). These chambers utilize supersaturation of a gas by cooling by expansion to produce tracks of water droplets along the paths of charged particles passing through the chamber. These tracks are photographed for a permanent record. Magnets surrounding the chambers bend the charged particles as they pass through the chamber, permitting a measurement of the momentum of the particles. Carbon or lead plates may be inserted in the chamber to study the interaction of mesons with various nuclei. There is also a 16 inch diameter diffusion cloud chamber, using a thermal gradient to produce the supersaturation. The nuclear emulsions are special photographic emulsions which give a record of developed grains along the track of the particles. These tracks are studied and analyzed with microscopes. The primary work done with these emulsions involves the interaction of mesons with various nuclei, and the modes of decay of the mesons themselves.

Although the shielding reduces the radiation in the building, for health reasons the cyclotron is controlled from a room in another building, about 300 feet from the machine. The electronic analysis apparatus for the experiments is also located in this building, and a minimum of personnel are allowed in the cyclotron building while the machine is operating.

The laboratory employs approximately 35 operating, maintenance, shop, and administrative personnel, and provides experimental facilities for 30 to 40 scientists. The laboratory is administered by the Department of Physics of Columbia University, under the direction of Prof. James Rainwater. Certain experiments are being done in cooperation with Brookhaven National Laboratory. Although the Nevis cyclotron is no longer the largest such machine, a heavy schedule of basic experimentation is now in progress, and shows no signs of slackening.



by J. PICHERT, Project Engineer,
Machlett Laboratories, Incorporated

Just short of ten years ago the need for d.c. power outputs at high voltages led to the development of the ML-5575/100 high-voltage rectifier, carrying ratings of 150 peak inverse kilovolts, 1 ampere peak anode current, and 750 watts anode dissipation. Subsequently, other tubes were developed to suit particular high voltage and load applications. These rectifiers included the smaller ML-102 with 75 p.k.v., .75 peak ampere, and 750 watts anode dissipation ratings; and the higher power ML-5576/200 with 150 p.k.v., 2.5 peak ampere, and 1000 watts anode dissipation ratings.

Recently developed diode requirements for even higher power supplies and line-type pulsers, such as are used in particle precipitation units and hydrogen thyratron test equipments, have caused Machlett Laboratories to design and produce a rectifier tube rated at 110 peak inverse kilovolts, 10 amperes peak anode current, and 1500 watts anode dissipation. Bearing the tube type designation ML-199, it widens the range of Machlett high-voltage industrial rectifier tubes available for high power applications.

Design and Construction

The ML-199 conforms dimensionally with the widely used ML-5575/100 and ML-5576/200 tubes. However, it incorporates a thoriated-tungsten filament, designed to operate at 12 volts and 23 amperes, capable of providing high peak plate current with low cathode power consumption. Anode current characteristics of the ML-199 are shown in figure 1.

Thoriated-tungsten cathodes were limited, until World War II, almost exclusively to use in tubes operating at 5,000 volts or less with some sporadic use in tubes for 35 to 40 kilovolts operation during the war. Their limitations in higher voltage tubes were generally considered to be twofold. The first was the inability of the thoriated-tungsten filament to withstand the stresses set up by the high electro-

THE ML-199

FOR HIGH VOLTAGE HIGH POWER RECTIFICATION

Another advance by Machlett in the use of thoriated tungsten cathodes in high voltage service

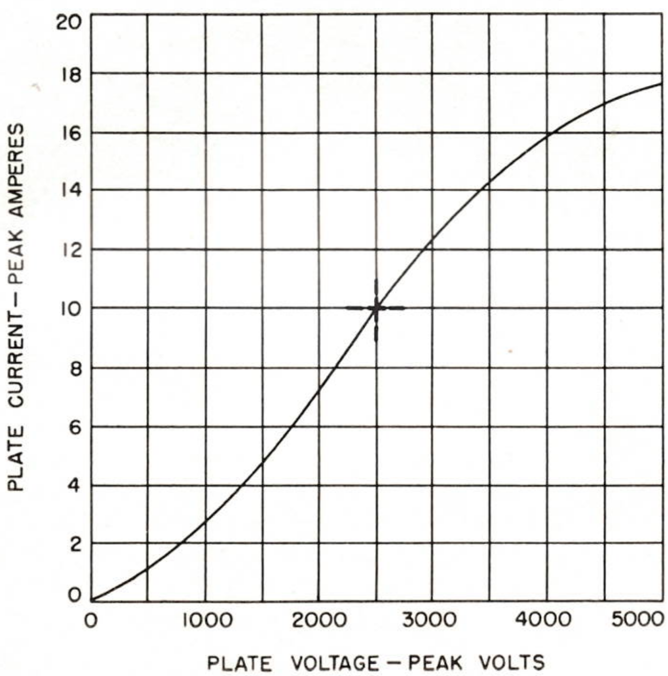


Figure 1 — ML-199 Anode Current Characteristics.

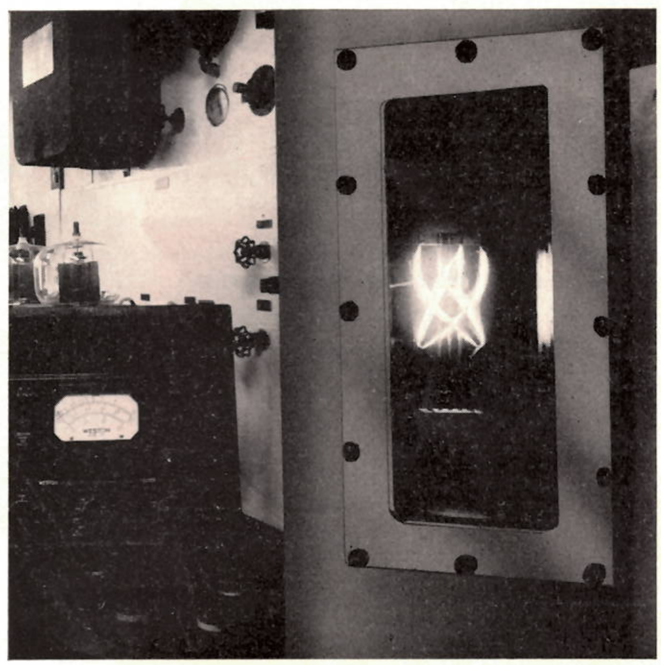


Figure 2 — Equipment Used In Carburization of ML-199 Filaments.

static fields which invariably led to filament distortion. The second was the rapid deterioration or "deactivation" of the thoriated-tungsten filament by positive ion bombardment and residual gas effects.

The first problem (that of filament distortion) is overcome in the ML-199 by use of a cathode of the catenary filament design, developed by Messrs. Skehan and Magnusson* of Machlett Laboratories and successfully used in ML-5575/100, ML-5576/200, and ML-102 tubes. The principle of this design offers maximum resistance to the electrostatically developed stresses by resolution of the forces tangentially along the length of the filament. The catenary filament offers another tube design feature by permitting close cathode to anode spacing with resultant low internal voltage drop and high average load current capability.

The second problem (that of deactivation) is circumvented in part by application of the same rigid processing and exhausting techniques to the tube components that are in daily use at Machlett Laboratories in the production of

*Skehan, J. W., and Magnusson, B. K. M.—Cathode Structure for Electron Discharge Devices—U. S. Patent No. 2,422,142.
Skehan, J. W.—U. S. Patent No. 2,422,141.

high quality x-ray and high power industrial tubes. Specifically, parts are subjected to complete degreasing, chemical and electrolytic cleaning methods, and thorough rinsing to remove all traces of cleaning solutions. In addition to the surface cleaning given the component parts, they are wherever possible subjected to hydrogen and vacuum firing processes to rid them of objectionable occluded metallic or chemical compounds. Throughout the entire anode processing operation, extreme caution is exercised to keep the anode free from metallic as well as chemical impurities, particularly those of low work function which would give rise to thermionic emission and unstable operation.

Cathode Processing

The filament strands of the ML-199 are made of selected thoriated-tungsten wire formed and treated to relieve them completely of mechanical stresses. Then, in the wake of the previously described cleaning processes, the cathode components are assembled, taking particular care to assemble the strands to supports so that they will be held in a stress-free state. The cathode is then carburized in an atmosphere of hydrocarbon gas slightly above atmospheric pressure.

A carburized filament is considerably more brittle than an uncarburized one, or for that matter, more brittle than a filament made of pure tungsten wire. An optimum degree of carburization commensurate with both long filament life and high strength is achieved under carefully controlled conditions.

Anode Processing

The cylindrical molybdenum anode is coated on its outer surface with finely divided zirconium metal, which is sint-

Figure 4 — View of Hydrogen Thyratron Test Equipment With ML-199 Tube Used As Hold-Off Diode For Resonant Charging of Line-Type Pulser.

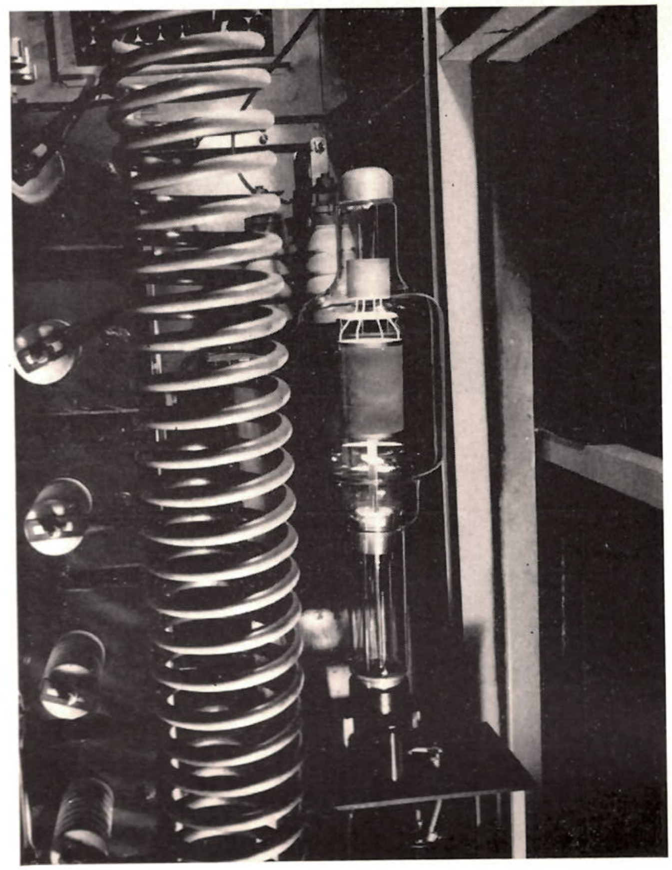
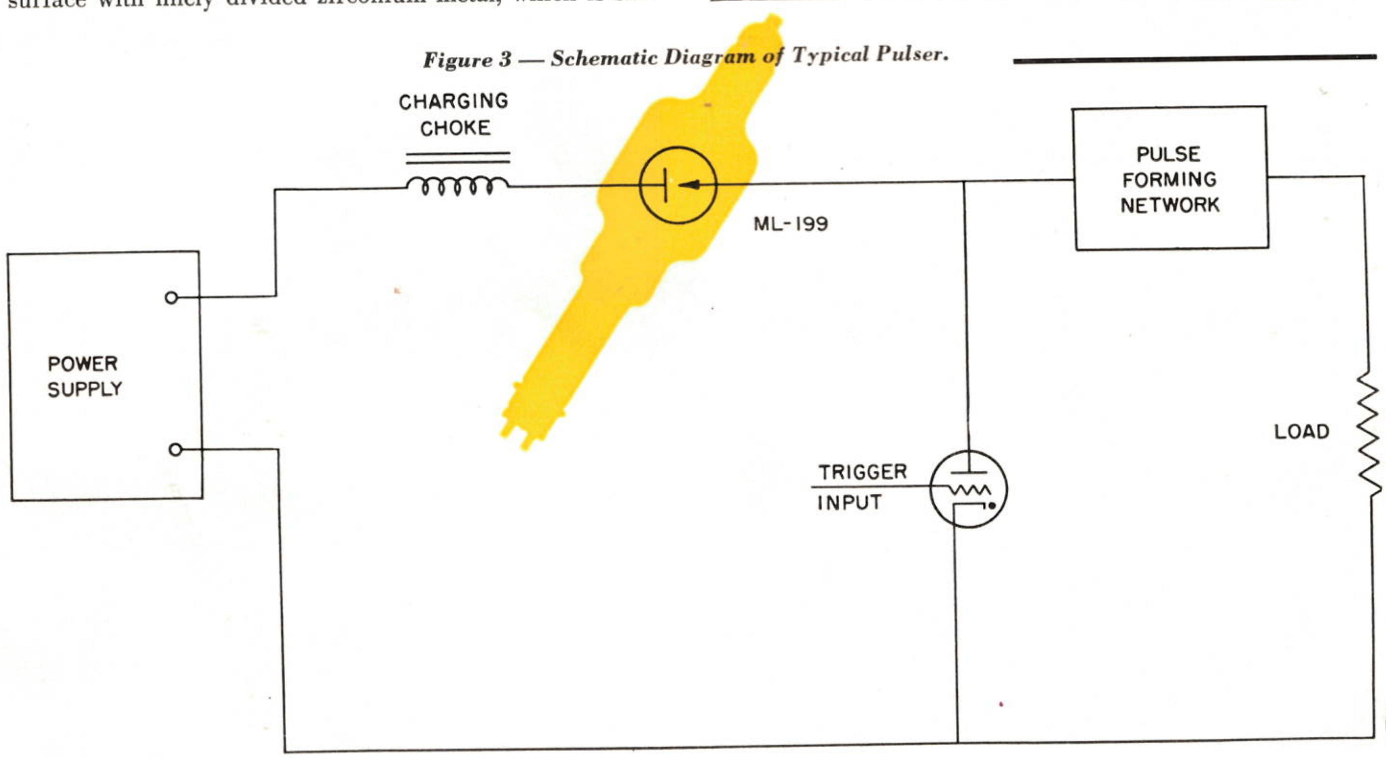


Figure 3 — Schematic Diagram of Typical Pulser.



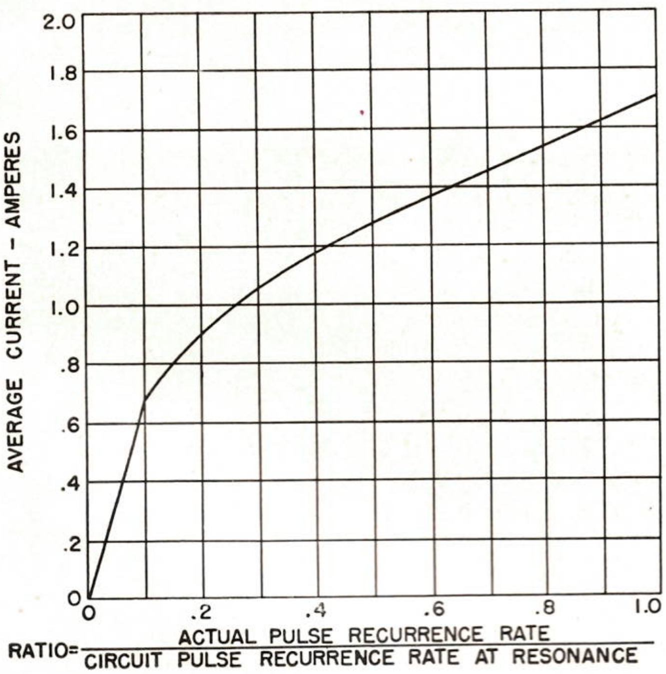


Figure 5 — ML-199 Average Current For Resonant Charging in Pulser Circuits.

ered thereon prior to its assembly into the tube. With this sintered zirconium coating the anode will satisfy the rated tube anode heat dissipation capabilities. Additional benefit is derived from the zirconium because of its inherent "gettering" action, thereby assuring a suitably low pressure throughout tube life.

End Processing

The concept of cleanliness is emphasized in tube assembly and "seal-in" operations, insuring tubes capable of rapid and complete exhaust. The evacuation procedure for the ML-199 is closely controlled, using the special exhaust techniques developed by Machlett for high-voltage x-ray tubes. Following exhaust the tube is subjected to a series of test requirements; included are stringent overvoltage and anode heat dissipation conditions which every usable tube is required to pass.

ML-199 Applications

The high voltage and high peak current ratings of the ML-199 make it particularly well suited to use as a hold-off diode in connection with resonant charging of high-power line-type pulsers. In this application the ML-199 is capable of withstanding the high voltage and peak currents associated with this kind of circuitry and prevents the reverse flow of current from the pulse-forming network in the pulser driver circuit, shown schematically in figure 3.

The tube therefore maintains the charge on the storage condenser in the pulse forming network until the pulser switch tube is fired. An example of such ML-199 diode use is shown in figure 4, a view of an equipment used to operation-test hydrogen thyratrons.

In service of this type it is often desirable to vary the pulse recurrence rate. When various pulse recurrence rates are to be employed, it is necessary to determine the average current value which can be employed without overheating the anode of the hold-off diode. The curve in figure 5 affords a means of ascertaining the average current permissible for various ratios of actual pulse recurrence rate to circuit pulse recurrence rate at resonance.

Continued on Page 31

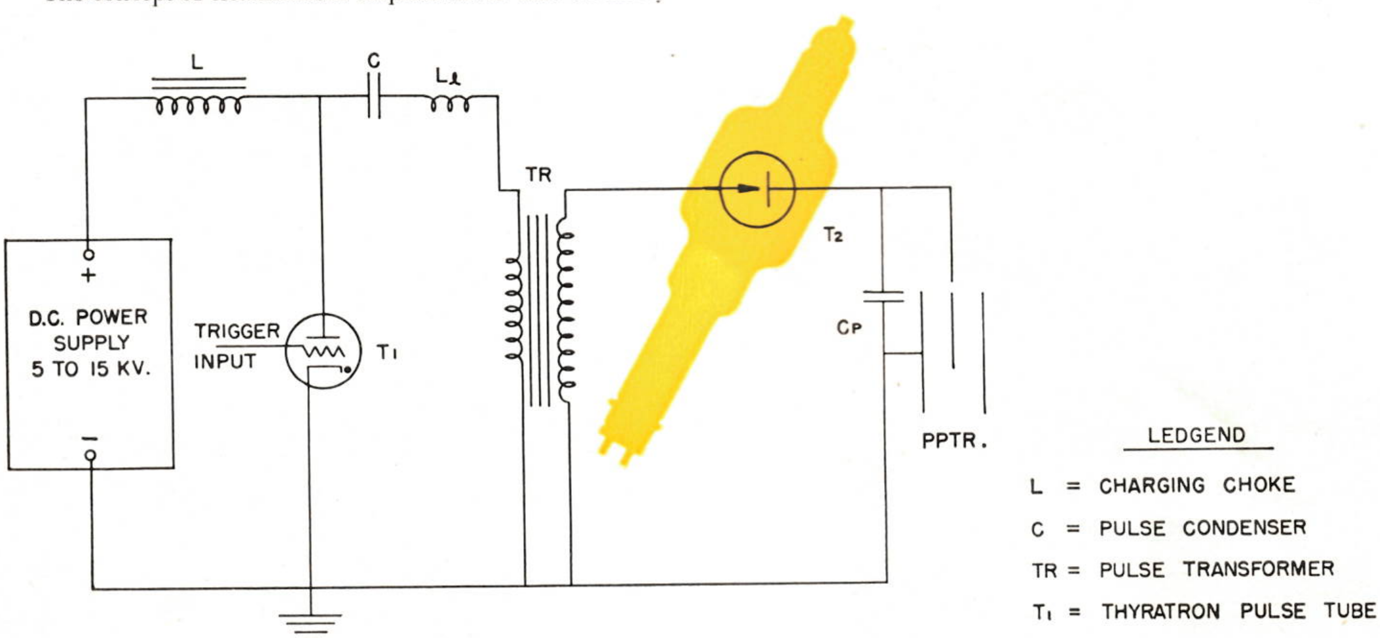


Figure 6 — Schematic Drawing of Pulser For Supplying High-Voltage Power in Electrical Precipitation.

ROLL FILM EQUIPMENT...

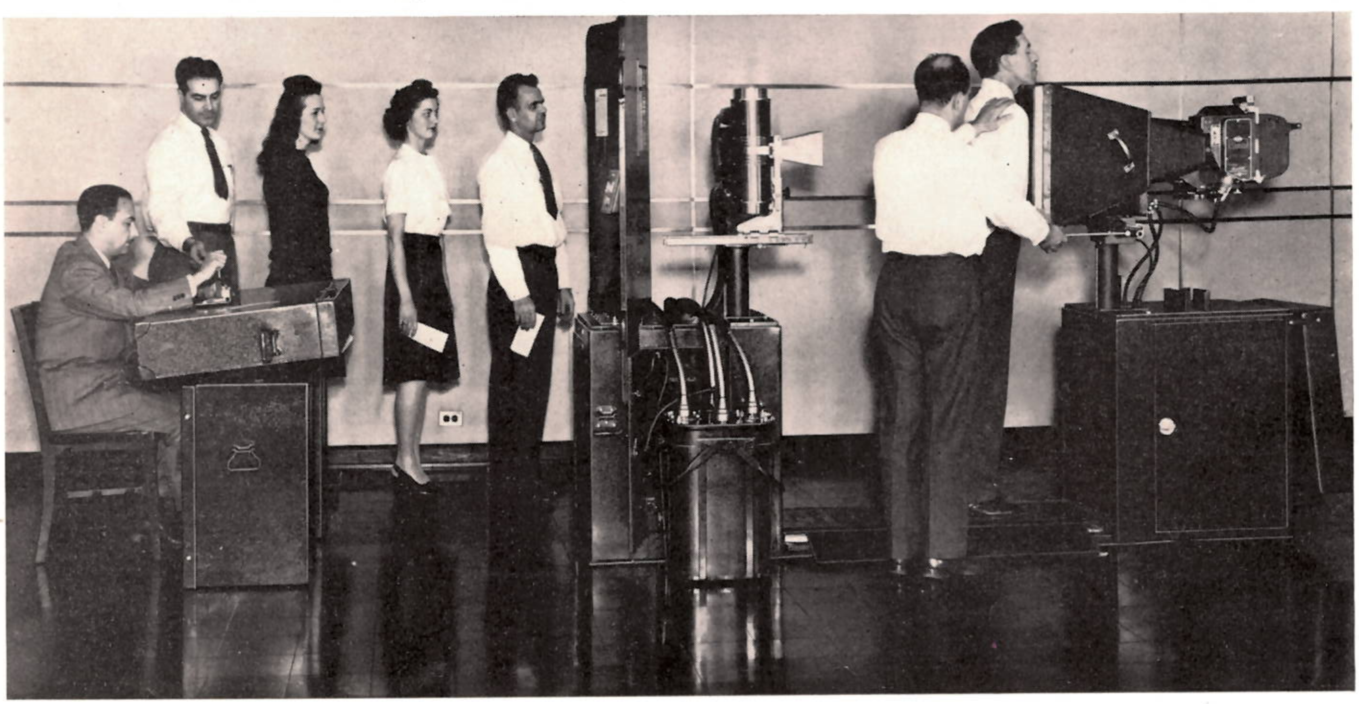
Continued from page 5

graphy. This procedure consists of injecting a radiopaque substance into one of the veins of the arm. The flow of the blood into the vein carries the opaque into the heart where it is pumped out into the vessels of the lung and then returned into the other side of the heart, from which it is pumped up through the large arteries of the body. While the opaque is passing through the heart and vessels of the lung, a radiograph will show the shape of the inside of the heart and associated vessels. A series of radiographs beginning just after the injection and showing various stages of the passage of the opaque through the vessels, gives considerable more information to the radiologist. This information is important in diagnosing a number of types of abnormalities and diseases of the heart and vessels.

Angiocardiographic serial work was being attempted by several radiologists by means of home made devices for shifting x-ray film cassettes into and out of radiographic position as rapidly as possible. The difficulty in building and using these cassette shifters resulted in the suggestion that it might be a good idea to adapt a 70mm photofluorographic unit for the purpose and make the angio series on roll film. In due course, Fairchild was asked to speed up the roll film transport cycle of one of the 70mm cameras from two seconds to ½ second. The photofluorographic unit on which the camera was used was equipped with a synchronizing circuit for making the x-ray exposures while the film was stationary. The camera operated on "run away," advancing the film in ½ second at the completion of each exposure. The x-ray exposures were determined by the photo-timer in the hood of the photofluorographic unit and varied in proportion to the thickness of the patient. It was not unusual to obtain 14 or 15 exposures in 10 seconds with this device. This new roll film angio technique created considerable interest and Fairchild arranged to supply high speed drives for any of the 70mm cameras then in use to make them available for angiocardiographic studies. This speed up version included a gear shift to permit the camera to operate at a normal 2-second cycle for chest survey purposes and then shift gears and advance the film at ½ second intervals for angiocardiography. This new technique put considerable extra strain on the drive of the camera and the x-ray tube, which was required to make exposures at intervals of approximately ½ second instead of 2 or 3 times a minute, the normal exposure speed in chest x-ray surveys.

The strain on the x-ray tube can be better appreciated when it is remembered that a single photofluorographic exposure on 70mm film requires 20 times the x-ray exposure needed for a direct radiograph. Fortunately, heavy duty x-ray tubes were soon made available which made

Figure 4—Typical survey unit capable of handling large numbers of examinations in a short period of time and using a minimum of personnel.



the roll film angiographic studies possible with 70mm photofluorographic units. However, a comparatively small number of units were actually converted for this type of work because of two factors. Some of the radiologists found the 70mm film rather small to make a diagnostic study of the details of the heart valves and blood vessels and expressed a wish for a larger sized roll film for the same type of work. Other radiologists pointed out that with the photofluorographic method, the radiation dose to the patient for an angiographic series of 15 to 20 exposures was approximately one Roentgen unit per exposure, or 15 to 20 R units. This radiation dose was regarded as undesirable for patients who would have other types of x-ray examinations in the normal diagnostic routine.

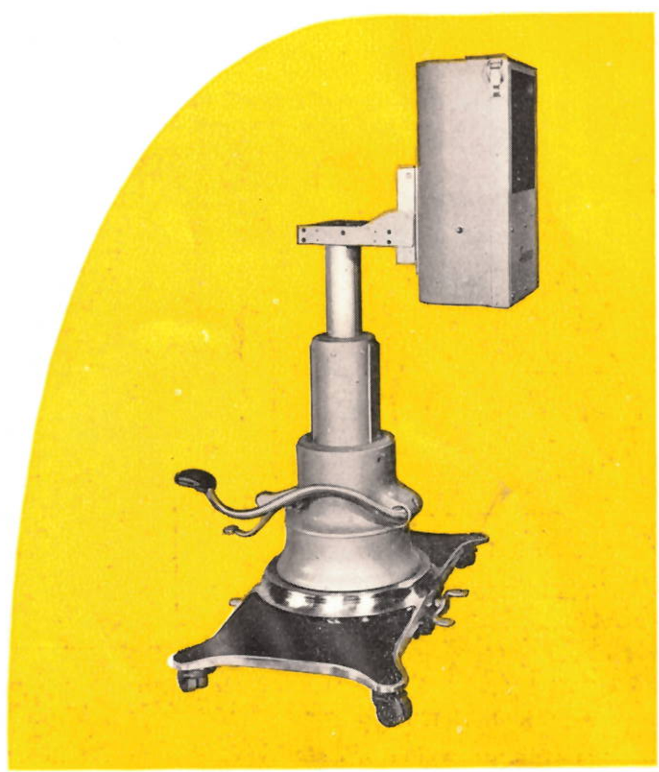
With these objections to the photofluorographic approach to angiocardiography in mind, radiologists began looking for a method of making angiographic studies on a larger size roll film by direct radiography instead of photofluorography. Fairchild was able to assist in this development by loaning aerial camera roll film magazines to several interested radiologists for experimental purposes. As a result of the pioneer work by these radiologists, the Roll Film Cassette was developed, which is now used for both angiocardiography and the similar technique applied to the blood vessels of the brain. The roll film cassette accommodates a roll of x-ray film 75 ft. long and 9½″ wide. The operation of the roll film is synchronized with the operation of the x-ray tube to make a series of x-ray exposures at intervals of ½ second, 1 second, 2 seconds or 3 seconds. Provision is also made for manual operation so that the radiologist can trigger off exposures at any intervals he may select. During the x-ray exposure, the film is sandwiched between fluorescent intensifying screens which press against the emulsions on the top and bottom surfaces of the film. Immediately after the exposure, the screens separate to permit the roll film to pass through between them and then close again for the next x-ray exposure. The roll film cassettes are used on a variety of different types of x-ray supporting stands and the illustration shows the cassette mounted on an adjustable pedestal which permits the roll film to be used either in a horizontal or vertical position.

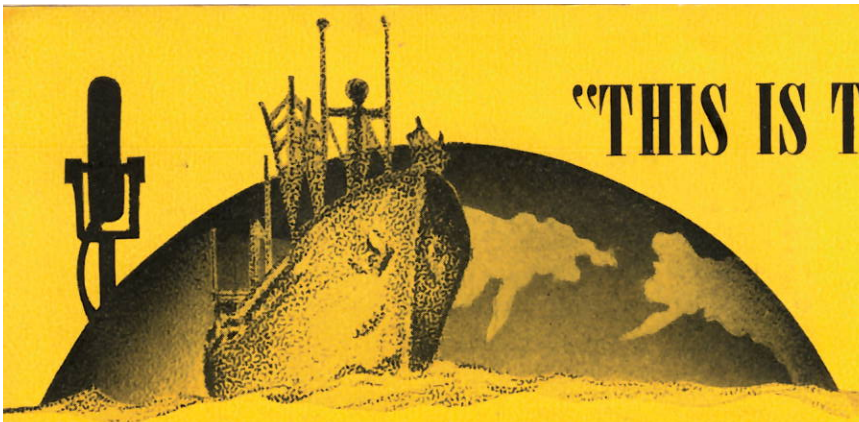
Roll film applied to photofluorography has made possible an all-out attack on tuberculosis in the U.S.A. and in many other countries. Roll film applied to radiography is being used in angiographic serial work to diagnose many heart and cerebral conditions. Roll film radiography is still in its infancy. According to some radiologists, there is a place for roll film in many types of x-ray examinations to reduce the labor of cassette handling and increase the efficiency of both exposing and processing the film. Equipment is now being designed which will eventually make roll film available for routine radiography and spot film examinations.

Figure 5—Self-contained, trailer-mounted chest survey unit.

Roll film x-ray work has presented interesting problems to manufacturers of lenses, screens, grids, timers and x-ray tubes. Many of these problems have been successfully solved. However, every improvement in one component suggests a possible improvement in other parts of the apparatus, and provides, in turn, the continuing possibility of new applications and techniques.

Figure 6—Fairchild roll film cassette mounted on pedestal stand.





"THIS IS THE VOICE OF AMERICA...

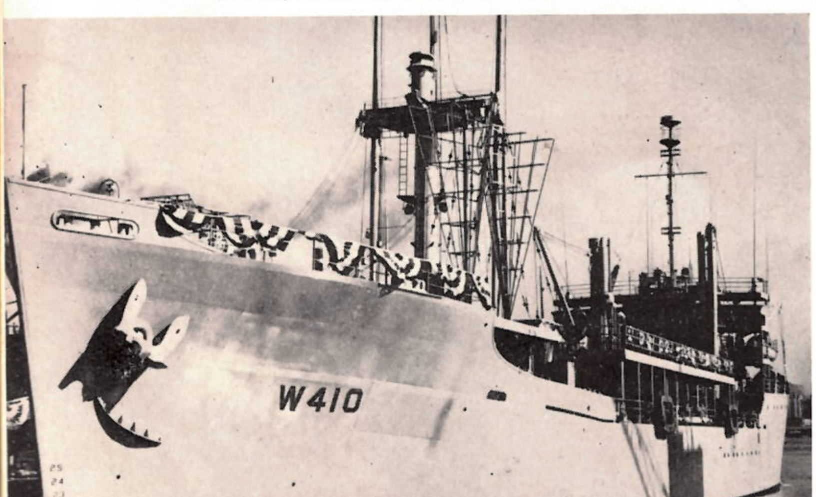
Continued from page 13

Effectiveness Of "Voice Of America"

As to the third question of Voice of America effectiveness —"are we affecting the minds and actions of our audience?" —many intangibles are involved. The contents of Voice programs, the reactions of sample audiences to special programs, and the level and quality of the 46 languages spoken undergo continuous appraisal. During 1951 evaluation of the VOA's effectiveness was based on evidence gathered from more than 325,000 sources.

In addition to other achievements the Voice has served to keep Communist propaganda on the defensive. One notable example was in the case of the Katyn massacre, which was brought to public attention by Congressional investigation. Although the case was one which the Kremlin and the Communist regime in Poland preferred to keep buried, their propaganda organs were obliged to make lengthy defenses of the Soviet position as a result of the heavy attention given the case by VOA's Russian and Polish broadcasts.

Figure 8 — 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.



The change in tide of the psychological offensive is attested by the constantly increasing size and interest of the free world audience. It is reflected in ever-growing demands for program schedules and by the upward trend of audience mail. Letters and interviews frequently provide striking examples of changes in audience attitude as a result of the Voice.

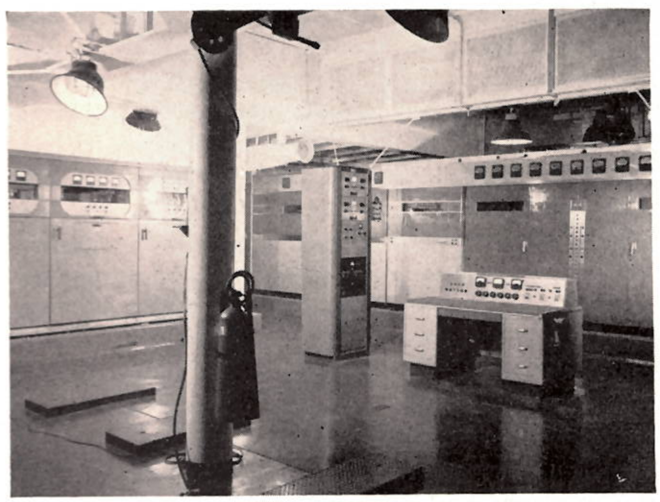
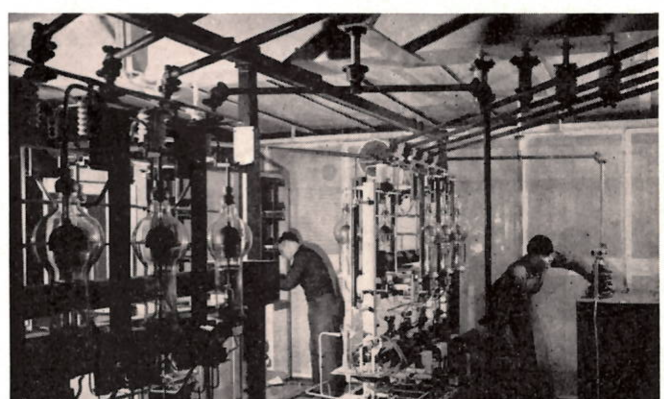


Figure 9 — Transmitter room aboard "Courier."

Figure 10 — Power supplies and rectifiers for "Courier" transmitters.



The unabated efforts of the Kremlin to keep Voice messages out of the Soviet Union by the use of their colossal jamming network is another measure of the Kremlin's own estimate of our effectiveness with the Soviet citizenry. Even better is the constant stream of attacks made on us over the Soviet radio and in the Soviet press. They give us a concept of the extent and composition of our audience, and they indicate the themes to which the Kremlin is particularly sensitive and feels compelled to try to rebut to its own people. They have reacted with special violence to our comparisons of living standards in the Soviet orbit and the outside world—to our demonstration that even minor improvement in living conditions in the Soviet Union proper is matched by a worsening of conditions in the satellites.

In a general way the Voice can claim a considerable share of the credit for fostering the growing strength and determination of the free world—and of Communist dominated peoples who still look to the free world for independence.

Figure 11 — VOA master-control in New York City. Twenty programs can be handled simultaneously.

Programming The Voice

With a few exceptions VOA programs originate in New York. The only broadcasts originating overseas are brief Polish, Russian, Lithuanian, Estonian and Hungarian programs transmitted daily from Munich; these programs are the first of a number planned for East Europe coverage and programmed close to prime audiences.

Voice broadcasts from the New York studio are fed through the largest master-control (Figure 11) in the United States, being capable of handling up to twenty programs at one time.

Programs go over land lines to one or more of the short-wave Voice transmitters in the United States for broadcasts to relay stations or direct broadcasts to radio target areas.

A staff of 1600, nearly all American citizens, work with VOA to win friends for the cause of democracy. Securing personnel qualified for the many special requirements of the Voice operation is a continual problem. Some of those who voice programs must prepare their own scripts—this requires a pleasant radio voice; knowledge of the language, customs, and psychology of the particular audience; editorial ability and knowledge of Department of State and VOA policies.

The technical staff required to engineer and operate Voice facilities is a large and important part of the I.B.S. Top caliber personnel, such as radio engineers, diesel power engineers, men familiar with installing and operating radio stations are in continual demand, particularly in view of the additional U. S. stations and overseas relay bases being set up.

The Voice of America has developed into a world-wide radio system worthy of the American people. Its total broadcasts now equal the combined output of the four major American domestic networks.

Since Voice broadcasts are beamed (at short-wave frequencies: 6, 7, 9, 11, 15, 17, and/or 21 megacycle bands) to listeners abroad and are in many foreign languages, the average American has little opportunity to make direct appraisal of what the Voice is saying or how well it is serving his interests. It is hoped that the foregoing general discussion leaves an impression of its importance to the security of the free world and its contribution to the struggle for peace.

An American Ambassador who recently returned from behind the Iron Curtain said that the Voice of America constitutes in effect, "a powerful opposition press which daily prevents the regime from blotting out the political consciousness of the people and which makes every measure taken by that regime infinitely more difficult and ultimately more susceptible to failure." This the Voice will continue to do to an ever increasing degree so long as millions of people remain subjugated.

SERIAL RADIOGRAPHY...

Continued from page 7

These charts indicate that this tube can be operated at currents up to 400 MA or 500 MA on the large spot or at values of 150 MA to 200 MA on the small spot. Thus, it can be seen that most conventional serial radiography can be accomplished by using the small (1.0 mm) focal spot providing maximum possible detail.

The tube design feature that makes it possible for the Super Dynamax to dissipate large amounts of heat and which permits high milliamperage exposures is the large pure tungsten disc that forms the anode. Figure 4 shows this tube with its massive four inch diameter anode. The design philosophy[1] used in this tube and in the other members of the Dynamax family, the Dynamax "20," the Dynamax "25" and "26" and the new Dynamax "30" and "36," is the dissipation of heat by radiation from the anode disc into the surrounding oil as rapidly as possible rather than allowing it to be absorbed by the remainder of the anode structure. This design restricts the amount of heat to which the bearings are subjected and permits the bearings to operate at a minimum temperature which, in turn, assures maximum tube life. Another important feature that has been incorporated into the design of this tube as well as in all other Dynamax tubes, is the use of a newly designed spring loaded bearing system[2] which eliminates the noise and vibration that were objectionable in rotating anode tubes of older design, and which has remarkably increased the bearing life and operating efficiency of this series of tubes.

To make practical the use of the Super Dynamax in the widest possible range of applications it has been designed for operation at voltages up to 125 PKV. This factor is important for serial radiography as it is often desired to increase the kilovoltage to reduce the radiation dosage that the patient receives.

The Super Dynamax is one of the series of tubes which uses the "Federal Standard Cable Terminals"[3] making possible an x-ray department in which all of the shockproof tubes use interchangeable cables, important where breakdown occurs or where department layout is changed, and, at the same time, assuring the maximum in flexibility of operation.

The Super Dynamax can be used for all conventional radiographic procedures, and as has been discussed herein, it is ideally suited for use in conjunction with the roll film cassette for angiocardiographic examinations or other forms of serial radiography because of its high order of permissible heat loading and heat dissipation, its superior bearing system and its ability to be used at high voltages.

[1] "Fundamental Factors Underlying Rotating Anode Performance" by T. H. Rogers, *Cathode Press*, December 1948.

[2] "An Improved Vacuum Bearing System for Rotating Anode Tubes" by R. R. Machlett and T. H. Rogers, *Cathode Press*, Fall 1951.

[3] "New Federal Standard Cable Terminals" by H. S. Cooke, *Cathode Press*, Winter 1951-52.

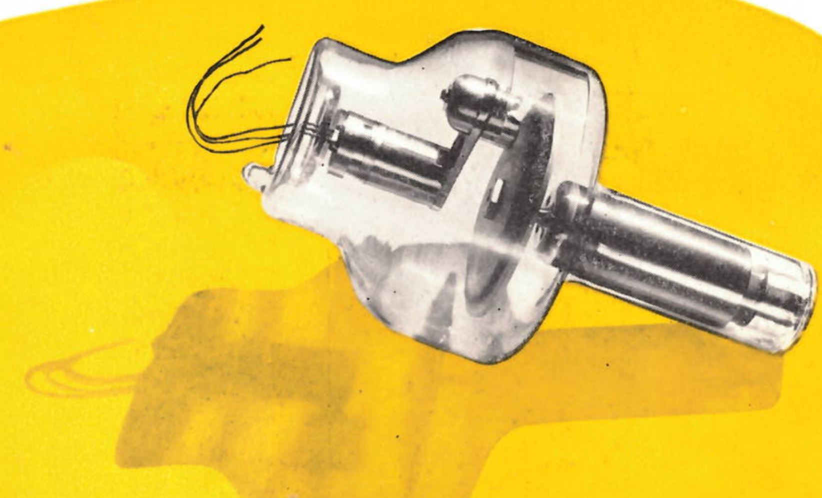


Figure 4 — Super Dynamax insert tube.

THE ML-199 . . .

Continued from page 25

For ratios below 0.1, the average current value is limited by the available filament emission rather than by the plate dissipation capability of the hold-off diode.

Another application of the ML-199 is in connection with a pulse method for supplying high-voltage power for electrostatic precipitation, as indicated in figure 6.

The output, or hold-off diode, T_2, in this circuit prevents reverse flow of power from the precipitator through the pulse transformer secondary after each pulse. A unique feature of this type of precipitator power supply is the inherent equipment protection against high-current sparking. Since the energy storage condenser, C, is completely discharged on each pulse, no more energy than is available on a normal cycle can be supplied if a spark occurs in the precipitator.

The physical layout of this type of precipitator power supply is shown by a scale model, figure 7.

ML-199 series hold-off diode is shown mounted on pulse transformer output bushing in the foreground. ML-199 tube operating conditions of the commercial unit include:

Peak Voltage—	70 kilovolts
Peak Anode Current—	6.5 to 10 amperes
Average Anode Current—	300 milliamperes
Average Power—	15 kilowatts
Pulse Frequency—	480 pulses/sec.
Pulse Duration—	100 to 150 microseconds

The calculated anode dissipation of the ML-199 in this service for half-sine wave pulse operation is:

Average Anode Power Dissipation

$$= 0.286 \text{ f t } I_p^{5/3} \text{ kilowatt}$$

where:

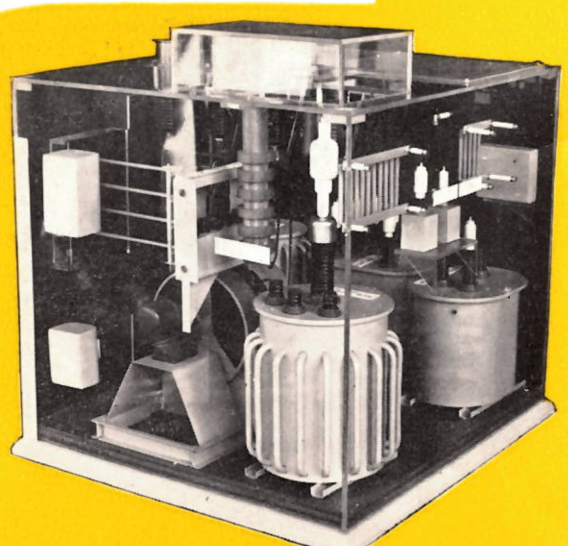
f = pulse repetition rate—pps

t = pulse duration (half-sine)

Ip = peak anode current

The foregoing are examples of increasing applications of the ML-199. Others include use of the tube for high-voltage very-high-power direct current supplies. The ML-199 with thoriated-tungsten filament and the three other types with pure-tungsten filaments mentioned previously make up the expanding family of Machlett industrial rectifier tubes of a proven basic design available for high-voltage high-power applications.

Figure 7—Plastic Model of Pulser-Type Power Supply Used in Industrial Precipitator Service (Courtesy of Research Corporation, Bound Brook, N. J.)



IMPROVING THE LIFE OF X-RAY AND VALVE TUBES

Continued from Page 17

tube replacement, considerable information and experience has been gained by those people whose duty it is to analyze tube failures. With this background, an exact analysis can usually be made as to the amount of service a tube has given, the type of equipment in which it has been used and the reason for failure. For example, Figure 4 shows a rotating anode tube and a stationary anode tube that give positive indication of excessive filament temperature. In the case of the rotating anode tube on the left, a very clear shadow of the cathode structure has been cast by the tungsten vapor that has deposited on the glass walls. The stationary anode tube on the right has an even heavier tungsten deposit on the glass wall indicating very intense filament loading. Further evidence of filament overheating can be obtained from the condition of the filament wire itself with respect to its physical appearance and grain structure.

Figure 5 shows the tungsten discs which form the targets for Machlett rotating anode tubes all of which have been used for approximately the same number of exposures. Disc "A" indicates normal use whereas discs "D" and "E" show the result of severe overloading which has resulted in extremely high temperatures causing damage to the bearings to such a degree that the anode has ceased to rotate.

Figure 6 shows the anodes from three stationary anode tubes all of which failed prematurely due to overheating or overloading. Anode "A" has been overloaded by a single exposure at a milliamperage value far greater than that of its rating. Anode "B" shows positive indication of overheating as a result of a series of exposures, over a long period of time, which have exceeded the heat storage capacity of the anode. Anode "C" is also a case where the anode heat storage capacity has been exceeded, but in a short time, resulting in a localized melting of the copper rather than destruction of the glass-to-metal seal.

Many examples of this sort could be given to further prove this point, but from those given it can be seen that the physical evidence gives positive proof of the reason for failure.

In conclusion, it is hoped that pointing out the factors which generally result in reduction of the life of x-ray and valve tubes has been of aid to the serviceman who has the responsibility of equipment maintenance, and who is anxious to take every precaution to provide operating conditions which will assure the user of the longest possible tube life.

Figure 5 — Tungsten anode discs showing, "A" normal wear at operation within the tube ratings, "D" & "E" damage as the result of consistent overloading.

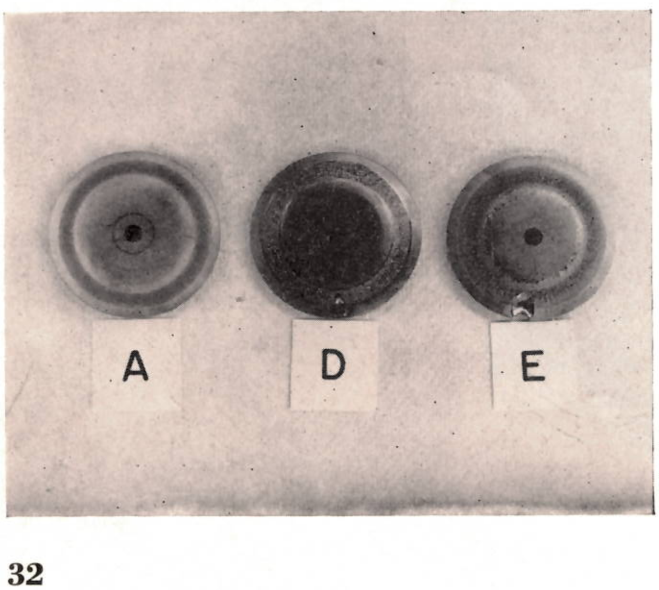
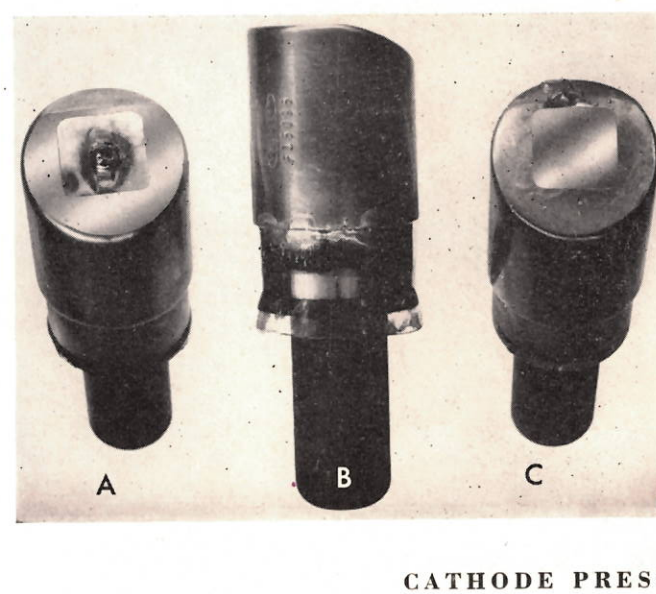


Figure 6 — Anodes from x-ray tubes showing damage by, "A" overheating at high milliamperage, "B" exceeding anode heat storage capacity over extended period, "C" exceeding anode heat storage capacity in short period.



NOW AVAILABLE... A COMPLETE LINE OF

Interchangeable

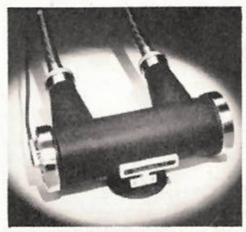
DIAGNOSTIC X-RAY TUBES

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.

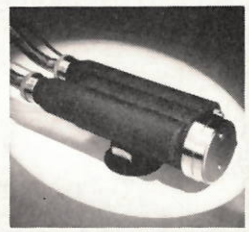
Realizing the needs of large institutions with multiple installations and those of the user whose one tube stand must serve for all diagnostic techniques, Machlett Laboratories have made available a complete line of diagnostic x-ray tubes which are designed to provide for complete interchangeability 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.

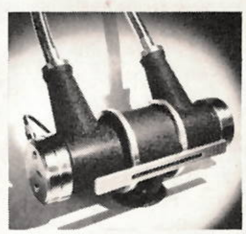
Write for complete tube data and an article, "New Federal Standard Cable Terminals," Cathode Press, Winter 51-52 issue.



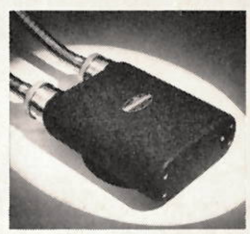
THE DYNAMAX "30"
a high capacity, all purpose rotating anode tube incorporating the world famous Dynamax "25" insert Ideal for all general radiographic applications. Operating voltages to 100 PKV, tube currents to 100 MA self-rectified, 500 MA rectified.



THE DYNAMAX "36"
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.

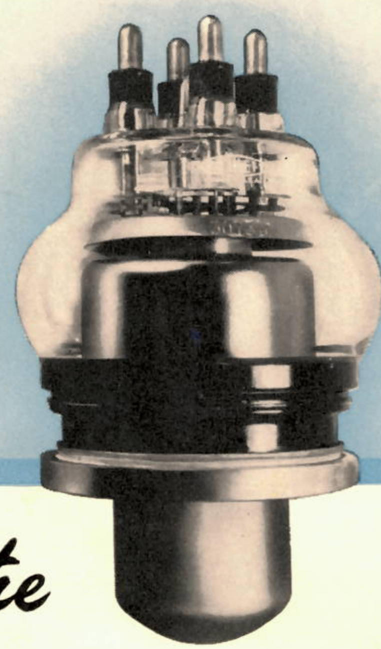


THE AEROMAX "16"
extremely light weight stationary anode tube designed for under-the-table spot film work and fluoroscopy. Voltages to 110 PKV, tube currents to 500 MA.

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

MACHLETT LABORATORIES, INC., SPRINGDALE, CONNECTICUT

If you use the 880 you will get BETTER PERFORMANCE LOWER OPERATING COSTS and LONGER LIFE . . .



. . . with the

ML-5658

THE ML-5658 is an improved and directly interchangeable version of the widely used 880. Designed originally as a better, more rugged tube for electronic heating equipment, it has since found extensive use in the high power broadcast field and in such exacting applications as cyclotron and synchrotron oscillators.

The ML-5658 incorporates in its design many of the outstanding features developed by Machlett Laboratories for all its industrial tubes. Typical of these design and process improvements which have given broadcast and industry better, more dependable tubes are:

1. **Kovar-to-glass seals. The elimination of the inherently weak feather-edged copper seal —increasing seal strength and providing greater stability of the internal electrode structure.**
2. **An improved, stress-free, self-supporting filament structure which substantially eliminates filament distortion, provides uniform filament emission throughout tube life and reduces the complexity and the hazards of the older spring-supported filament construction.**
3. **A unique pre-exhaust treatment of all parts and the thorough, high voltage exhaust of each tube on Machlett's special high voltage, high temperature exhaust system.***

These, and many other improvements in tube design and processing, provide for every installation which uses or contemplates the use of an 880 type tube, a far more rugged longer lived tube in the ML-5658. It will directly replace the 880 with *no* electrical or mechanical changes and will provide better performance, longer tube life and more economical operation.

The ML-5658, like other Machlett industrial tubes, is available with the Machlett automatic seal water jacket.† This new jacket eliminates the use of tools and the hazard of tube breakage and water leakage. The jacket cannot be opened unless the water pressure is off, nor closed unless the tube is properly installed.

Complete technical data on both tube types is available upon request. Write direct to Machlett Laboratories, Inc., Springdale, Connecticut.

* Patent No. 2,324,559. † Patent applied for.

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