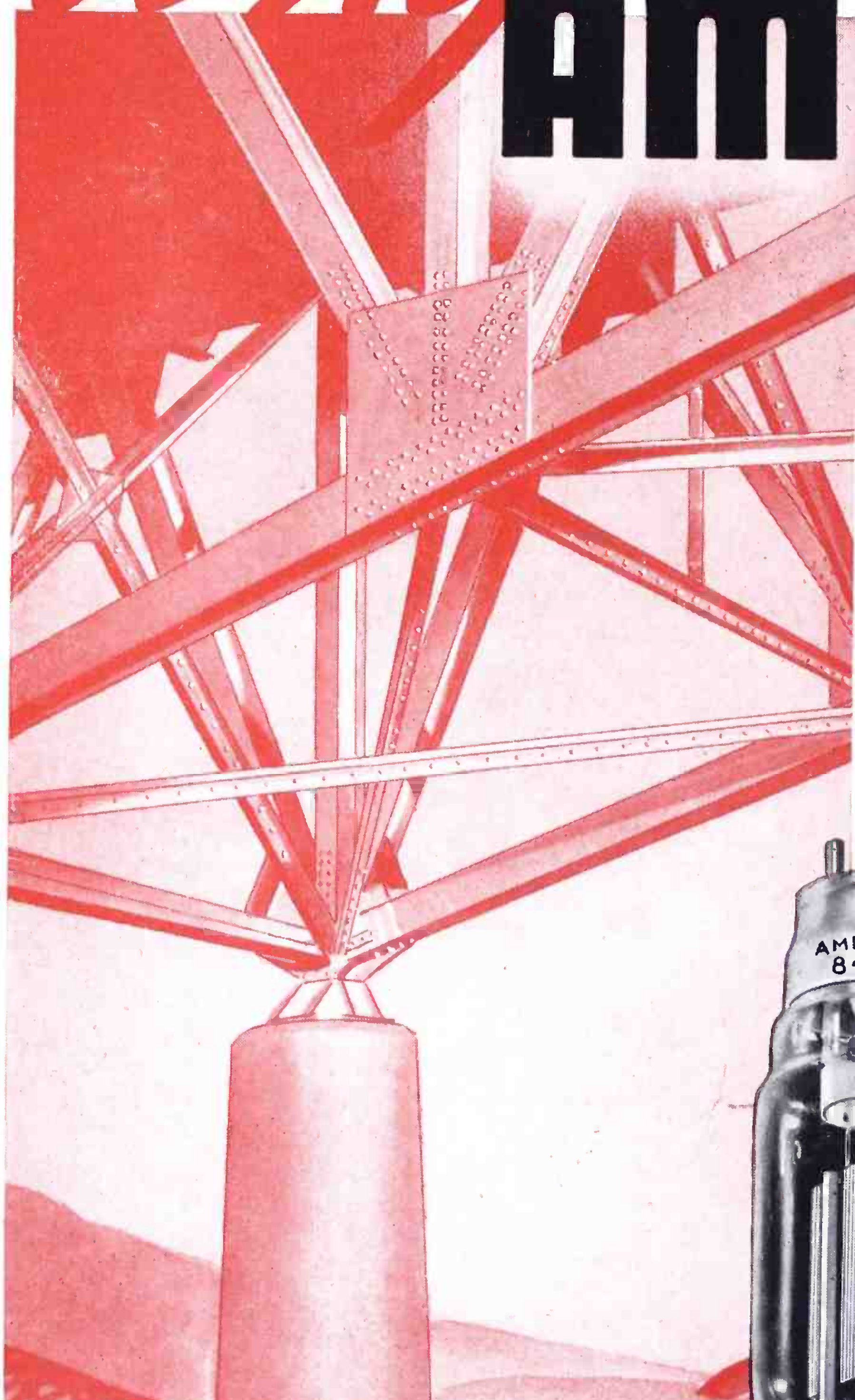
COMMUNICATIONS

NOVEMBER 1944

- ★ RADIO ENGINEERING
- ★ OWI 200-KW BETHANY TRANSMITTERS
- ★ GRAPHICAL COURSE ALIGNMENT AIDS
- ★ REPORT ON FCC TELEVISION HEARINGS
- ★ QUARTER-WAVELENGTH INSULATORS
- ★ TELEVISION ENGINEERING

Why AMPEREX



WATER and AIR COOLED
TRANSMITTING and RECTIFYING

TUBES

Of exclusive Amperex design! These four words, denoting an "Amperextra" reflected in better performance, have been used in a number of instances when describing our products. Of exclusive Amperex design, for example, is the channel support of our transmitting tubes. This feature results in more rigid support of tube elements. Exact inter-element alignment is assured. This, in turn, means absolute freedom from change in characteristics that might ordinarily arise from shock and vibration either in shipment or service.

There are more than 100 different types of ***Amperex*** tubes for broadcasting, industrial and electro-medical applications. An ***Amperex*** engineer will gladly assist you with your present or postwar problems.

AMPEREX *. . . the high performance tube*

Keep Buying . . .
Keep Holding . . .
More War Bonds

ARMY E NAVY

AMPEREX ELECTRONIC CORPORATION

79 WASHINGTON STREET • • • • • BROOKLYN 1, N. Y.
Export Division: 13 E. 40th St., New York 16, N. Y., Cables: "Arlab"

LEWIS WINNER, Editor

F. WALEN, Assistant Editor

We See...

A MODEL DEVELOPMENT-ENGINEERING-PRODUCTION-MANAGEMENT theme for the communications industry was presented at the recent Rochester Fall Meeting by Canadian RMA president Brophy. The theme . . . *better radio for more people.* Extensively applied for transmission and reception activities, this approach will build for a mighty communications system.

APPROXIMATELY $2,000,000 ARE BEING SPENT annually now for ground communications development by the Signal Corps Laboratories, Major General Roger B. Colton disclosed recently. In addition, the laboratories are spending around $17,000,000 annually for equipment and special services. General Colton also reported that crystals have played a major role in war communications, and that crystals worth close to $200,000,000 have already been purchased, with more to come!

HANDIE TALKIES AND WALKIE TALKIES received quite a tribute from Inspector Francis A. Burns of the New York Police Department at the recent FCC allocation hearings in Washington. He pointed out that these battery-operated units are invaluable to any police department. Describing applications, he cited the control of crowds and traffic, uses at fires and riots, and particularly detection of criminals by detectives. He stated that these compact units have provided the detectives with an inconspicuous means of effective communications. So important did he consider this phase of police work, that a separaate frequency for secrecy of operation was requested.

TELEVISION RECEIVED A SUBSTANTIAL assortment of frequences in the final RTPB proposal offered to the FCC in the closing sessions of the allocation hearings. The 60 to 102 and 152 to 218-mc bands, arranged to allow for general, metropolitan area or government uses, were requested. The 66 to 72-mc bands, for instance, would be used for areas outside of the metropolitan, while in the 84 to 90-mc bands, the metropolitan areas would be served only. For experimental television broadcasting and relaying, the 460 to 956-mc bands were requested. FCC approval or modifications of the requests are scheduled to appear around the first part of December.—L. W.

COMMUNICATIONS

Including Television Engineering, Radio Engineering, Communication & Broadcast Engineering, The Broadcast Engineer. Registered U. S. Patent Office.
Member of Audit Bureau of Circulations.

NOVEMBER, 1944

VOLUME 24 NUMBER 11

COVER ILLUSTRATION

Invasion radio-communications equipment at Cherbourg, France and the Mt. Trocchio area, Italy.
(Courtesy, U. S. Signal Corps)

Published Monthly by the Bryan Davis Publishing Co., Inc.

BRYAN S. DAVIS, President — **PAUL S. WEIL, General Manager**

F. WALEN, Secretary — **A. GOEBEL, Circulation Manager**

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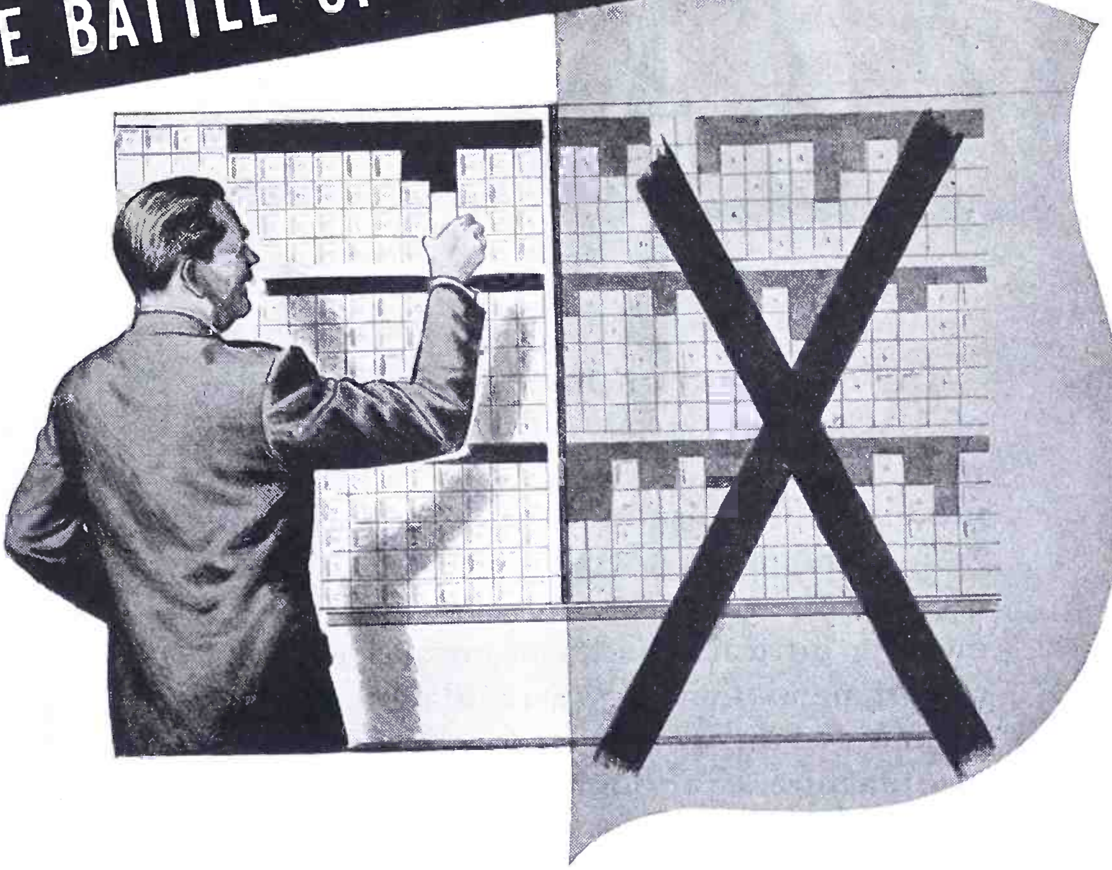
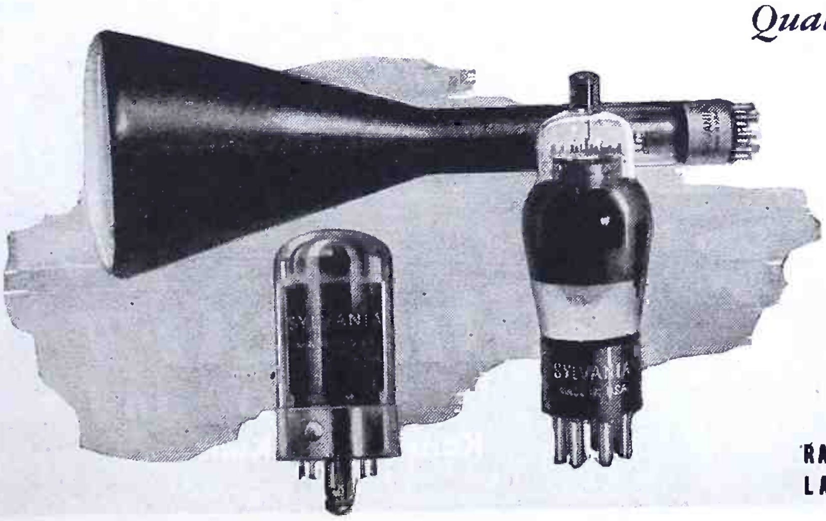
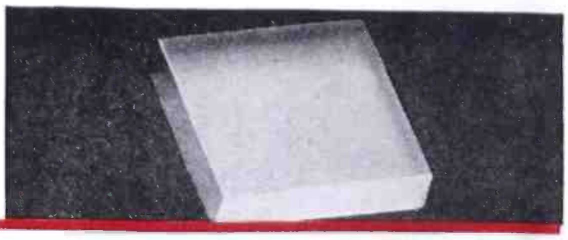
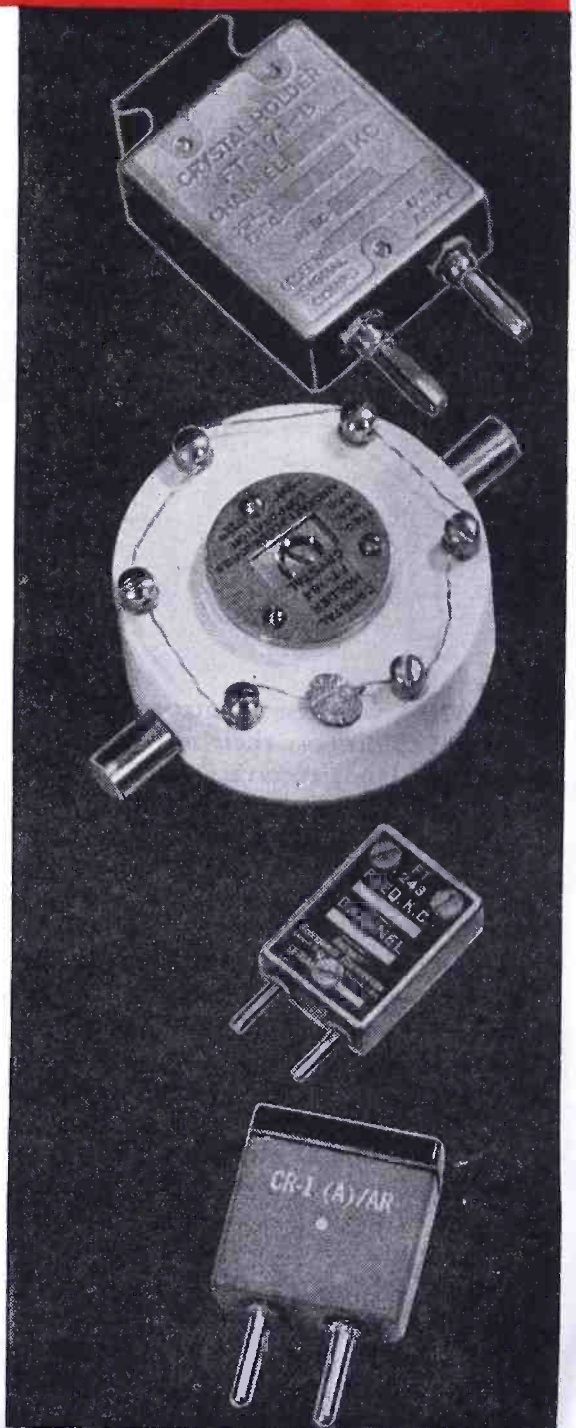




AAC CRYSTALS





The recognized quality and dependability of AAC quartz crystals is the result of AAC's wide experience as one of America's largest producers of transmitters and other precision radio equipment. AAC quartz crystals and crystal units have proved so outstanding in meeting intricate specifications and exacting requirements that they are today demanded by many of the world's greatest airlines, radio manufacturers, various branches of the armed services and other government agencies.

This practical achievement background—*plus* AAC's staff of skilled engineers and modern-to-the-minute manufacturing facilities is ready to meet your crystal needs advantageously. Rapid delivery of standard types—also special types, ground and mounted to your specifications.

ELECTRONICS DIVISION
Kansas City, Kansas

WRITE now for your free copy of the new AAC crystal catalog giving detailed facts about AAC quartz crystals and crystal units.

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RADIO and
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PRECISION MADE FOR PRECISE PERFORMANCE

and

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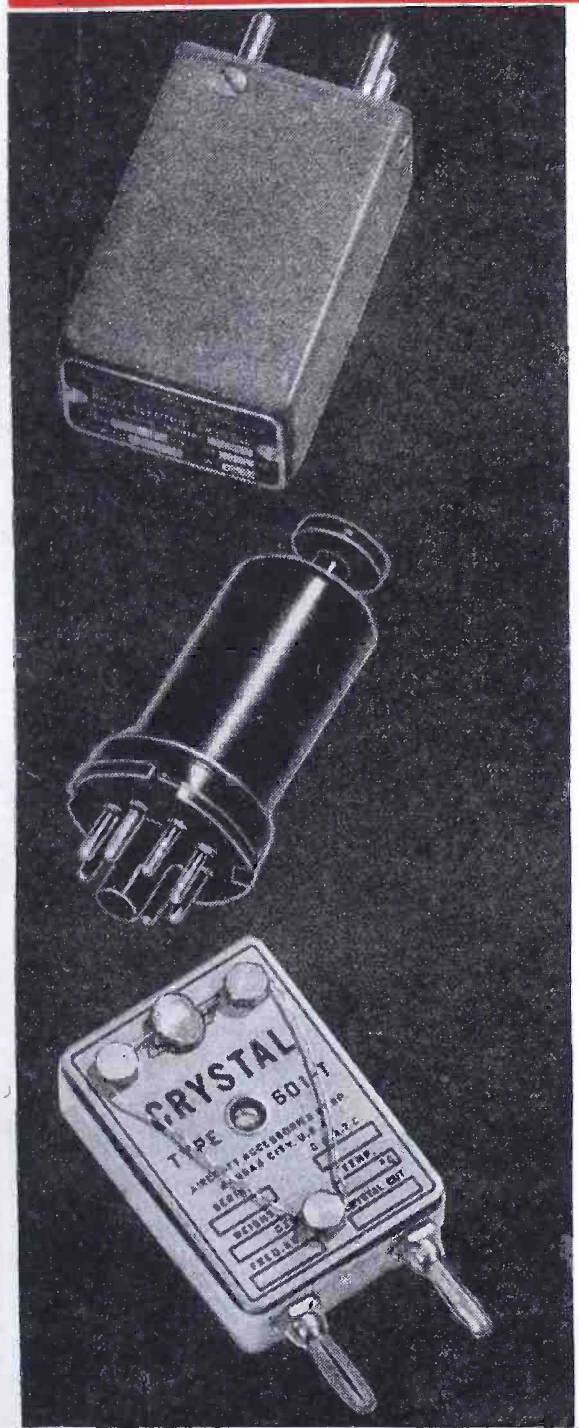


There is no question about AAC crystals meeting the most exacting requirements under severe operating conditions. Their reliability has been tested and proved a thousand times over . . . in battlefront service to the armed forces . . . in helping to keep the communication systems of many leading airlines working efficiently . . . in meeting the quality demands of radio manufacturers. The list of users of AAC crystals shown below is a tribute to the engineering skill and fine manufacturing facilities behind AAC crystals.

Braniff Airways, Inc.
Chicago & Southern Air Lines, Inc.
National Airlines, Inc.
Northwest Airlines, Inc.
Pan American Airways System
Pan American-Grace Airways, Inc.
Pennsylvania-Central Airlines Corp.
Transcontinental & Western Air, Inc.

Colonial Radio Corp.
Columbia Broadcasting System, Inc.
Stewart-Warner Corporation
Western Electric Company, Inc.
Zenith Radio Corporation

Remember, crystal production is only one of AAC's services to the aviation and electronics industries. The production of airborne and ground radio equipment at the rate of more than 30 million dollars yearly for U. S. government and leading airlines demonstrates the wide scope and high rating of AAC manufacturing ability.

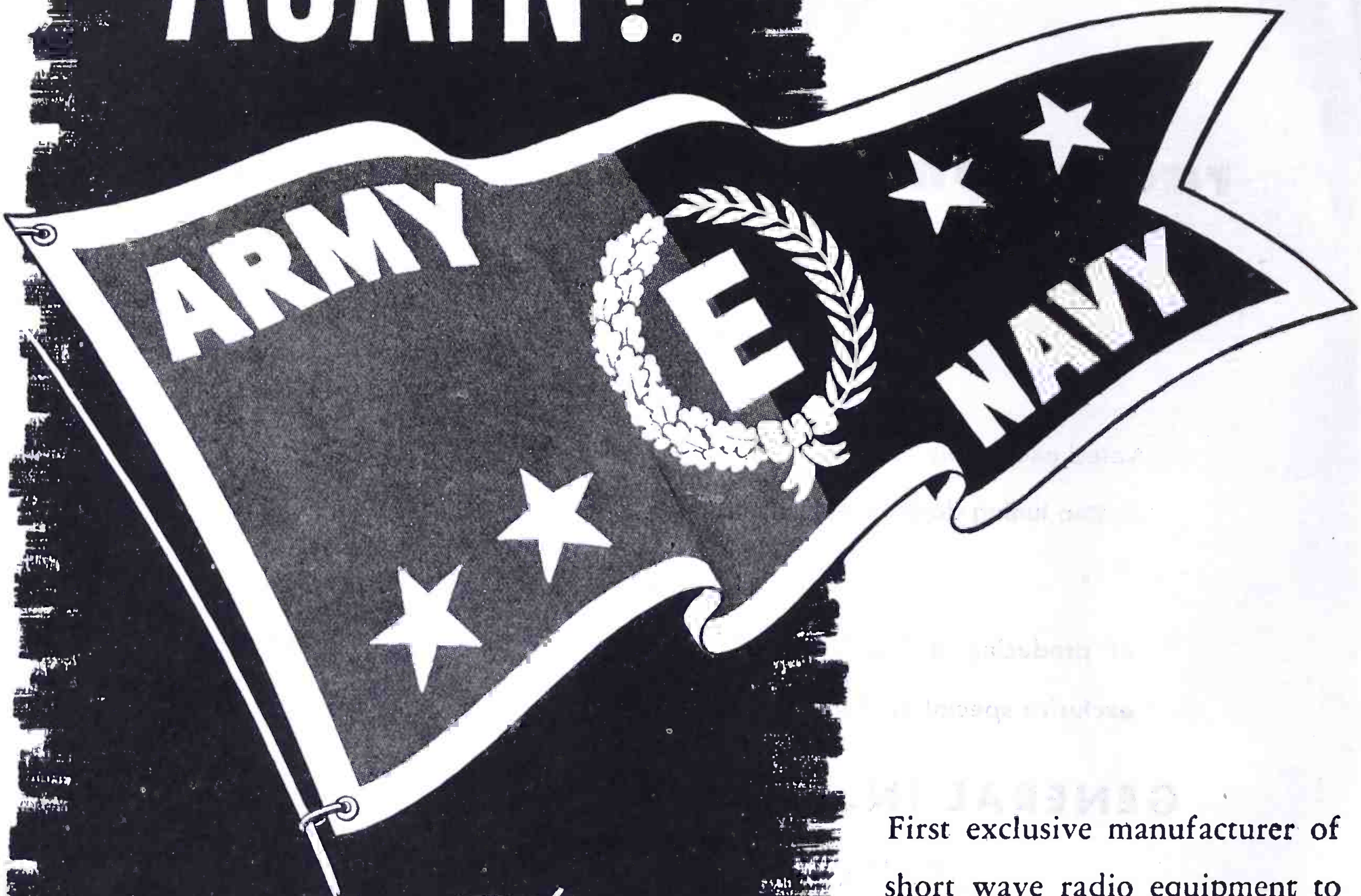
E-134

AIRCRAFT ACCESSORIES CORPORATION

ELECTRONICS • ENGINEERED POWER CONTROLS

New York, N. Y. Burbank, Calif. Cable Address: AACPRO

AGAIN!



For the 5th time

hallicrafters

employees win Army-Navy "E" Award!

First exclusive manufacturer of short wave radio equipment to receive the coveted Army-Navy "E" Award for the fifth time . . . the result of the continued and untiring devotion to duty of the company's 1,500 employees.

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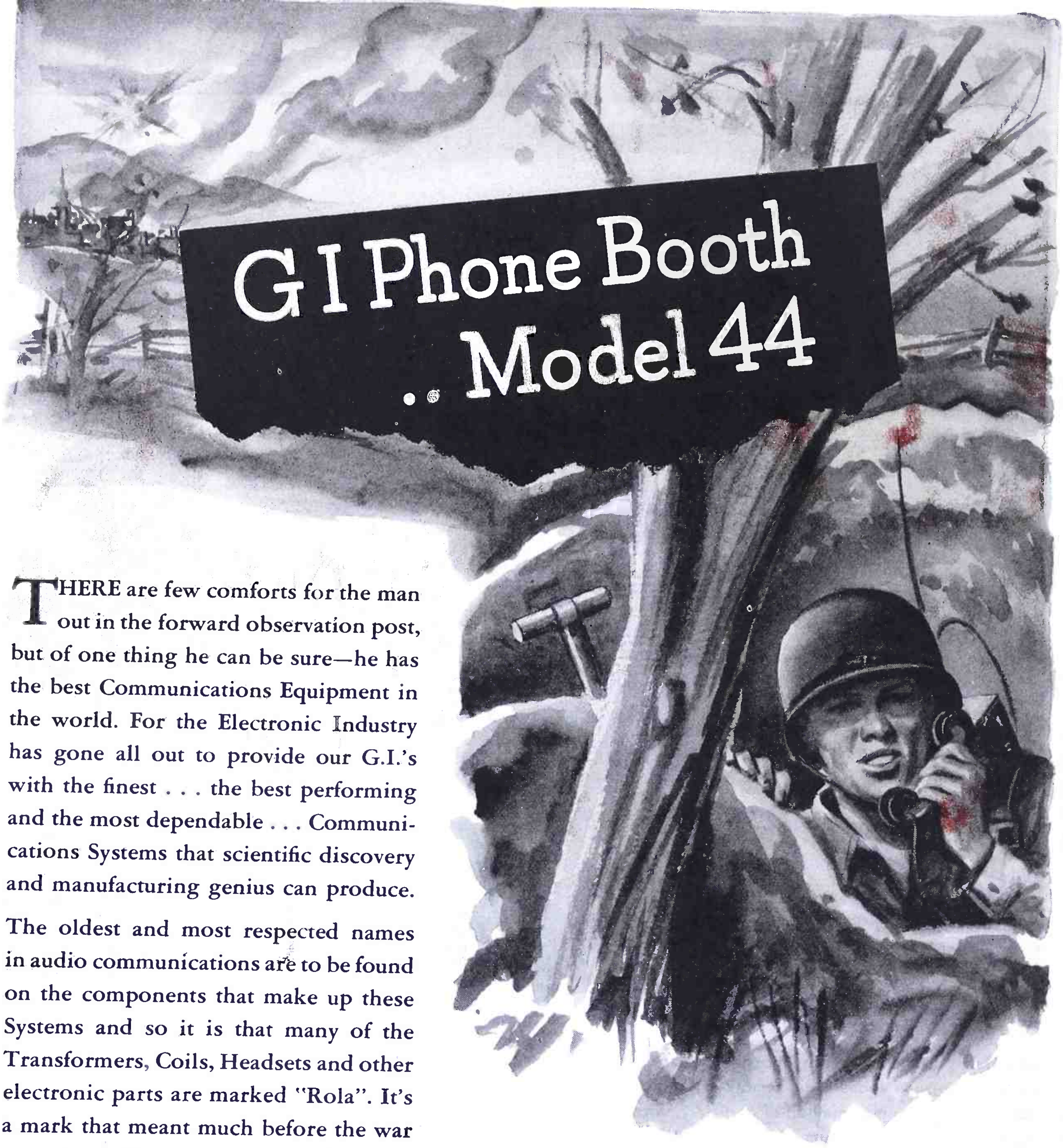
THE HALLICRAFTERS COMPANY • MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT • CHICAGO 16, U. S. A.

Builders of the famous SCR-299



THERE are few comforts for the man out in the forward observation post, but of one thing he can be sure—he has the best Communications Equipment in the world. For the Electronic Industry has gone all out to provide our G.I.'s with the finest . . . the best performing and the most dependable . . . Communications Systems that scientific discovery and manufacturing genius can produce.

The oldest and most respected names in audio communications are to be found on the components that make up these Systems and so it is that many of the Transformers, Coils, Headsets and other electronic parts are marked "Rola". It's a mark that meant much before the war . . . that will mean more in the Electronic Age now just beginning.

ROLA

THE ROLA COMPANY, INC.
2530 SUPERIOR AVENUE • CLEVELAND 14, OHIO

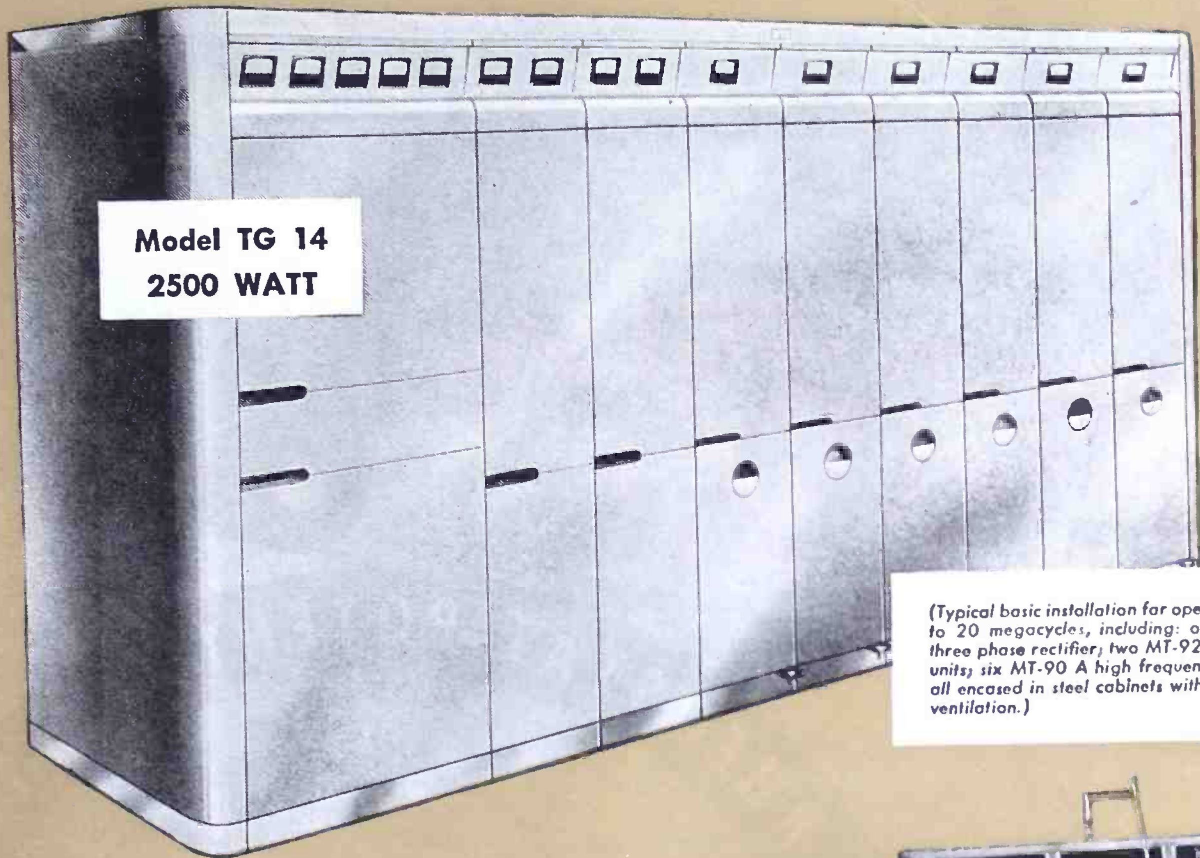
Let's do more *(ARMY E NAVY)* in forty-four!

MAKERS OF THE FINEST IN SOUND REPRODUCING AND ELECTRONIC EQUIPMENT

Bendix Radio Presents

A NOTABLE IMPROVEMENT

IN AIRLINE GROUND STATION EQUIPMENT



(Typical basic installation for operation on 2.5 to 20 megacycles, including: one MP-36 A three phase rectifier; two MT-92 A modulator units; six MT-90 A high frequency RF units—all encased in steel cabinets with forced draft ventilation.)

Great Flexibility . . . Exceptional Sturdiness . . . Complete Tropicalization

Bendix Radio*—center of radio research and production for the aviation industry—has now turned its broad experience and extensive facilities to the production of the finest of ground station equipment—and here is one result: a new, unit-type installation providing an unlimited number of operating channels in the frequency range of 200-425 kc. and 2.5 to 20 mc. . . . with sufficient power supply capacity to permit simultaneous operation of 2 radio telephone, 1 radio telephone and 2 telegraph, or 3 telegraph channels . . . and designed to allow quick installation of additional RF channels as traffic loads increase.

Constructed to the quality requirements which have made the products of Bendix Radio the Standard of the Aviation Industry, this equipment has hermetically sealed transformers for tropical use, and is studded throughout with other features to assure peak performance under all conditions. As a further guarantee of reliability, *special attention has been given to adequate overload protection,* and *improved electrical design assures the effective reduction of Harmonic Radiation to a minimum.*

Information as to dimensions, weight, construction, electrical characteristics and easy-service features will be sent promptly on request.

The MS-77 Remote Control Unit, built to individual requirements, provides a method of installing control equipment in a manner which will place all the equipment in locations readily accessible to the operator. The compact low structure of this unit permits it to be installed in such a way that the operator may have a full unobstructed view in all directions.

*TRADE-MARK OF BENDIX AVIATION CORPORATION

Bendix RADIO DIVISION

BENDIX AVIATION CORPORATION BALTIMORE 4, MARYLAND

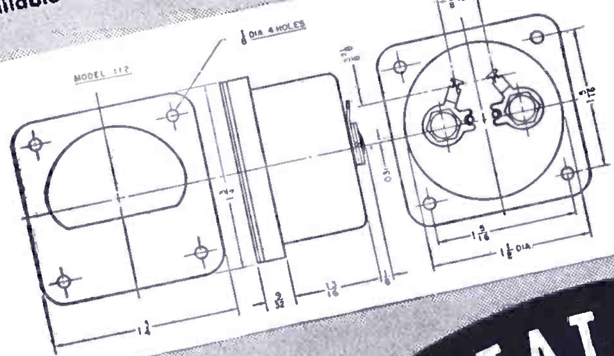
STANDARD FOR THE AVIATION INDUSTRY

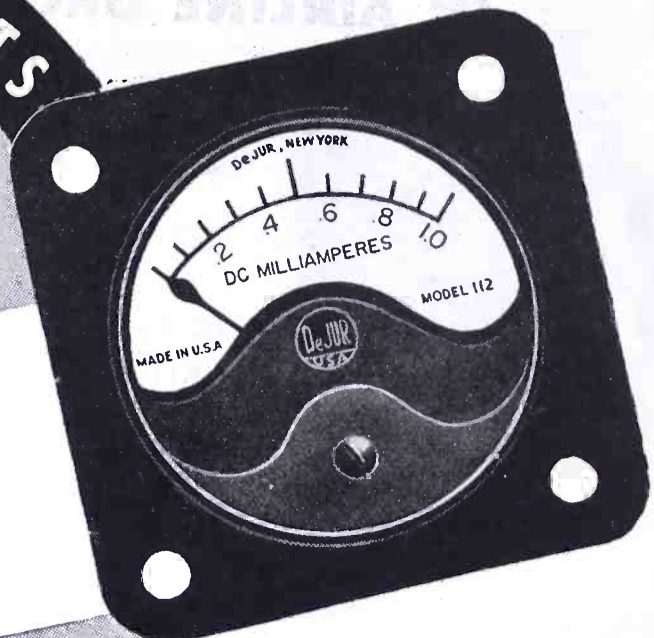
For special requirements

DeJUR ELECTRICAL INSTRUMENTS

1½ INCH METER · SQUARE TYPE · MODEL 112

This miniature instrument may be successfully used in a variety of applications, and it is particularly useful where space is an important factor. The DeJur 112 measures only 1¾" square and 25/32" deep, and uses basically the same carefully designed components as our larger instruments. In order to conserve space, soldering lugs are used for the terminal connections instead of the conventional studs. Available in standard ranges.

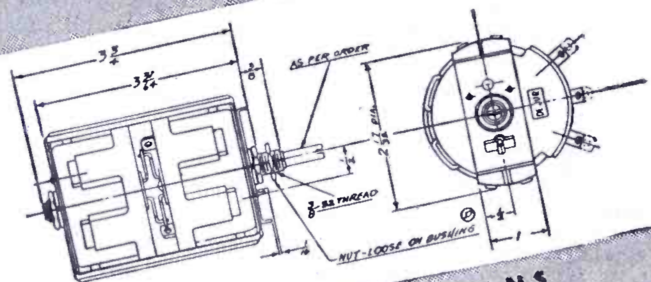




DeJUR RHEOSTAT-POTENTIOMETERS

MODEL 241 D

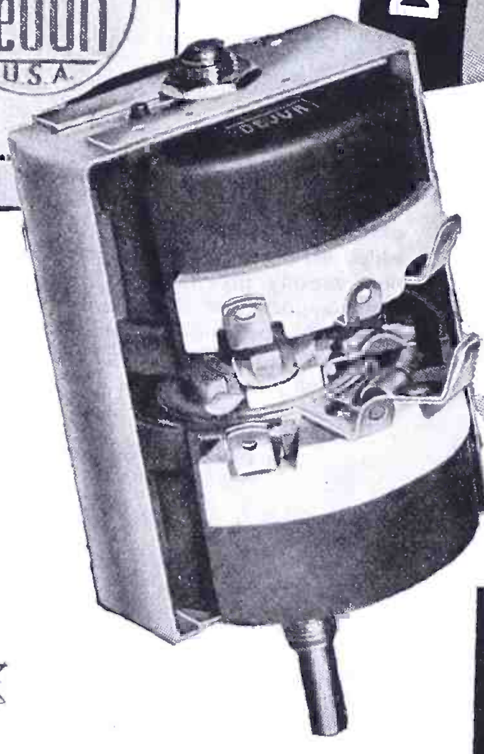
A dual unit model, with both units mounted together. The Model 241 D is typical of the many types developed by DeJur engineers for special requirements. We are equipped to serve your needs, too.



SPECIFICATIONS

50 WATTS
RANGES—10 to 10,000 Ohms
MECH. ROTATION—300°
ELEC. ROTATION—270°
WEIGHT—7 Oz.

RANGE IN OHMS	MODEL NO.
0. 10	241 D
0. 50	241 D
0. 100	241 D
0. 500	241 D
0. 1,000	241 D
0. 5,000	241 D
0. 10,000	241 D

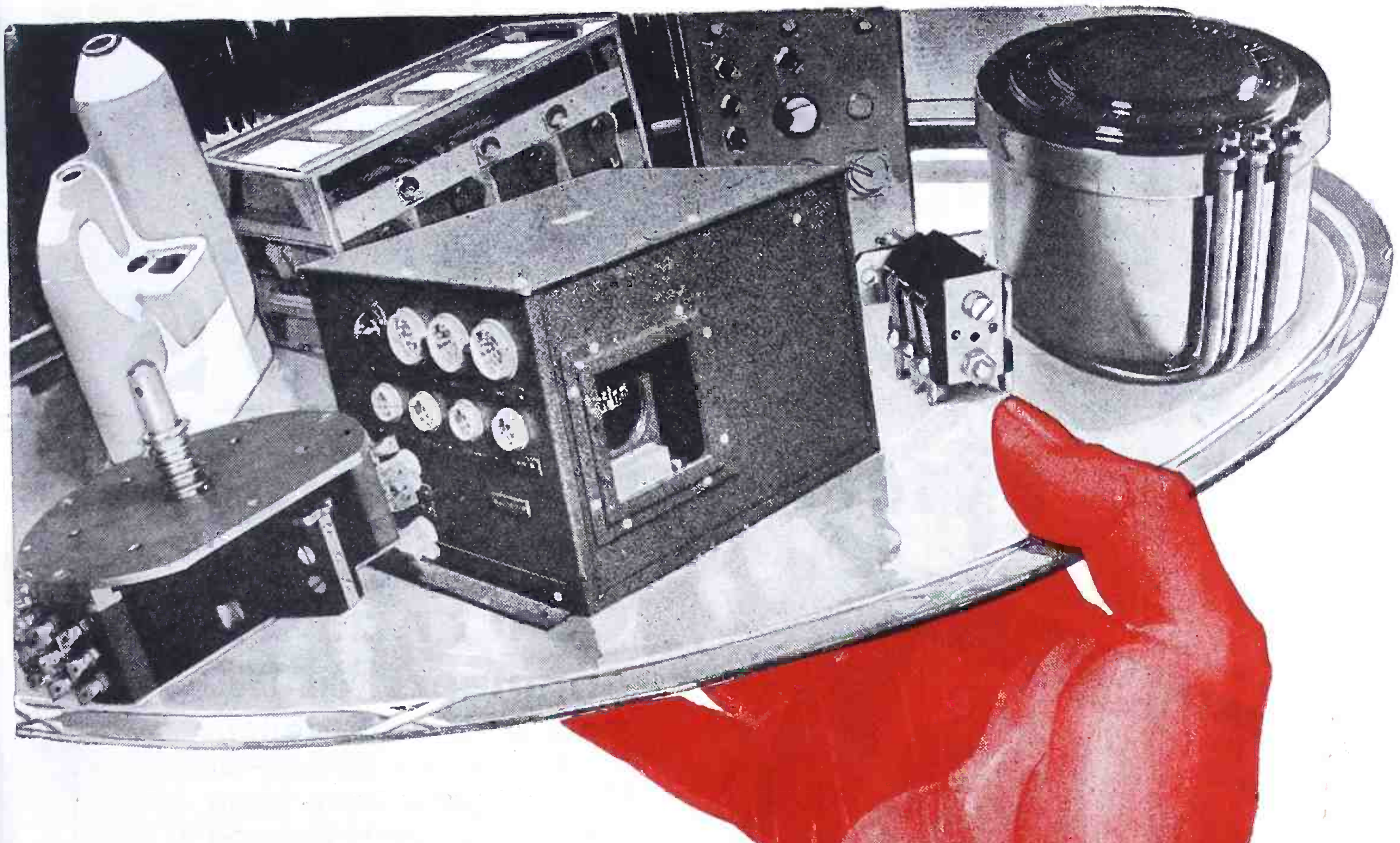


Write for the NEW DeJur Catalog

DeJur-Amsco Corporation

GENERAL OFFICE: NORTHERN BLVD. AT 45th ST., LONG ISLAND CITY 1, N. Y.

Buy and Hold More WAR BONDS



SPECIALIZED SKILLS A DIME A DOZEN

BUT what makes Lewyt "different" is the ability with which we use our specialized skills for *your* benefit . . . especially when you've got your eye on post-war cost-conscious buyers.

Will there be many sub-contractors in wartime products bidding for your work? Be cautious, then, with those of only war-born experience . . . whose production education is largely limited to the lush years of "Cost-Plus" operations.

But in the period of re-conversion to a civilian economy, cost-sensitive production will be an imperative *must*. There will be no place or time for carelessness, or laxity, or indifference to costs.

Lewyt is *not* a war baby. Lewyt is a "Manufacturer's Manufacturer" with 56 years of widely diversified production experience . . . with highly developed skills for making things better at less cost. We are doing it for many of the greatest names in American Industry. Perhaps we can "whet your appetite" for some of these skills, too.

It costs nothing to consult us. Even if present conditions preclude figuring on the job *now*, we *can* quote on WAR BONDS. They start at $18.75.

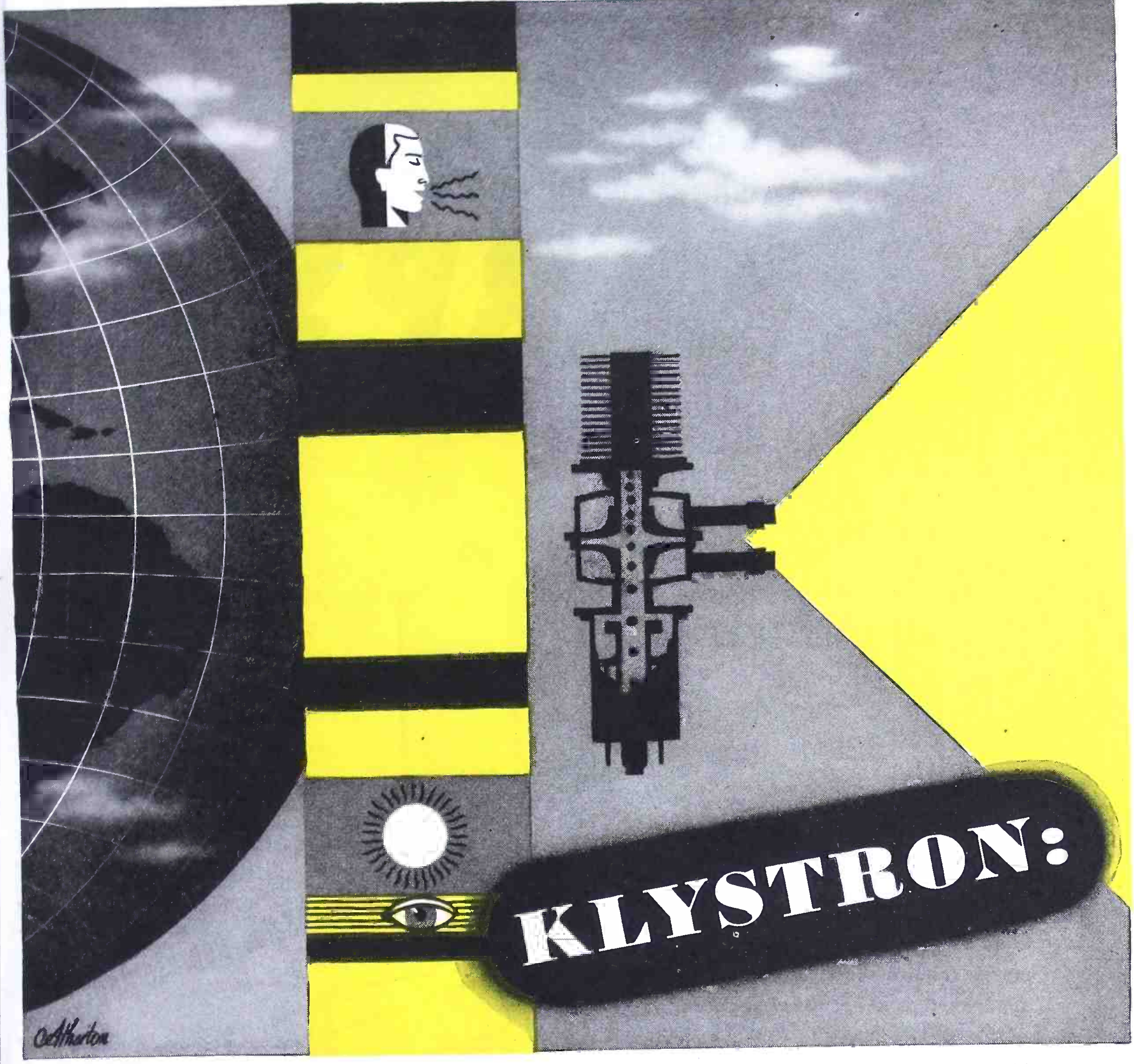
CHECK THESE OPERATIONS FOR IMPORTANT SAVINGS

We specialize in electric and electronic instruments, chassis and housings; mechanical and electrical assemblies; highest precision machine work; sheet metal fabrications; all types of welding, product finishing, etc. Write on your business stationery for illustrated 48-page book, "Let Lewyt Do It" . . . postage paid, no charge, no obligation. See Lewyt listings in Thomas' Register. LEWYT CORPORATION, 76 BROADWAY, BROOKLYN 11, N. Y

ARMY E NAVY

Lewyt

LET LEWYT DO IT



Makes *vhf* waves behave

THE KLYSTRON converts DC energy into radio frequency energy by modulating the velocity of an electron beam between spaced grids.

The ultra-high-frequency waves thus generated are so short that they approach heat and light waves in the electro-magnetic spectrum.

This makes it possible to project, by reflection, a shaped beam of *vhf* waves. Sperry engineers have put this principle to work in important wartime devices for our Armed Forces.

► **Klystrons are now in quantity production, and certain types are available. Write for information.**

The name "**KLYSTRON**" is a registered trade-mark of the Sperry Gyroscope Company, Inc.

• • •

Like other Sperry devices, Klystrons are also being made during the emergency by other companies.

Sperry Gyroscope Company INC.

GREAT NECK, N. Y. • DIVISION OF THE SPERRY CORPORATION

GYROSCOPICS • ELECTRONICS • AUTOMATIC COMPUTATION • SERVO-MECHANISMS

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★ **We have engineers and craftsmen with a "golden touch" to create anything in sheet metal.**

★ **We have complete metal working facilities, including hundreds of stock dies to lower or eliminate die costs.**

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Proving ground for *Norelco* Cathode Ray Tubes

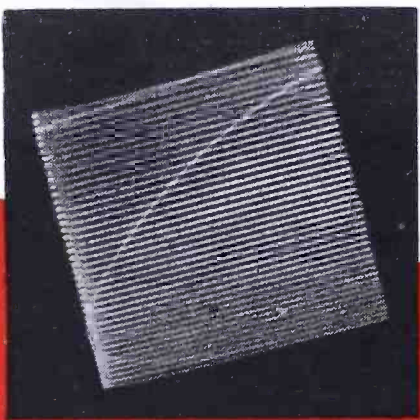
THE uniform characteristics, long life and outstanding performance of NORELCO Cathode Ray Tubes are the result of exceptional manufacturing skill supplemented by rigid tests applied to each tube as it comes off the production line.

As an example of the care exercised, the electronic test set, shown here, subjects every cathode ray tube to 30 different checks, such as line width, light output, plate alignment, base-to-shell alignment, uniformity of cathode surface, astigmatism, presence of gas, and screen condition. A total of 90 exacting tests of raw materials, parts, sub-assemblies, assemblies and performance guard cathode ray tube quality.

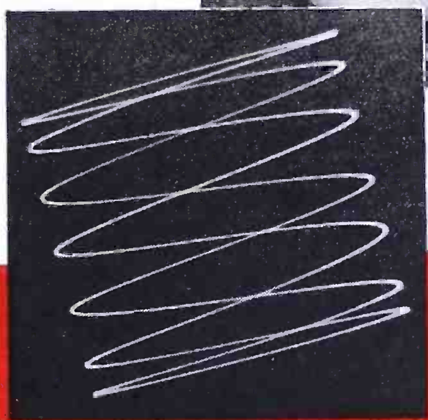
This is typical of the great lengths to which North American Philips goes in producing high performance NORELCO electronic tubes. Behind this company is an organization with world-wide experience resulting from over fifty years of electrical research and development.

Although all the tubes we produce now go to the armed forces, we invite inquiries from prospective users. A list of tube types we are especially equipped to produce will be sent on request.

Uniformly bright spot on screen of 5 CP1 cathode ray tube in test set indicates perfectly formed cathode.



Pattern used for measuring light output by means of photoelectric cell. Frequency—60 x 2940 cycles.



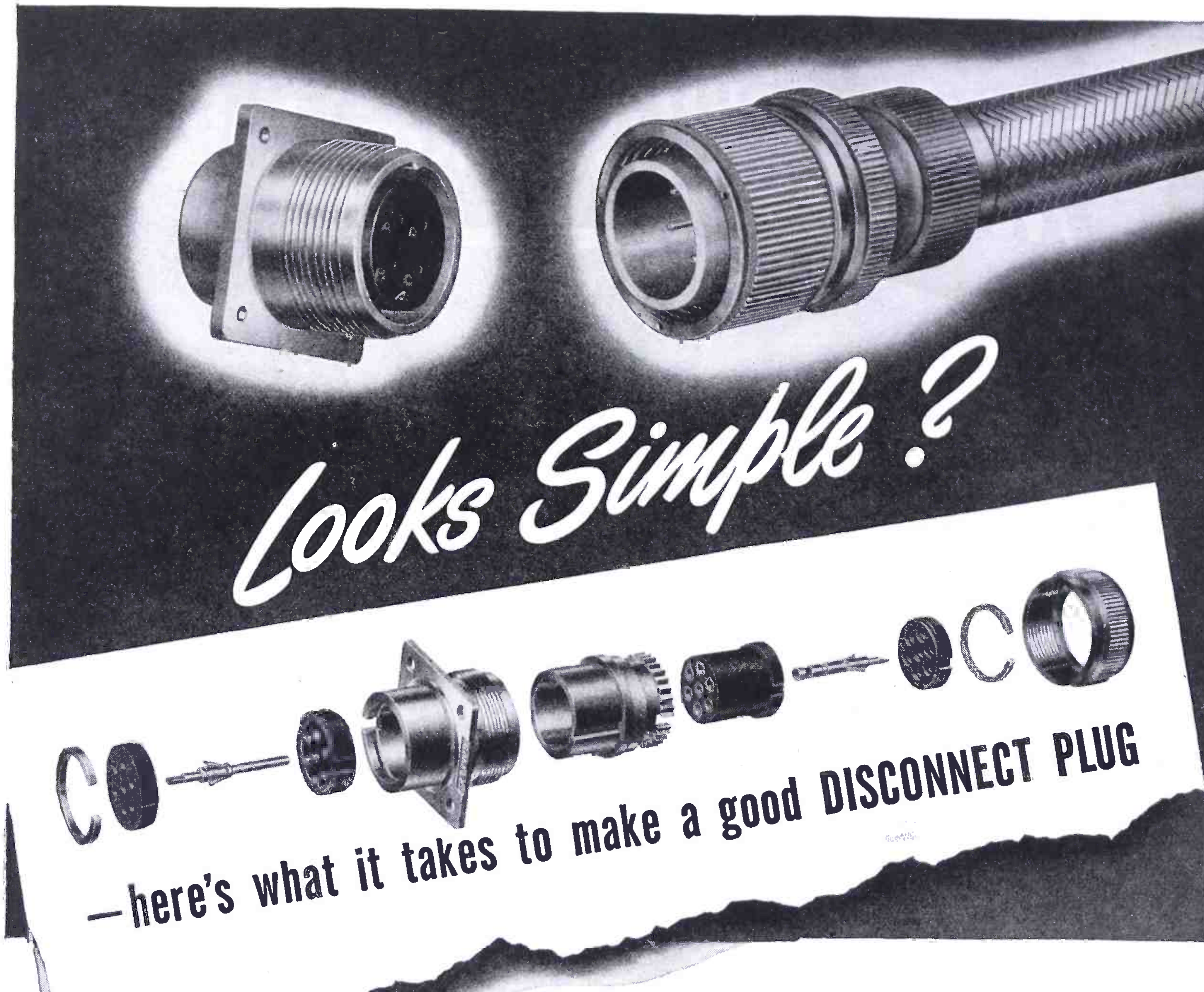
Trace showing absence of astigmatism. Frequency—60 x 420 cycles.

Write today for interesting booklet, describing the background of North American Philips in the science of electronics.

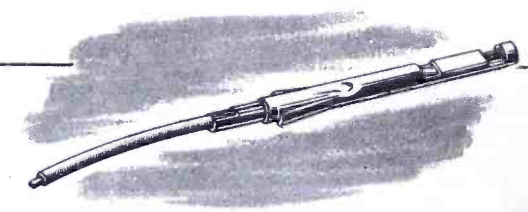
NORELCO PRODUCTS: Quartz Oscillator Plates; Amplifier, Transmitting, Rectifier and Cathode Ray Tubes; Searchray (X-ray) Apparatus; X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Electronic Measuring Instruments; High Frequency Heating Equipment; Communications Equipment; Tungsten and Molybdenum products; Fine Wire; Diamond Dies. When in New York, be sure to visit our Industrial Electronics Showroom.

Norelco Reg. U. S. Pat. Off. *Electronic Products by* **NORTH AMERICAN PHILIPS COMPANY, INC.**

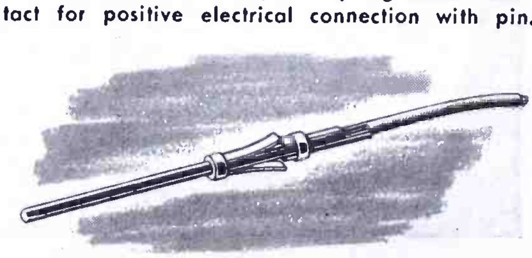
Dept. E-11, 100 East 42nd Street, New York 17, N. Y.
Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Div.); Lewiston, Me. (Elmet Div.)



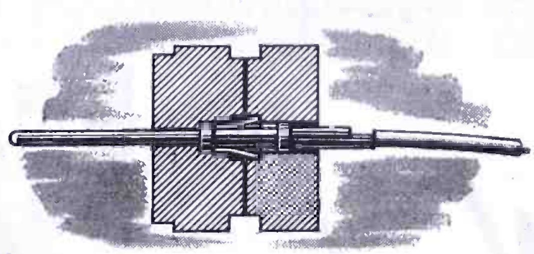
● There are more than 25 precision-made parts in the average Multiple Circuit Electrical Connector. When assembled, they perform their function—that of making or breaking many electrical circuits simultaneously—with the utmost simplicity and efficiency. Such simplicity in operation is the end result of years of research, many refinements and great skill in manufacture. The Breeze Multiple Circuit Electrical Connector reflects in the efficiency with which it does its job, the experience which went into its production—the background which has made Breeze a leading producer of many different types of aircraft and electrical accessories.



Socket construction features spring-loaded contact for positive electrical connection with pin.



Both pin and socket feature spring snap for ease of assembly in housing insulators after soldering



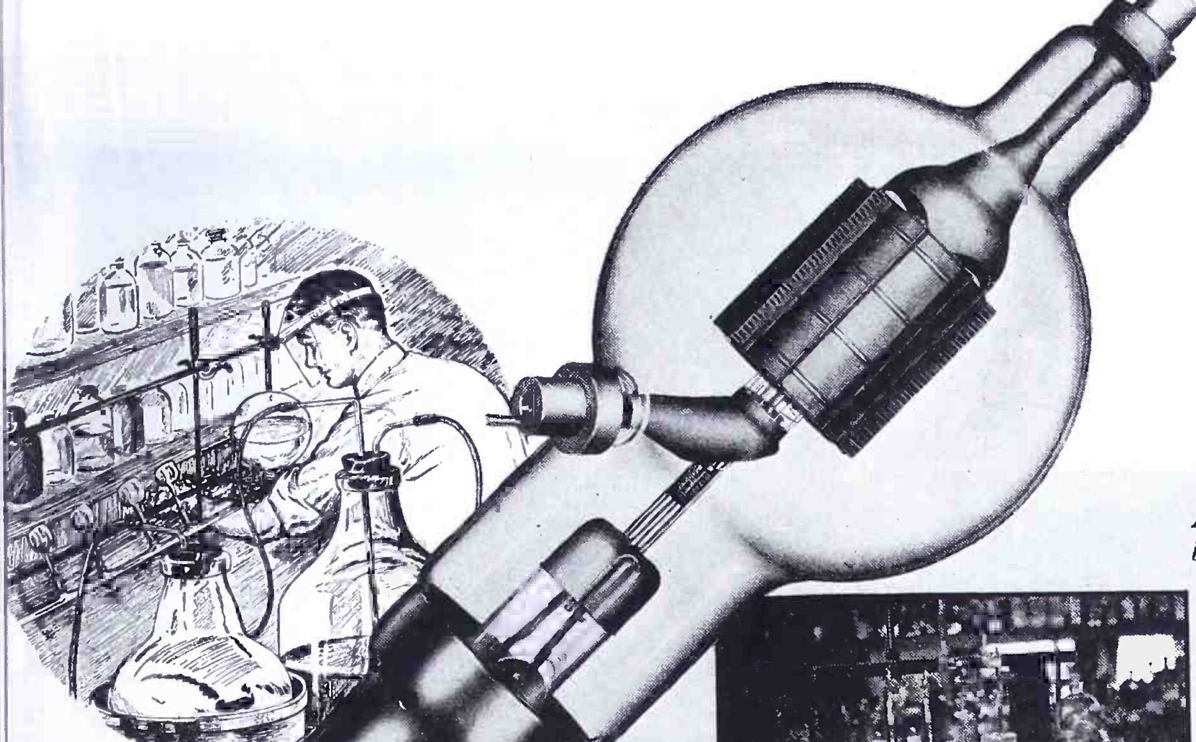
Cross-section illustrating how contact pin is snapped into place after soldering on lead wires.

Breeze BREEZE MARK

CORPORATIONS, INC.

NEWARK, N. J.

PRODUCTION FOR VICTORY — PRODUCTS FOR PEACE



the *Science* behind the science of electronics

The pattern of progress in the science of electronics is determined by the achievements in creating and developing new and more efficient electron vacuum tubes. Therefore, the whole complex task of vacuum tube development – involving the intelligent application of many sciences – comprises the real science behind the science of electronics.

To create and produce the modern vacuum tube requires experience and skill of the highest order in these many sciences in addition to complete facilities for their application. The list includes everything from chemistry and metallurgy – the technology of glass fabrication and vacuum pumping – to physics, optics, thermo-dynamics and most important of all – Electronics.

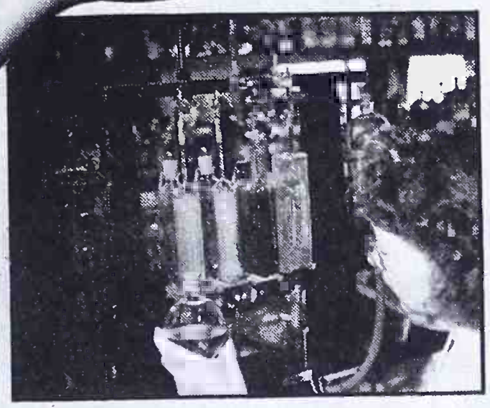
The resources and resourcefulness of Eimac laboratories have accounted for many outstanding contributions to the science of Electronics. A fact which is attested to by the leadership which Eimac tubes enjoy throughout the world. These comprehensive facilities are continuously being utilized to achieve better and better results for the users of Eimac tubes.

Eimac Engineering is devoted solely to the development and production of electron vacuum tubes. However, since the electron vacuum tube is the heart of all electronic devices it is advisable for users and prospective users of electronics to look first to the vacuum tubes required. A note outlining your problem will bring advice and assistance without cost or obligation.

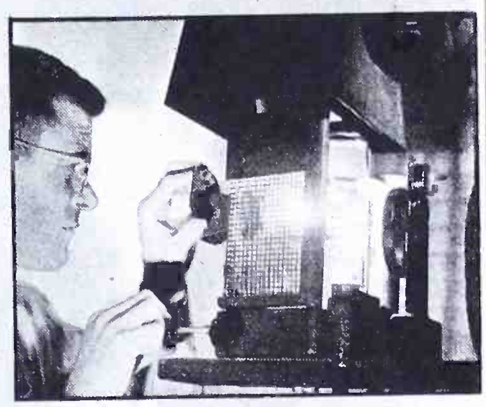
• • •

Write for your copy of Electronic Telesis – a 64 page booklet fully illustrated – covering fundamentals of Electronics and many of its important applications. Written in layman's language.

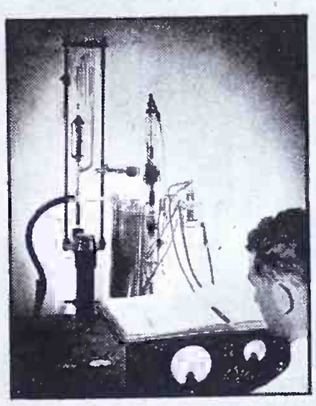
A few of the branches of the Science behind the Science of Electronics



CHEMISTRY—*Making Gas Analysis in the Eimac Laboratory*



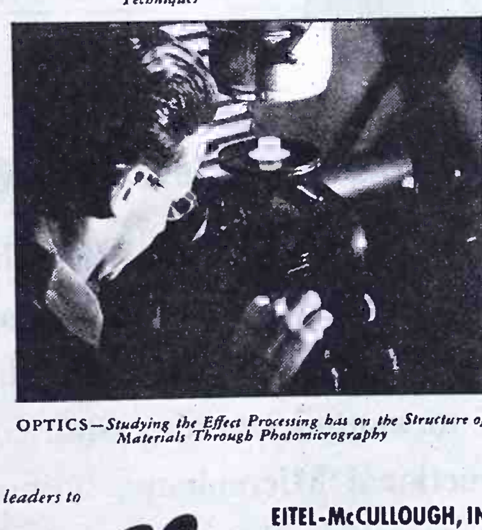
METALLURGY—*Spectrographic Analysis of the Rare Metals Used in Vacuum Tubes*



VACUUM TECHNOLOGY—*Constant Research to Develop Better Vacuum Techniques*

PHYSICS—*Actually Viewing Emission of Electrons with Electron Microscope*

ELECTRONICS—*Determining Facts about and Recording Data on Vacuum Tube Capabilities*



OPTICS—*Studying the Effect Processing has on the Structure of Materials Through Photomicrography*

GLASS TECHNOLOGY—*Special Equipment and Technique to Produce Complicated Glass Structures*

Follow the leaders to

Eimac REG. U. S. PAT. OFF. **TUBES**

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Plants located at: San Bruno, California and Salt Lake City, Utah

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. . . in Directional Microphones

It is not enough to design a Microphone that merely converts sound waves into electrical impulses. A Microphone, to be truly useful in modern broadcasting, should be discriminating enough to accept wanted sounds — and reject unwanted sounds. Shure Research was the first to develop a single unit uni-directional Microphone, both crystal and dynamic.

Shure Research is the reason why practically every major broadcasting station uses the Shure 556 Unidyne. Shure Research is your assurance of postwar microphone superiority.

ARMY E NAVY

SHURE MICROPHONES

SHURE BROTHERS, 225 West Huron Street, Chicago
Designers and Manufacturers of Microphones and Acoustic Devices

FIRST OFFICIAL PICTURE

Of the New

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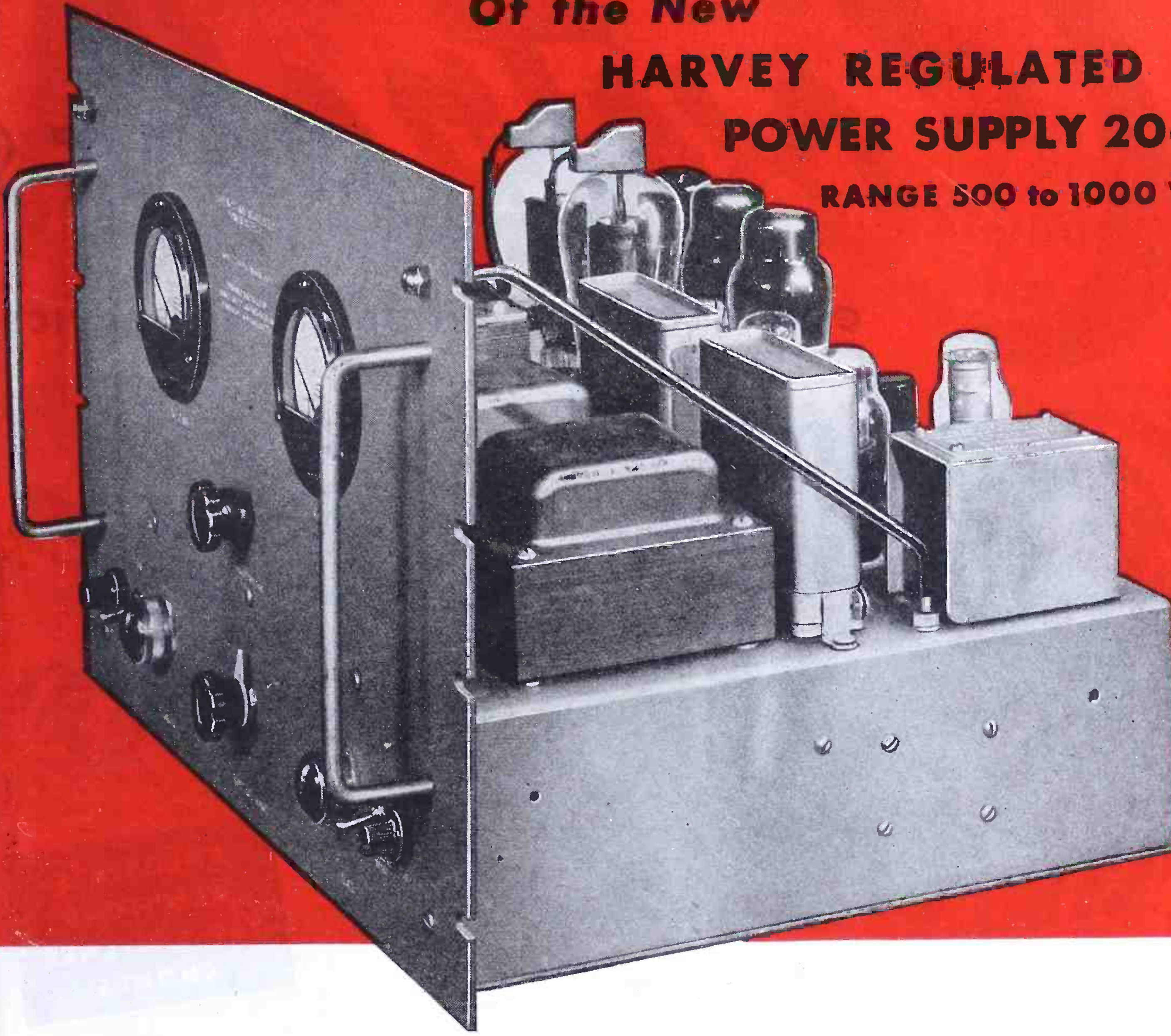
RANGE 500 to 1000 VOLTS



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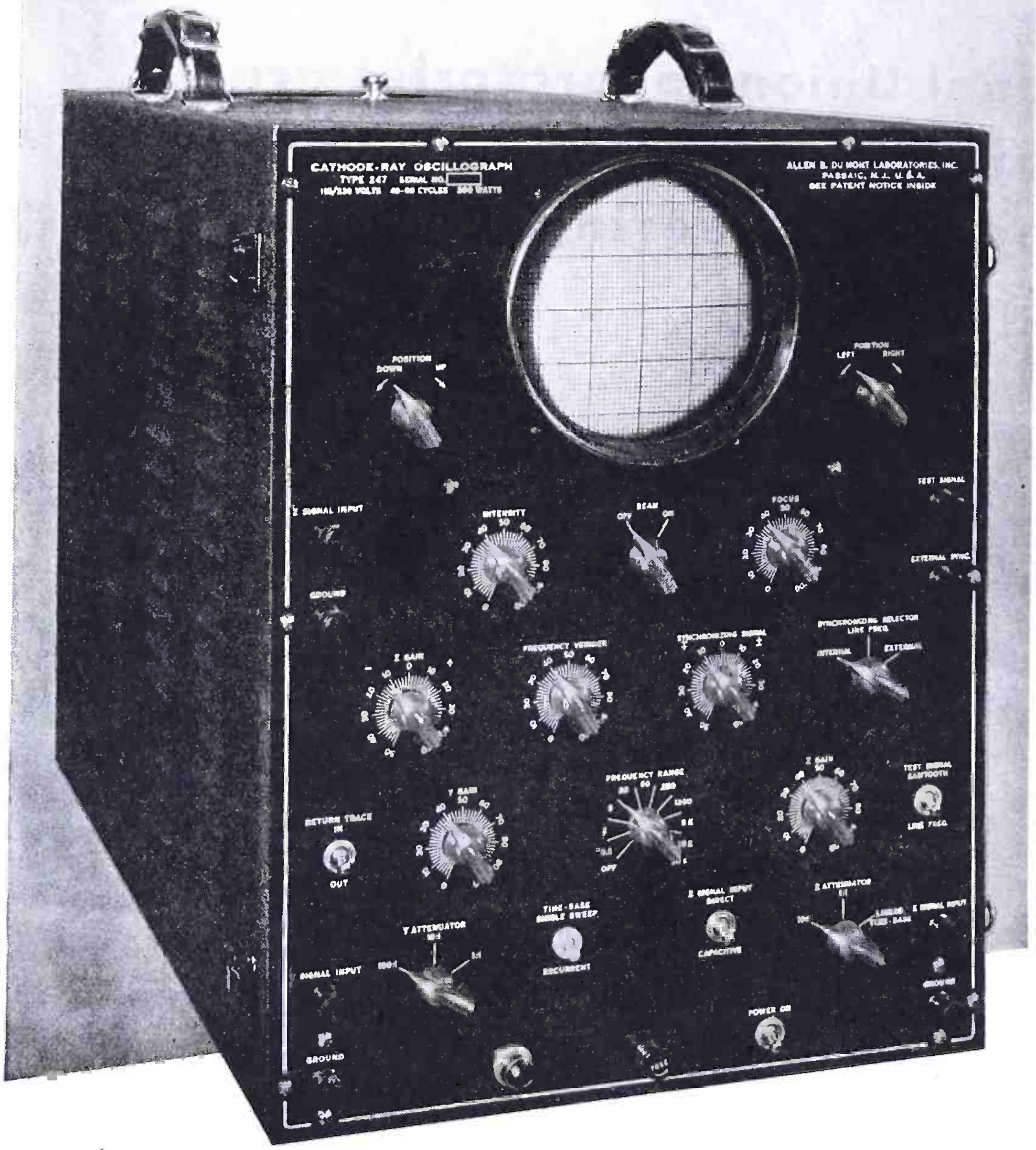

Uses new Army-Navy preferred Type 5CP1 cathode-ray tube with intensifier electrode operated at overall accelerating potential of 3000 v. High-intensity patterns. 5" dia. screen.

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Vertical or Y-axis amplifier response does not fall more than 10% below the uniform value from 2 to 200,000 C.P.S. Sufficient gain for maximum deflection factor of 0.05 r.m.s. volt input signal for 1" deflection of beam.

Distortionless, continuously-variable low-impedance attenuator or gain control. Stepped attenuator with ratios of 1:1, 10:1 and 100:1.

X-axis or horizontal amplifier accommodates signal produced by linear time-base generator. Reasonably uniform response from d-c to 100,000 sinusoidal C.P.S. Signal amplitude of 0.5 v. r.m.s. sufficient for deflection of 1" through amplifier.

Recurrent, repetitive and single-sweep operation of linear time-base generator. Continuously variable from 0.5 to 50,000 sawtooth cycles per second. Single sweep of writing rates corresponding to 0.5 to 10,000 cycles per second.

Z amplifier channel for applying external signal to grid or modulating electrode of cathode-ray tube.

Steel case. Black wrinkled finish. Copper-finished steel chassis. Two carrying handles. 14" w.; 19" h.; 26" d. 130 lbs.

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The sweep frequency range has been extended. The instrument may be used for observations on low-speed machinery and for other low-frequency signal functions—even down to ½ cycle per second. At the other extreme, the instrument handles radio-frequency signals as high as 500 kilocycles. The time-base has the necessary range to display such signals properly. Also, the vertical amplifier can satisfactorily accommodate them.

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BY MYCALEX CORPORATION OF AMERICA

Issued in an Effort to Clear up and to Avoid Continued Confusion in the Trade.

It has come to our attention that in some quarters electronic engineers and purchasing executives are under the erroneous impression that the MYCALEX CORPORATION OF AMERICA is connected or affiliated with others manufacturing glass-bonded mica insulation, and that genuine "MYCALEX" and products bearing similar names are all "the same thing" . . . or "put out by the same people" . . . or "come from the same plant."

These are the facts:

1. The Mycalex Corporation of America is not connected or affiliated with any other firm or corporation manufacturing glass-bonded mica insulating materials. It is 100% American in ownership and operation.

2. The word "Mycalex" is a registered trade-mark owned by the Mycalex Corporation of America, and identifies glass-bonded mica insulating materials manufactured by Mycalex Corporation of America.

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4. The Mycalex Corporation of America has behind it over 20 years of research leadership, dating back to work done by the original Mycalex (Parent) Company, Ltd. of Great Britain, from which it obtained its American patents. Mycalex Corporation of America owns U. S. patents and patent applications on improved glass-bonded mica insulation marketed under the trade-mark "Mycalex."

5. The products of Mycalex Corporation of America are: (a) "Mycalex 400"—the most highly perfected form of Mycalex, approved by the Army and Navy as Grade L-4 insulation. Mycalex 400 is sold in sheets, rods and fabricated form. (b) "Mycalex K"—an advanced capacitor dielectric with a dielectric constant of 10 to 15, which can be fabricated to specifications. (c) Molded Mycalex available to specifications in irregular shapes and into which metal inserts may be incorporated.

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History of Communications. Number Nine of a Seri

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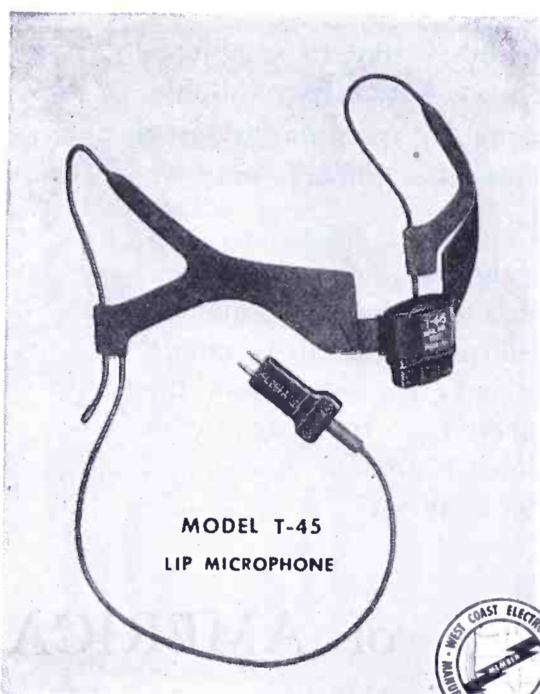

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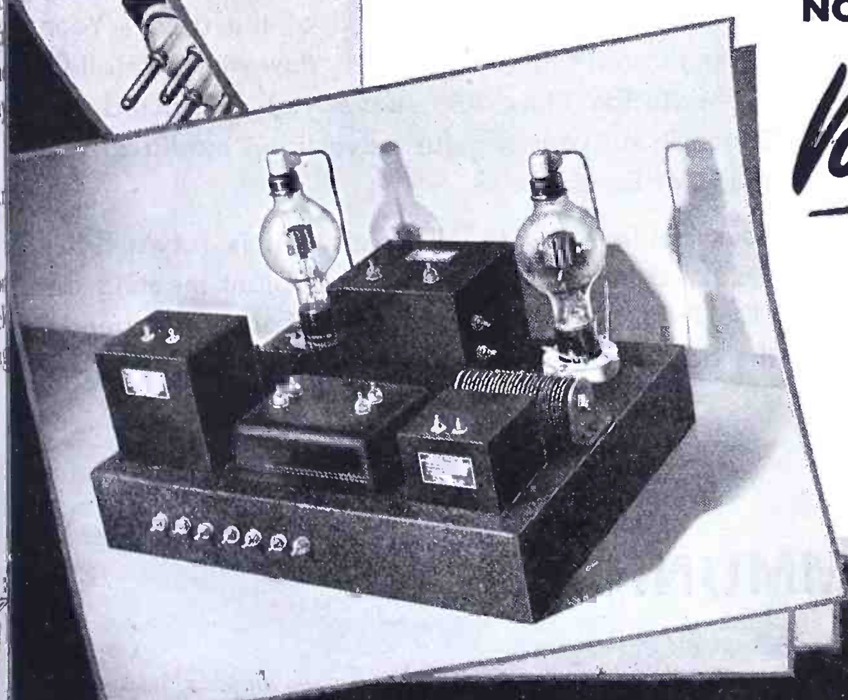

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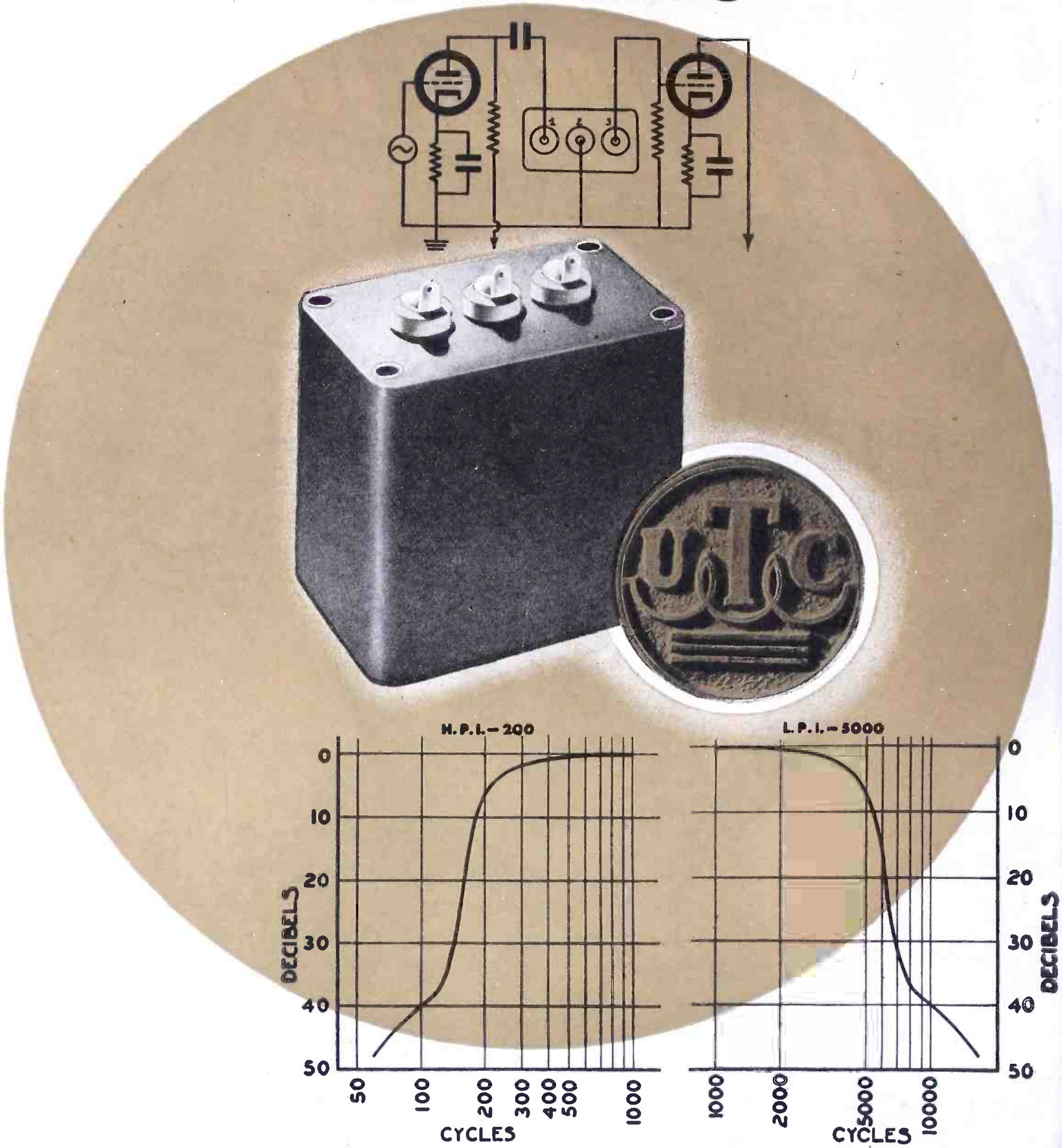

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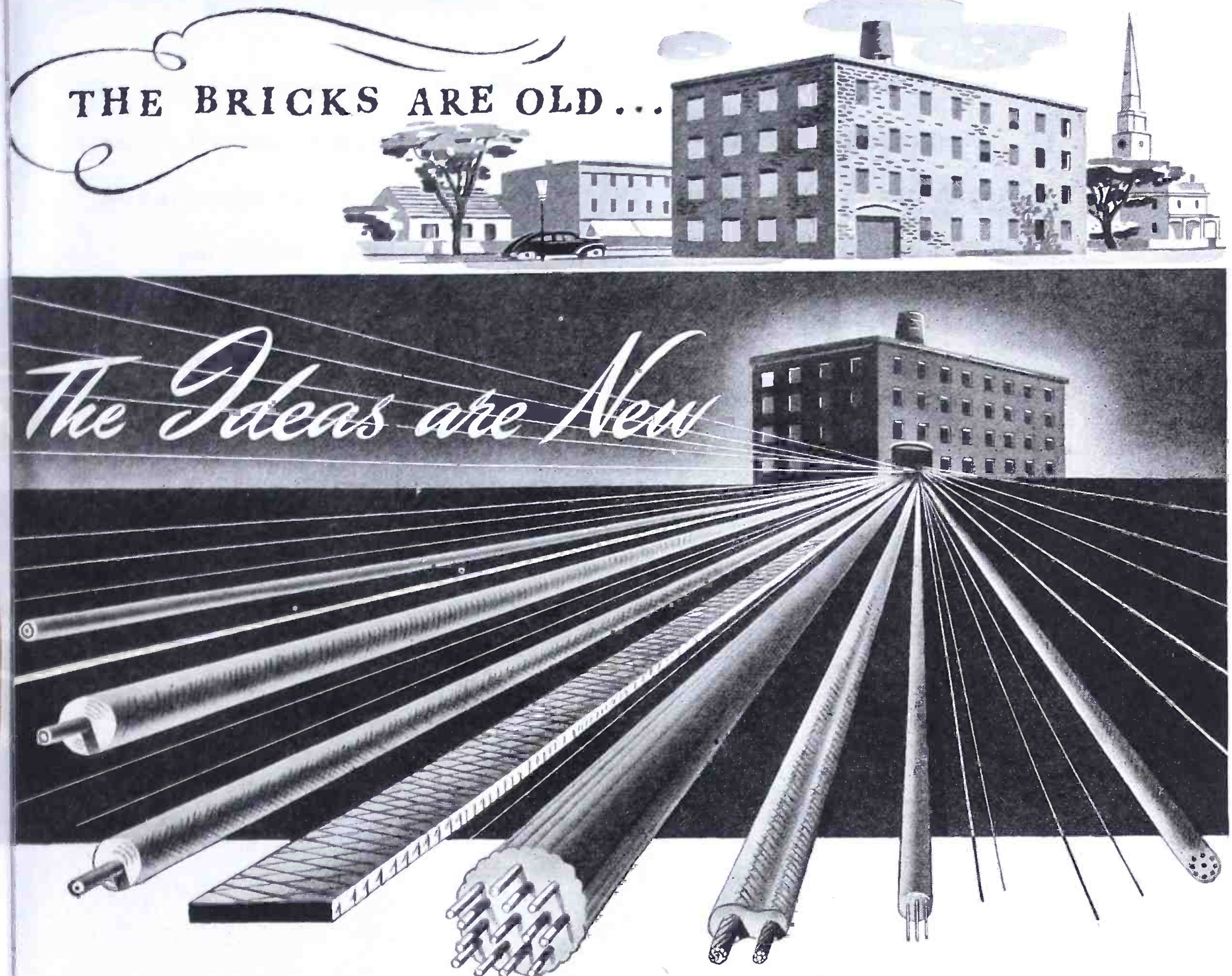

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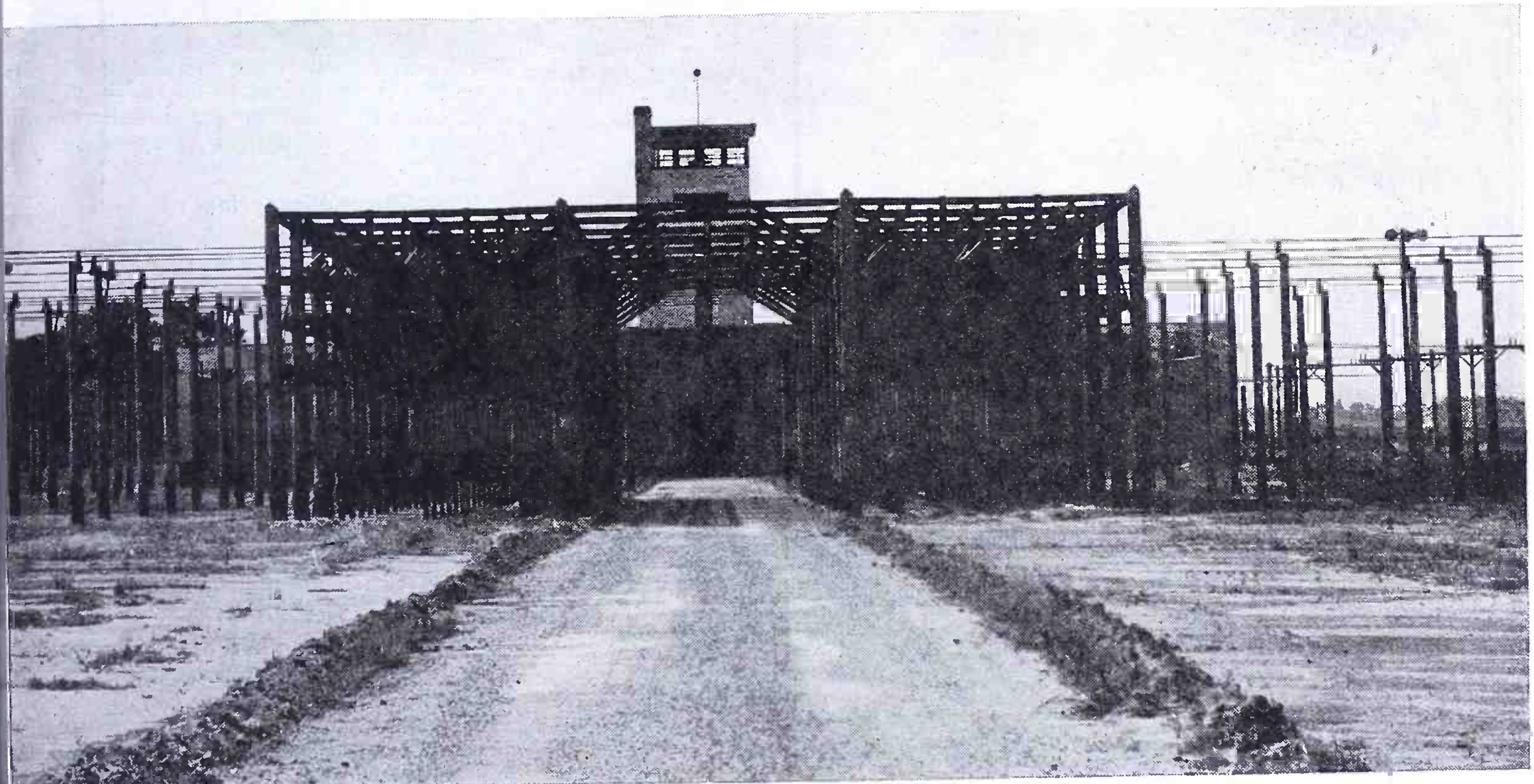


OWI 200-KW H-F TRANSMITTERS AT BETHANY, OHIO

by R. J. ROCKWELL

Director of Broadcast Eng.
The Crosley Corporation

ON September 23, 1944, the Office of War Information, the Office of the Coordinator of Inter-American Affairs and the Crosley Corporation officially dedicated three new 200-kw transmitters at Bethany, Ohio.

This was the culmination of almost two years of planning, designing and building, of invention and adventure in the field of radio engineering. This was the end of a trail that started with an urgent war necessity, and the beginning of another trail that leads forward to a new kind of *air supremacy* for the United States of America. This was *the loudest voice in the world* trying its young lungs.

On that fateful December Sunday in 1941, when bombs rained down on Pearl Harbor, Uncle Sam was internationally inarticulate, as compared with the enemy. Six international licensees were operating only 13 short-wave stations, several of which were incapable even of 50-kw output. In contrast to this, Germany had at least 68 short-wave transmitters under her control, and it was reported that from 12 to 20 additional units of 200-kw output might be in operation by December, 1942. Japan controlled 42 known transmitters, ranging up to 50 kw. Thus, the Axis was able to carry the same program on as many as 20 different frequencies. In fact, Germany's regular service to the Americas was then using 16 frequencies.

Illustration Above

A view of the main antenna switching station with transmission lines leading to the antenna.

By the most conservative estimates, we needed at least 36 international transmitters, operating on a total of 70 frequencies between 6 and 20 mc, with powers ranging up to 200 kw, if possible. But that was a big *IF*! For, at that time, no vacuum tubes, output circuits or antennas which were capable of such powers were known to exist.

In a drastic effort to remedy the situation, the Board of War Communications called a *council of war* in Washington. All interested parties were invited—international licensees, equipment manufacturers, representatives of the Federal Communications Commission, Office of War Information, Office of Coordinator of Inter-American Affairs, the Department of State, and others—to determine how soon existing facilities could be augmented and new facilities added, and what powers could be attained. As a result of this and subsequent meetings, it was decided that, within one year, a total of 32 transmitters could be in operation and at the disposal of OWI and CIAA. It was felt that installations could be greatly expedited by duplicating existing maximum power output, which was 100 kw, and required operation of tubes in parallel to achieve even this power.

But, to be on a parity with the Axis, and to be able to override interference and cope with inferior receiving conditions in foreign countries, we had to do more than just *duplicate* existing powers; we had to *exceed* them, we had to *double* our *greatest* previous powers!

As a part of this mammoth program, the Crosley Corporation undertook to redesign its equipment, for an output of 200 kw. Tubes were designed and developed, circuits were calculated, and antennae were devised to do the job. This paper will describe the installation in some detail, and tell of its operation.

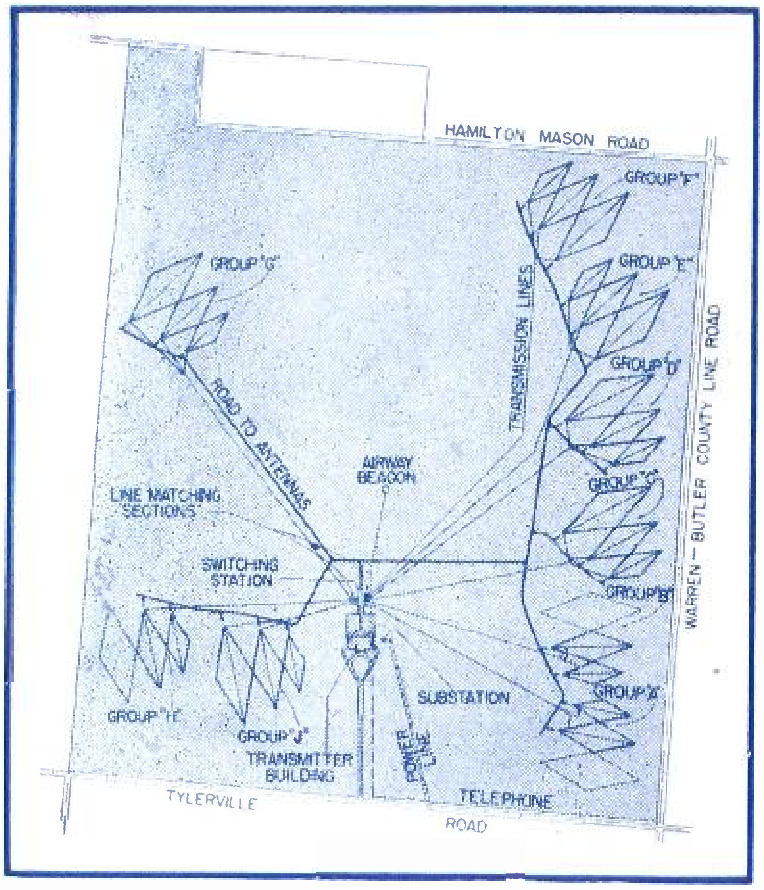
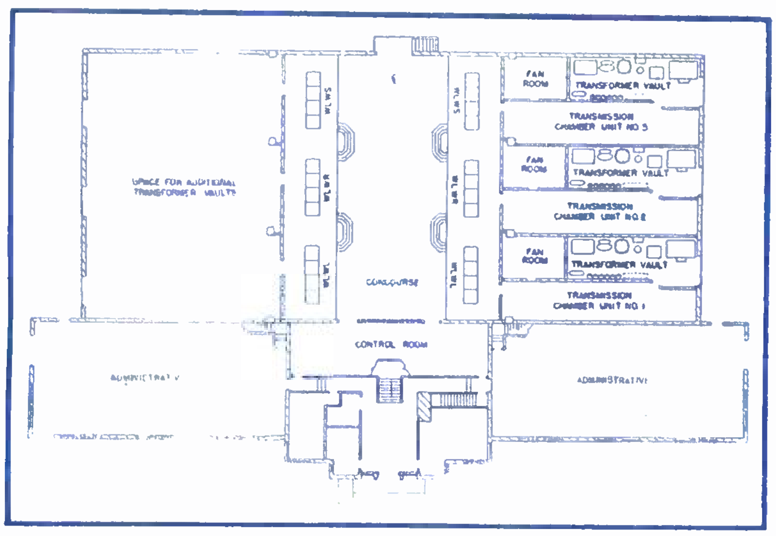
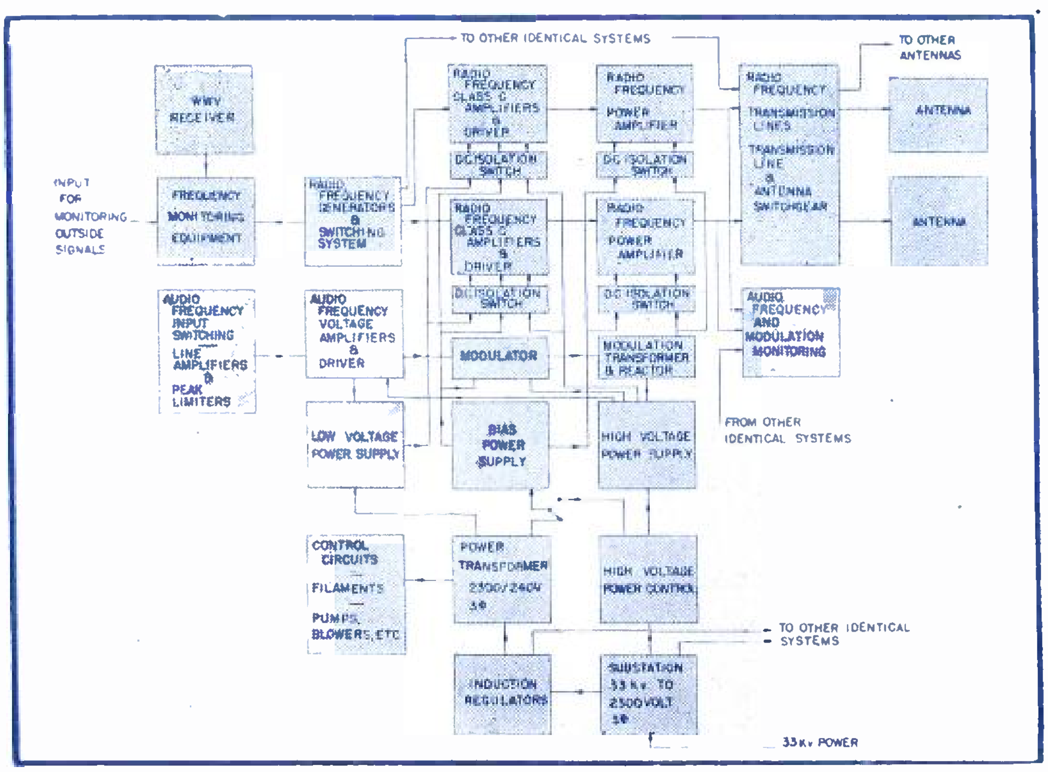


Figure 1
A general layout of the property where the 200-kw transmitters are located, with building, substation, switching station and antenna system.



Figures 2 (left) and 3 (below)
Figure 2, floor plan of the transmitter building, showing the fireproof vaults where the high voltage transformers, filter reactors, filter condensers, and high voltage control components are placed. Figure 3, block diagram of the complete transmission system.



High Power Pioneering

The story of Bethany really goes back far beyond Pearl Harbor. In the very early days of high-power, high-frequency broadcasting, when 10 kw was the power maximum, Crosley's W8XAL was a pioneering leader. Always experimenting with higher powers, its staff had already built a 50-kw transmitter when FCC made that output a license requirement. Through continuation of these experiments, tubes were developed capable of 75 kw, and in 1940, another momentous dedication was held, of the most powerful short-wave station in this country at that time, WLWO.

Even in the standard band, Crosley had pioneered in high power. Its world famous W8XO, on the WLW frequency of 700 kc, had operated successfully for several years prior to the war with 500-kw power. And even today, the unmodulated signal of W8XAL serves the U. S. Bureau of Standards, providing a variety of information on radio skywave transmission, notably on absorption and its variation. From measurements of this type, the Bureau supplies OWI with advance information which enables them to schedule optimum usable frequencies for all American international stations for various times of day, season and solar cycle.

Because of these qualifications, as well as the fact that Crosley's offer to construct the three 200-kw transmitters did not conflict with urgent military orders, this responsibility was placed in the hands of the Crosley Corporation by OWI. Moreover, since at the time the decision was made, it was still considered a possibility that bombings of the East coast might be attempted by Germany, a middle-west location was desirable for security reasons.

Selecting a Site

Once the basic plan was evolved, the first big problem was the selection of a site on which to build the project. The specifications were extremely exacting. About a section of land was required for the building, switching station and 24-rhombic antennae. And it was necessary to leave some space for future expansion without overcrowding. The ground had to be as high, or higher, than surrounding territory, and relatively level throughout and for some distance beyond. A uniform slope under and ahead of the antennas in the direction of transmission was needed, in order to lower the angle of maximum radiation of the high frequency, directional radiators. The land had to be virtually free of wooded or populated areas for a considerable distance. A source of 3000-kva primary power was required, as well as provision for broadcast type telephone circuits, leading from the master control room of WLW in Cincinnati.

The Bethany site was chosen only after thorough studies had been made of U. S. topographical maps covering a radius of about 50 miles around Cincinnati, and after every other posssible site had been investigated. It is slightly less than a full section of high, relatively flat land, gently sloping generally in all directions from center, and the surrounding land is also flat and slopes slightly in favorable directions. The area is remarkably free from housing, and the few slightly wooded areas could easily be avoided in layout.

The same dual-power circuit feeding the WLW, WLWO and WLWK transmitters near Mason, Ohio, passes along the southern boundary of the property, and the telephone cables for those stations run along the eastern boundary. Thus expense, and use of critical materials, could be held at a minimum, in obtaining these vital services. Two rail lines are within a few miles of the place, and a good hard surface road runs past the south entrance to the property, while satisfactory all-weather roads skirt the east and north boundaries. This was of considerable importance, due to the physical size of some of the components of the project, such as antenna poles, transformers, etc., which had to be transported to the site.

Figure 1 shows a general layout of the property, with building, substation, switching station and antenna system indicated and identified.

Tailoring the Transmitter Building

The building is composed of two separate units, an administrative section and a transmitter section. Although, due to the character of the design, there is an expansion joint between these sections, the two are actually one building.

Since this paper deals primarily with the transmitters, concentration will be on the details of that section, and the administrative portion will be dismissed with the information that it is two stories high, with a four-story central tower that serves as a guard station and revolving searchlight beacon house. Offices and living quarters for resident engineers, a machine shop and a garage occupy the two stories of the building itself, while the first three levels of the guard tower contain radio-testing equipment, a storage tank for distilled water used in tube cooling, and two 1500-gallon water storage tanks for general building purposes.

The transmitter section is entirely functional. It was designed to accommodate six transmitters with their associated equipment, and is actually six similar units, three on each side of a center concourse. This section is a monitor type building 175′ wide by 75′ long, with a high bay measuring 24′ from floor to roof slab. Ceiling height in the side bays is 17′. This section contains some interesting features. A tunnel extends under the center of the concourse, connect-

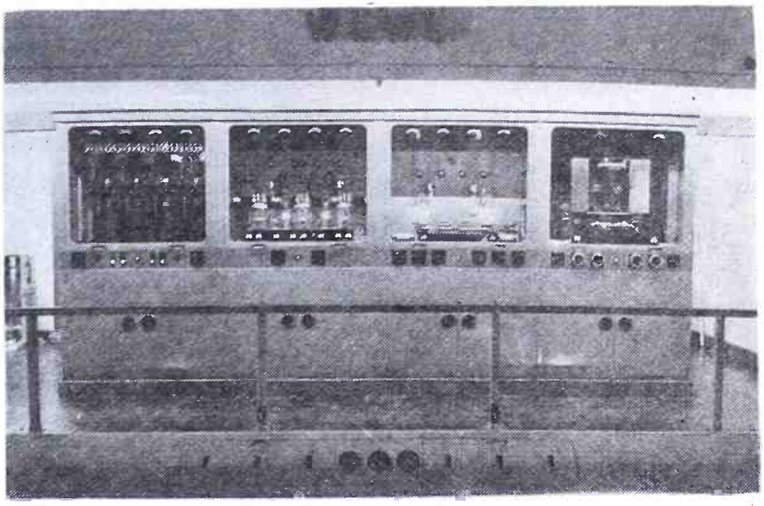


Figure 4
View of a section of the transmitter. Unit, third from left, is r-f driver, which operates at carrier frequency throughout; range is 6 to 22 mc.

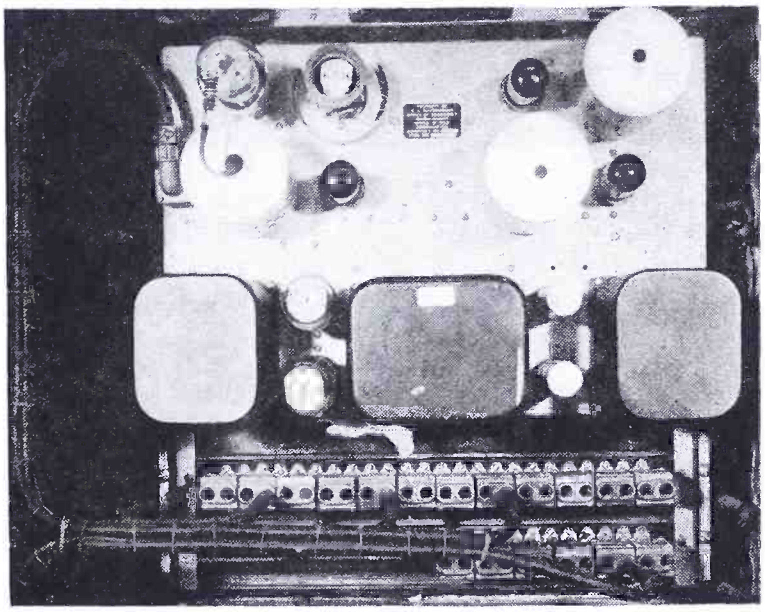


Figure 5
Rear view of one of the r-f generators. Shield has been removed from second buffer stage coil to shown construction.

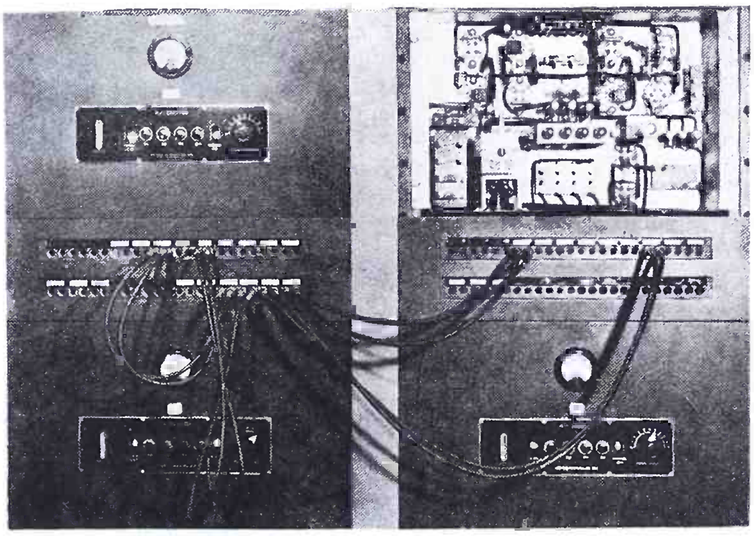


Figure 6
Partial view of the equipment bays in which the r-f units are mounted. Note coaxial patching panels. R-f generator front panel has been removed to reveal internal construction.

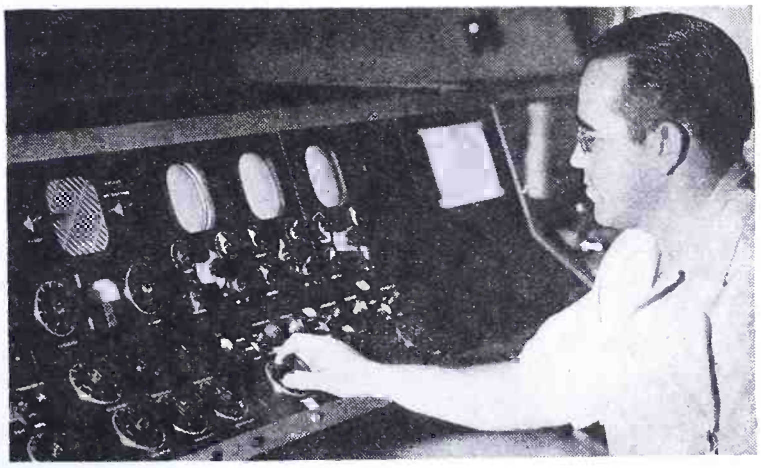
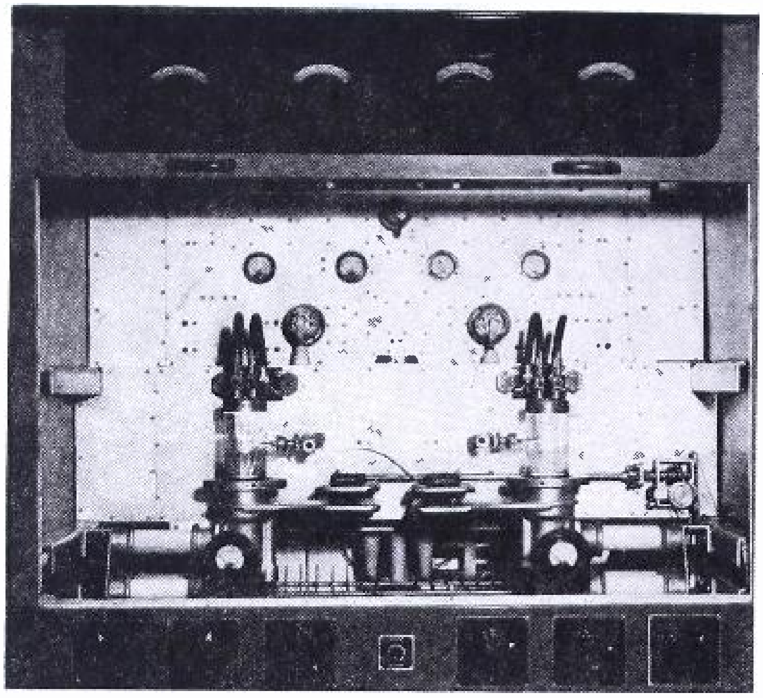
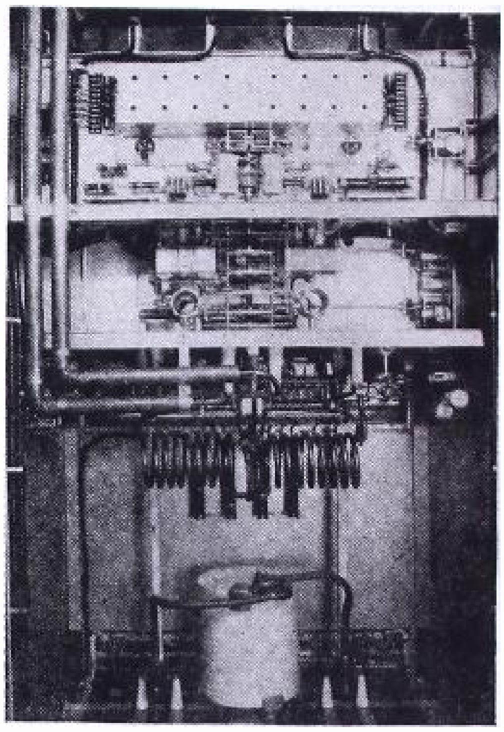


Figure 7
Cathode-ray oscilloscopes used for monitoring carrier of each transmitter. These are mounted in the control desk.





Figures 8 (left) and 9 (right)
Figure 8, front view of the r-f driver which is composed of three stages. Each stage is separately tuned in both grid and plate circuits, and is link-coupled to the succeeding stage. Figure 9, output coupling adjustment, which is completed by swinging a small link coil into the field of the center of the driver plate inductance.

ing with the boiler room under the administrative section, and provides cross-connecting facilities for the transmitters on either side. To permit the extraordinary flexibility for piping and wiring required in this installation, a cellular steel floor was set between two mats of concrete, the upper layer being the floor of the concourse. This steel *Q-floor* extends from the sides of the tunnel walls to the undersides of the transmitter catwalks.

Another unusual design feature is its cantilever construction. The high bay has a span of 64′ between column supports. The monitor width of the high bay is 99′. To reduce the depth of the girders supporting bay beams, 17′ 6″ cantilevers were designed on the outside of the columns, to support the extension of the monitor beyond the column centers. This cantilever action produced negative moments in the center of the span, permitting a reduction of the beam depth of the girders bridging the high bay. The roof slab of the side bays is suspended from the bottom level of the cantilevers, producing a design in which only three spans are necessary to bridge a total distance of 175′, and which, at the same time, accomplishes the difference in ceiling heights incident to monitor-type roof construction.

The transmitter section interior consists of the center concourse, flanked by catwalks, on which are mounted six transmitter units. Directly behind these units is a continuous wall, in which is mounted, behind each individual unit, a group of cabinets which include 240-v power distribution panels, magnetic switch panels, automatic air control equipment, etc. Beyond the wall to the rear are individual fan rooms, in which are cooling fans, water pumps, and plenum chambers for distributing inlet and heated air as described later. Directly behind these fan rooms are the transformer vaults. Under the catwalks are the filament transformers, and plumbing for distributing the water to water-cooled tubes. On the slanted front edge are water-flow meters, temperature gauges, and water controls, Figure 4.

The entire building is thoroughly grounded, a mat of wires radiating on all sides for a distance of 50′, and extending to the reinforcing bars which are welded together within the concrete. This was done to eliminate the possibility of cross-modulation, and to provide a good ground matting for the transmitters.

The Transmission System

A general over-all picture of the complete transmission system appears in the block diagram of Figure 3. The diagram shows one complete transmission system with its three essentials: primary power, r-f power, and a-f power, separately obtained and combined into high power modulated r-f energy, which is radiated by the antenna system.

Radio frequency at carrier frequency is generated continuously on all frequencies assigned to this plant. Separate 15-watt exciters for each frequency are mounted, six to a bay, in the control room. Exciter power is fed to the transmitters through a plug and jack panel, using multiple, double conductor coaxial lines and jacks.

The r-f driver unit, third from the left in Figure 4, operates at carrier frequency throughout. Its range is 6 to 22 mc. Input power from the exciters is from 2 to 5 watts. A maximum output power of 10 kw can be obtained from this unit, which is coupled, through an adjustable link, to the power amplifier in the adjacent cabinet to the right.

The modulated class *C* amplifier employs two tubes, operating push-pull, capable of 200-kw carrier output. Conventional lumped constant circuits are used in the grid, while the plate circuit consists of a lumped variable capacity, and a shorted transmission line section for the inductance. Variable inductive coupling is employed to transfer power to the antenna transmission lines.

The a-f circuits originate in the control room, where the modulating signal is taken from incoming telephone lines, or local electrical transcriptions. A transmitter circuit includes a limiting line amplifier, to amplify the audio voltage and compress high level peak; peak clipper to chop both positive and negative peaks at a pre-set level, usually equivalent to 100% transmitter modulation; and the usual level controls and volume indicators. From the control room, a-f voltage is fed at zero level to the modulator unit of the transmitter. The modulator contains three push-pull voltage-amplifier stages, and a multiple-tube class *B* power stage, capable of delivering 180 kw of audio power. The modulation transformer, modulation reactor, and d-c blocking condenser are located in the transformer vault, and are connected to the modulator through high-voltage cables.

Primary power for these transmitters is derived from a substation at the side of the main building, and a stepdown transformer in the transformer vault. All rectifier tubes and their filament transformers are located in the rectifier unit of the transmitter.

The rectifier unit also serves as a control and supervisory unit for the entire transmitter. Momentary contact buttons, pilot relays, and supervisory relays and lights are mounted in the rectifier cabinet. All 240-v power contactors for filaments, low voltage supplies, etc., and a 240-v breaker and distribution panel are located in the wall cabinet behind the transmitter, as previously described. All equipment dangerous to personnel is completely interlocked, both electrically and mechanically.

Antenna System

The antenna system consists of a transmission line from each of the six transmitter bays to a common transmission line switching system. In this gear, any transmitter line can be connected to any outgoing antenna line. All antennas are of the reentrant rhombic type.

Each transmitter is equipped with a complete and separate cooling system, which supplies water for water-cooled tubes, and ventilating air for general cabinet cooling. This system is so arranged that all waste power is converted into heated air, which is automatically used for building heat in winter. In summer, heated air is forced through roof ventilators, causing cool air to be drawn into the building. A 50-gallon-per-hour still in the boiler room and a 400-gallon storage tank in the guard tower, with a common feeder to all systems, supply the distilled water for cooling.

A complete system of modulation monitoring, by means of oscilloscopes, of audio monitoring by means of diodes on the transmission lines, and of frequency monitoring, by means of a secondary standard and WWV comparison equip-

(*Continued on page* 56)

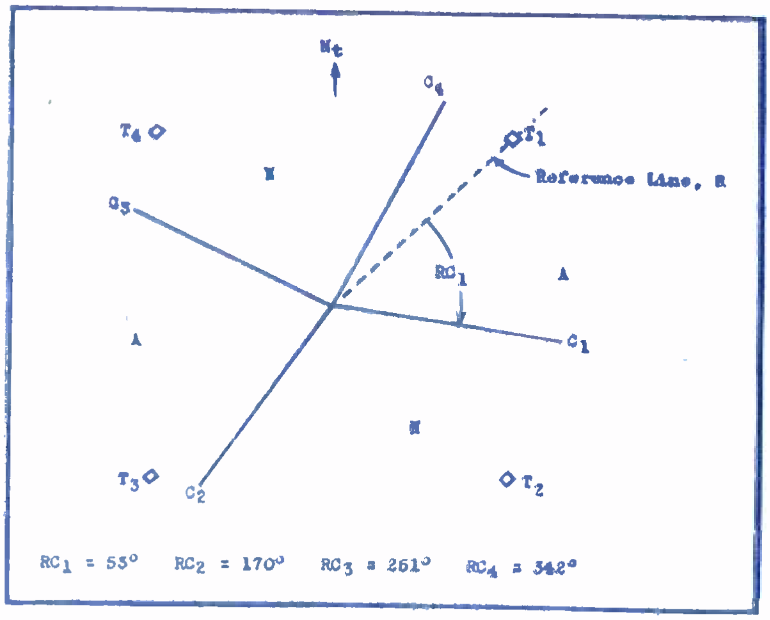


Figure 1
First step in solution; drawing of towers and required courses, correctly oriented.

GRAPHICAL CAA COURSE

by G. L. BREWER

Chief, High Frequency Unit
Signals Division, CAA

THIS paper describes a graphical method employed by the CAA for determining the adjustments necessary for properly orienting the four courses of a CAA radio-range station employing the modified Adcock antenna system.

The method discussed was introduced by the writer in 1938 to provide a simple and direct procedure whereby CAA personnel, especially those in the field, could predetermine the correct adjustments of the radio equipment for producing the required courses. In the past it was necessary to solve the following simultaneous equations to secure these data:

$$\frac{I_1 + I_2 \tan\theta}{I_2 - I_1 \tan\theta} = \frac{\cos(a \sin A_1)\cos\frac{\phi 2}{2} - \sin(a \sin A_1)\sin\frac{\phi 2}{2}}{\cos(a \cos A_1)\cos\frac{\phi 1}{2} - \sin(a \cos A_1)\sin\frac{\phi 1}{2}} \quad (1)$$

$$\frac{-I_1 + I_2 \tan\theta}{I_2 + I_1 \tan\theta} = \frac{\cos(a \sin A_3)\cos\frac{\phi 2}{2} - \sin(a \sin A_3)\sin\frac{\phi 2}{2}}{\cos(a \cos A_3)\cos\frac{\phi 1}{2} - \sin(a \cos A_3)\sin\frac{\phi 1}{2}} \quad (2)$$

$$\frac{I_1 + I_2 \tan\theta}{I_2 - I_1 \tan\theta} = \frac{\cos(a \sin A_2)\cos\frac{\phi 2}{2} - \sin(a \sin A_2)\sin\frac{\phi 2}{2}}{\cos(a \cos A_2)\cos\frac{\phi 1}{2} - \sin(a \cos A_2)\sin\frac{\phi 1}{2}} \quad (3)$$

$$\frac{-I_1 + I_2 \tan\theta}{I_2 + I_1 \tan\theta} = \frac{\cos(a \sin A_4)\cos\frac{\phi 2}{2} - \sin(a \sin A_4)\sin\frac{\phi 2}{2}}{\cos(a \cos A_4)\cos\frac{\phi 1}{2} - \sin(a \cos A_4)\sin\frac{\phi 1}{2}} \quad (4)$$

Where:

(a) *A_1, A_2, A_3 and A_4 are the angles which the courses make with the reference line.*
(b) *θ is the goniometer angle in degrees.*
(c) *I_1 and I_2 are the values of r-f current in the goniometer primaries. (I_1 feeds towers T_1 and T_3 when the goniometer setting is zero.)*
(d) *ϕ_1 is the phase difference between the voltages at towers T_1 and T_3.*
(e) *ϕ_2 is the phase difference between the voltages at towers T_2 and T_4.*

Many of the field engineers and electricians after spending considerable effort on the solution of the above equations for which there were no practical means of checking the results, resorted to the "trial and error" method. In order to aid this personnel, the graphical method was conceived and has proved a great aid in enabling the necessary data to be determined within a few minutes rather than hours, which was necessary in most cases, where the purely mathematical solution was employed.

THIS paper treats only the subject of the graphical method for course alignment and does not attempt to describe the theory and operation of a radio-range station as employed by the CAA since numerous previous presentations have discussed this subject in great detail.

Graphical Method Features

By the use of the graphical method, the following are determined:

(*a*)—The goniometer setting.
(*b*)—The electrical line length of the r-f transmission lines to each of the four sideband antennas.
(*c*)—The ratio of the r-f currents in the goniometer primaries.

These data supply the necessary information for orienting the courses, although it should be realized of course that correct alignment of courses is also dependent upon proper tune-up and adjustment of all component equipments.

The graphical method solution is based on the following information:

(*a*)—Tower bearings (measured clockwise from true north).
(*b*)—Course bearings (true and toward station).
(*c*)—Frequency (in kilocycles).
(*d*)—Diagonal tower distance (in feet).

The first step toward the solution is the drawing of the towers and required courses, correctly oriented, as in Figure 1, with the signal identification letters noted in their respective quadrants. The towers are designated by the letter *T* with subscript numbers starting with a tower in an *A* quadrant, through which a reference line is drawn as T_1, and continue in clockwise direction as T_2, T_3 and T_4. Likewise, the courses are designated by letters *C* with subscripts starting from the reference line and numbering in a similar clockwise direction. The angles measured from the reference line in a clockwise direction to the re-

For those who are not familiar with radio range systems, it is suggested that they review the paper by D. M. Stewart, Chief, Technical Development Division, CAA, entitled *Circuits Design for Low-Frequency Radio Ranges.* Although Mr. Stuart does not attempt to cover the operation of the radio range system, he does, in the first part, include sufficient information for the reader to understand the principle involved and the terminology employed.

SOLUTION FOR ALIGNMENT

spective courses are designated as reference angles and denoted by the letter *R*.

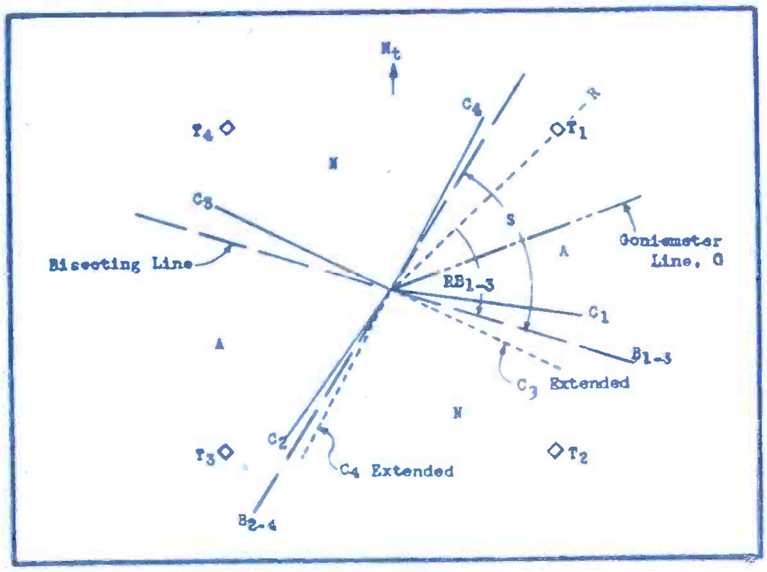


Figure 2
Bisecting lines, determined by bisecting angle between extension of one course of each pair of diagonally opposite courses and associated course.

Bisecting Lines

The bisecting lines are shown in Figure 2 and are determined by bisecting the angle between the extension of one course of each pair of diagonally opposite courses and the associated course.

The bisecting line is extended on either side of the center and denoted by the letter *B* of the subscripts of the associated courses. In practice the actual geometrical construction is not required since the reference angles for these bisecting lines can easily be computed and inserted by using a protractor. For example, the smaller reference angle is obtained by using the equation

$$RB_{1-3} = \frac{RC_1 + RC_3 - 180}{2}$$

Goniometer Setting

To determine the goniometer setting, a line (called *Goniometer Line*) is drawn radially from the center bisecting the angle between the bisecting lines, which places the Goniometer Line in an *A* quadrant. The reference angle of this line in degrees is the goniometer dial setting. This method yields two solutions which are 180° apart, both of which are correct.

The following rules govern whether course bending, course equeezing, or both are required:

(*a*)—If opposite courses are not 180° apart, course bending is required.

(*b*)—If the bisecting lines are not perpendicular to each other, course squeezing is required.

Course Squeezing

[*Charts referred to in following text will appear in December*]

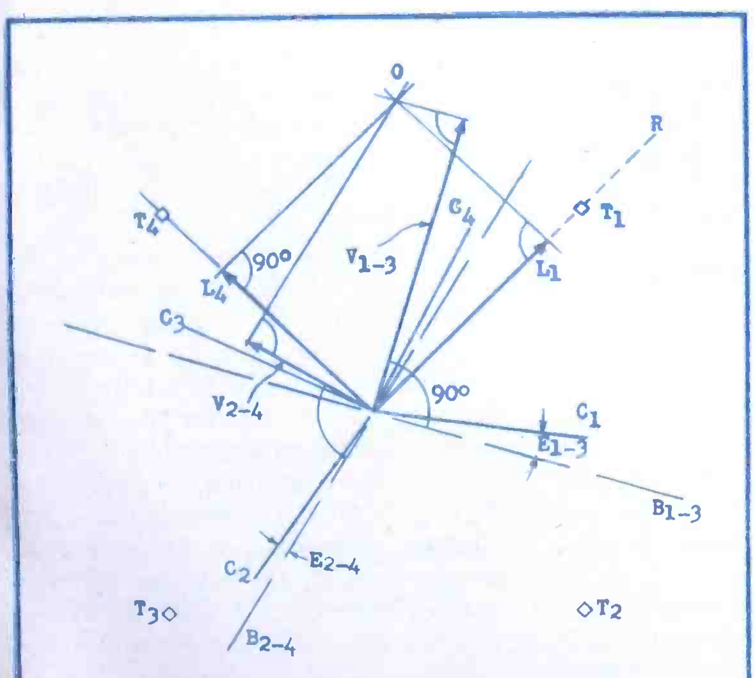
The smaller angle subtended by the bisecting lines (angle *S* in Figure 2) is referred to chart *1* and the ratio of primary currents determined. The smaller current is for the goniometer primary having the same signal identification letter as the smaller quadrants.

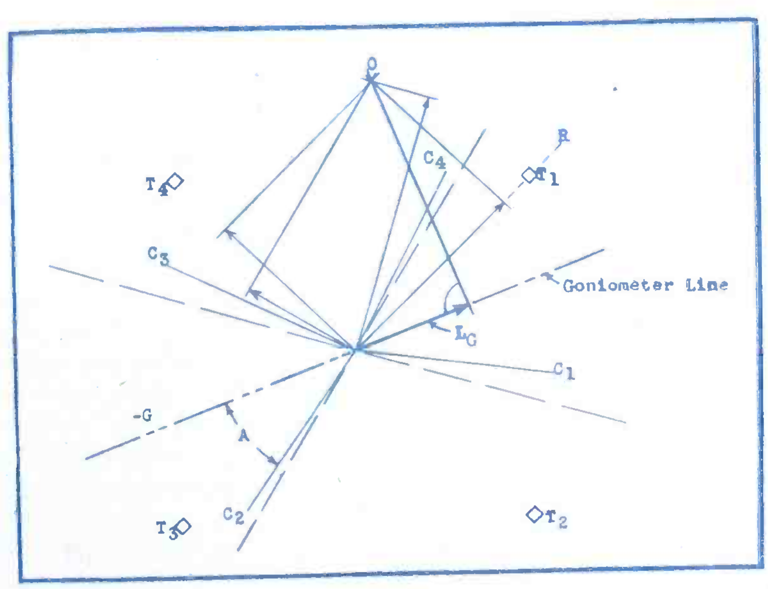
The angle of bend (*E* in Figure 3) for a pair of courses is the angle between either course and the corresponding bisecting line. The angle of bend for one pair of courses is referred to chart *2* and the bending effect, *L*, thus determined. A vector is drawn (length proportional to *L*) radially from the center, perpendicular to the associated bisecting line, and on the same side of the bisecting line as the associated courses, as in Figure 3. A perpendicular construction line is then drawn at the end of this vector. The same operation is performed for the other pair of courses. At the intersection of the two perpendicular construction lines *0*, a line is drawn to each of the adjacent tower's center lines and perpendicular to the latter. (Should only one pair of courses require bending, the intersection *0* will necessarily fall upon one of the unbent courses).

The scaled distances from the center to these intersections on the tower lines, using the same scale as for vectors *V*, represent the number of electrical degrees of line length that is added to the optimum line length for the respective towers. The opposite towers will have the same value of line length subtracted from the optimum value.

The units for the above results are in electrical degrees. For producing the departure from optimum line length, the above results are referred to the manufacturer's data for the par-

Figure 3 (left, below) and 4 (below)
Figure 3, angle of bend *E* is shown here. Figure 4, graphical method used to determine L_G and angle A.





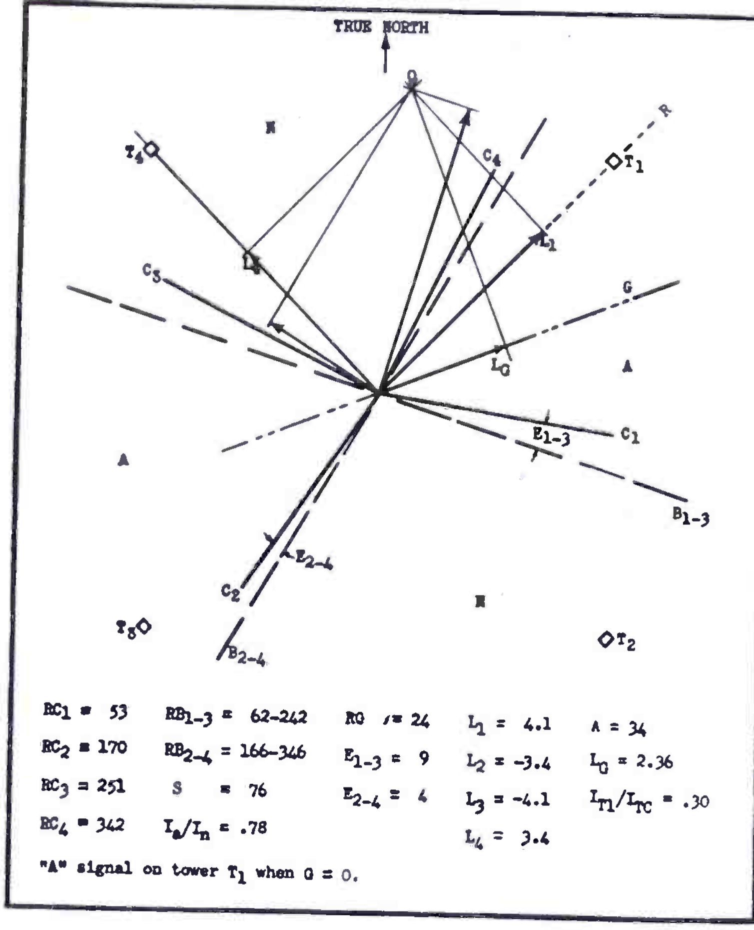


Figure 5

Sample work sheet showing all construction lines for a typical graphical solution. The magnetic declination is 5° W; tower distances, 600′ diagonal; frequency, 300 kc; courses, 35, 116, 207 and 278 (true azimuth and toward station); tower bearing 225° (true azimuth and toward center tower).

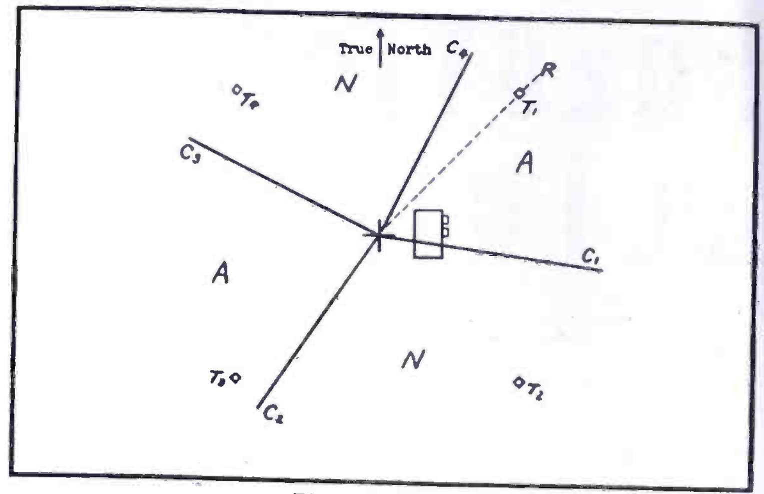


Figure 6 (above)

Portion of completed sample course alignment sheet as used by CAA. This appears on a data sheet with the following information: Diagonal tower distance, 600′; tower bearing, 225° true, toward center; magnetic declination 5° W from true North; required courses, 35, 116, 207, and 278, true and toward station; carrier frequency, 300 kc. Equipment settings (by graphical solution) . . . goniometer, 24°; current ratio, I (A)/I (N) = .78; L_1 = 4.1°; L_2 = —3.4°; L_3 = 4.1°; L_4 = 3.4°. L is the ± electrical line length from normal or optimum length. Ratio of tower currents for 30% modulation on strongest course (measurement made with goniometer set at zero) is $\frac{I_{T1}}{I_{TO}} = .30$. This computation is based on the understanding that towers T_1 and T_3 transmit an "A" signal when the goniometer is set at zero. If it should be found that towers T_1 and T_3 transmit an "N" signal when the goniometer is set at zero, or if it should become necessary to produce that condition by a reversal of connections in the goniometer primary, then 90° is added to the given goniometer setting and the goniometer is set at 90° instead of 0°, when adjusting current in tower T_1 for 30% modulation.

ticular artificial lines used and the equipment adjusted accordingly.

This method has an error of approximately 1.5° in orientation of the courses under certain conditions where both extreme shifting and bending exists. For alignments of moderate shifting and bending the average error is less than one-half degree orientation. As other errors are prevalent in actual alignments of courses, this error becomes negligible for initial alignments.

The graphical method can also be used during actual alignment of courses in the field. Numerous times the courses are not correct after the first attempt of setting the courses. The corrections required to bring the courses into proper position can be obtained by the following procedure: The courses that were produced, although incorrect, are used for working another solution. The difference between the results obtained from this second solution and the original solution which produced the incorrect courses, indicates the correction that must be applied to the original solution. These corrections are applied to the original solution in a direction opposite to that of the difference between the original and second solutions. For example, if the original solution gives a goniometer setting of 25°, the second solution based on the courses as found gives a goniometer setting of 27°; the correction is minus 2° and the setting for final adjustment is 23°.

This procedure, however, is only used to compensate for small inherent errors in the equipment, radiation, and terrain conditions. Large discrepancies usually indicate improper adjustment of the r-f circuits in the transmitter, coupling units, or antenna system. It is obvious that these errors cannot be rectified by the above procedure and must be eliminated by correct equipment adjustment in order that stable operation of the station can be assured.

A sample work sheet showing all construction lines for a typical graphical solution is shown in Figure 5 and a portion of a completed sample course alignment data sheet as used by the CAA is shown in Figure 6.

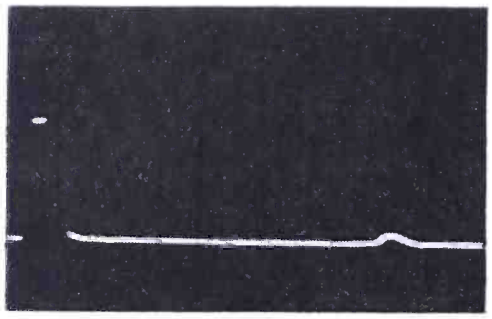
Solution for Determining Per Cent Modulation

The graphical method is employed further to cover the adjustment of the per cent modulation for the range signals. For stations equipped for simultaneous voice broadcasts, the maximum per cent modulation permitted for the range signals is 30%, the other 70% being allotted to the voice modulation. The constant output feature of the voice amplifiers limits the maximum voice modulation to 70% so that the range signals may employ the entire remaining 30% without causing over-modulation. Since the range signals are produced by the beating of the carrier, emitted from the center tower, and the single sideband radiated from the corner towers, the per cent modulation of the range signal is equal to the ratio of the sideband field strength to carrier field strength and the ratio varies with direction from the station because of the difference in field patterns of the two components.

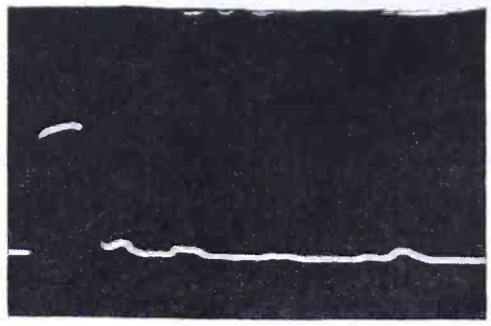
Since the *on-course* signals are of primary importance, the per cent modulation is set so that maximum allowable modulation exists on the *on-courses*. All courses will have the same percentage of modulation if course bending is not present; but if bending exists, the per cent modulation of the *on-courses'* signals will vary. Thus, under conditions of bend, only the modulation on one course can be set at 30% and the others will have a smaller value.

To adjust the relative output of the carrier and sidebands so that 30% modulation exists on the strongest course or courses, the power output of the carrier channel is first adjusted to the level designated for the desired coverage of the station. Then the sideband power is adjusted by setting the r-f current in the sideband tower T_1, when the goniometer is set on zero, in accordance with the ratio of currents obtained from chart 4, after the values of L_G and angle A are determined by

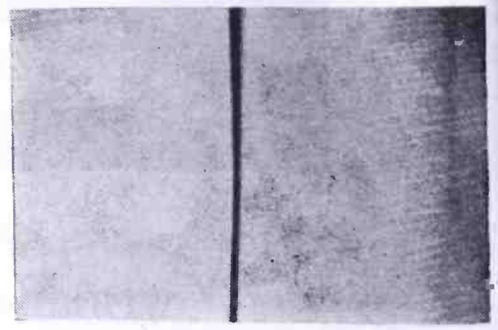
(*Continued on page* 81)



A



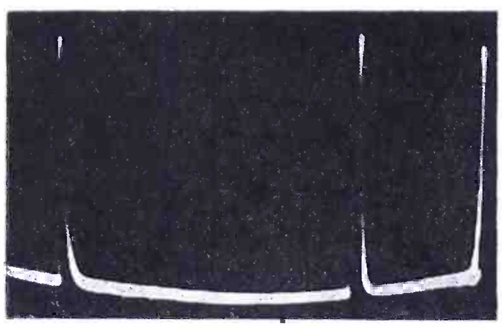
B



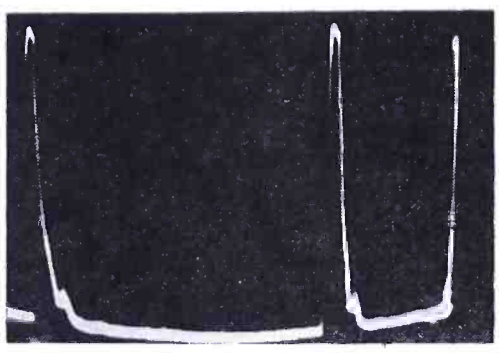
C

Photographs of oscilloscope responses (antenna pointed at transmitter) at 400 and 51.25 mc, and bar and test patterns at 51.25 mc included in multipath propagation test report of E. W. Engstrom. In *A* and *B* appear the responses at 400 mc for relative receiver gains of 1 and 10. A study of these views reveal that the multipath responses are relatively small compared to the main pulse. In *C* appears a photograph of one set of pulses in the middle of the television raster (51.25 mc). Horizontal deflection was synchronized on the other double frequency horizontal pulses. In *F* appears a photograph of the test pattern with the pulse modulation removed from the transmitter. A reasonable freedom from multipath effects is apparent. In *D* and *E* appear oscilloscope responses at 51.25 mc, for relative receiver gains of 1 and 10, respectively. Receiving antenna used for these tests was located at same spot as 400-mc antenna. Receiving antenna pointed down Fifth Avenue toward Empire State Building in New York City. It can be seen that there are no reflections whose amplitudes are greater than the order of 1% or 2% of the main pulse. The report states that an examination of the original negative from which *A* was made showed a response close to the main response, whose amplitude was 20% to 30% that of the main response. In view of the limitations in reproduction, this response does not show. The pulse nearest the right hand side of *A* and *B* are time marker pulses on the receiver oscilloscope and not responses to transmitted pulses.

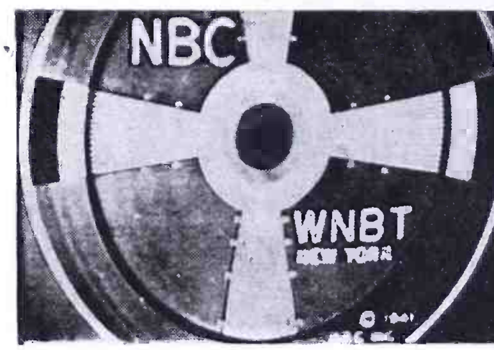
D



E



F



A REPORT ON THE FCC ALLOCATION HEARINGS ON TELEVISION

Highlights Of Statements Presented By E. W. Engstrom, Dr. P. C. Goldmark and G. L. Beers

by LEWIS WINNER
Editor

TELEVISION received quite a thorough analysis at the recent FCC allocation hearings in Washington. Statements offered by a score of technical and administrative experts from government and industry, covered a wide variety of subjects including lineage, bandwidths, antennas, multipaths, color, u-h-f/v-h-f techniques, etc.

Discussing the multipath problem, E. W. Engstrom, research director of RCA Laboratories, disclosed that a series of 400-mc multipath propagation tests had been made by the technical staffs of RCA Laboratories and NBC. The report indicated that for regions having large buildings and where difficulties have been had in the past from multipath transmission paths at 51.25 megacycles and at other television channels below 90 mc, the same difficulty was evidenced at 400 mc. The report stated that it appeared to be more difficult to find an antenna location at 400 mc reasonably free of multipath transmission effects, than at 51.25 mc. However, in residential areas at some distance from the transmitter where the 51.25-mc multipath transmission effects were not serious, a similar freedom from the trouble prevailed at 400 mc, according to the report.

A rather interesting procedure was used to conduct these tests. Short pulses of 400-mc signal were transmitted and observed at several receiver locations. Where multipaths effects were noticed, the time delay factor proved important. That is if two paths prevailed, one a direct path and one a path resulting from a reflection from an object such as a building off to one side, the first pulse would be the one arriving over the direct path and the second would be the one arriving over the path provided by the reflection. This second pulse would arrive a bit later than the first, depending of course on how much longer the reflection path was then a direct path. According to the report, if the reflection path were one mile longer than the direct path, the second pulse would arrive at the receiver approximately 5 microseconds after the first pulse.

Analyzing the transmitter and receiving equipment used to make these tests, the report stated:

"The transmitter which was available

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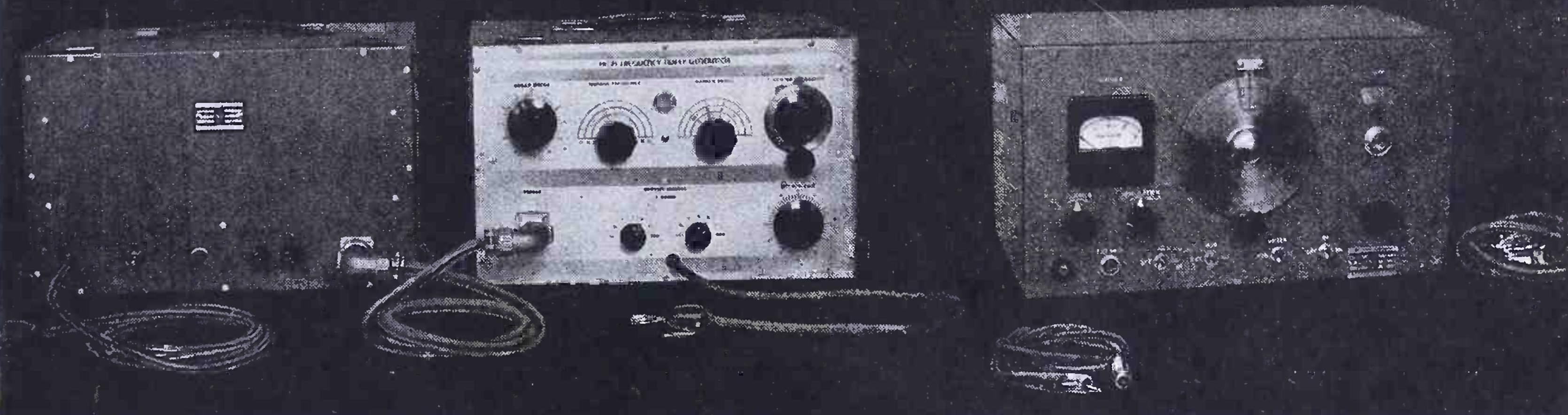

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for making these tests produced pulses of approximately two microseconds duration at 400-mc. The peak power in the r-f pulses was approximately 20 kw. The pulse repetition rate was approximately 1,000 cycles, and the receiver used for the tests had a bandwidth of approximately one megacycle. The received impulses were presented for observation on a cathode-ray type oscilloscope having a sweep rate of 1,000 cycles, with an expanded scale of approximately 120 microseconds for 9" of deflection.

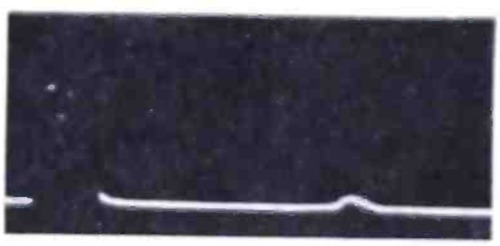
"The pulse rate at the transmitter and the sweep rate at the receiver were both controlled by crystal oscillators. No effort was made to synchronize the two since they were found to be quite stable and it was possible to pull the frequency of the crystal oscillators so that the system was substantially synchronized for periods long enough to make observations.

"For most of the tests a dipole antenna mounted a half wavelength in front of a rectangular reflecting plate, 20" by 24", was used at the transmitter. The receiving antenna was identical with this transmitting antenna.

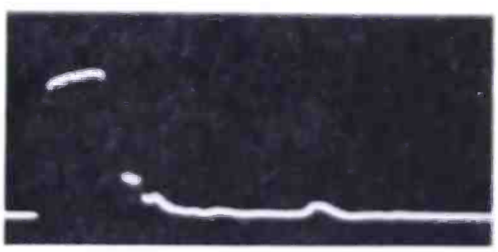
"All of the tests were made with the transmitter on the 85th floor of the Empire State Building in New York City, and horizontal polarization was used. The transmitting antenna was mounted in a window facing north. Tests were made with the receiver at several locations, varying from Radio City, three-quarters of a mile north of Empire State Building, to some detached private residences 15 miles north of the Empire State Building. At each location photographic records of the received oscilloscope traces were made with different antenna orientations. For each antenna position the receiver was adjusted so that the largest received pulse was just below saturation of the oscilloscope, and a photograph of the trace was made. The gain control was then increased by a known ratio, usually 10 to 1, driving the largest echo into saturation on the oscilloscope and bringing small echos which might be present up so they became visible. In this manner, a record was obtained which showed multipath responses whose amplitude was greater than 1 per cent that of the main response. Tests were made in this manner with the receiving antenna pointed toward the transmitter so as to receive the maximum signal over a direct path and then repeated with the antenna turned 45°, 90°, and 180° from its original direction. In all, some 80 different sets of data were taken in this manner.

"Similar tests on pulse transmissions from the regular WNBT television transmitter were made. For the 51.25-mc tests an RCA TRK120 television receiver was used. For presentation of the output pulses from the receiver a 9" oscilloscope was used. In order to duplicate as nearly as possible the conditions of the 400-mc tests at 51.25 mc, a dipole antenna was installed in a north window of the 85th floor of the Empire State Building and connected to the WNBT transmitter. Modulation on the transmitter consisted of double-frequency horizontal synchronizing pulses originating in a television synchronizing generator and shortened by a transmission line arrangement. These pulses drove the transmitter to peak power. The modulator was biased so that the carrier was a minimum between pulses. These pulses, as presented on the oscilloscope at the receiver, were considerably narrower than the pulses which had been received at 400 mc. This was due mostly to the fact that the bandwidth of the television receiver was 4 mc, while the 400-mc receiver had a bandwith of only 1 megacycle."

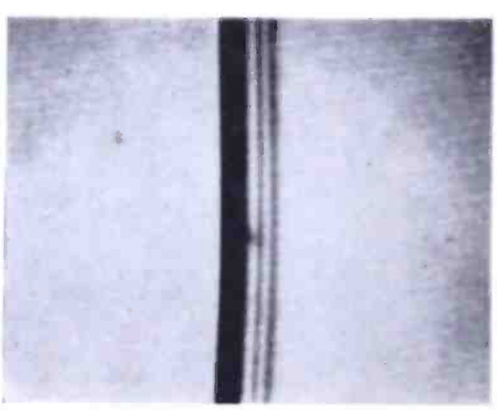
Six types of television interference were listed by Mr. Engstrom. In order of their importance they were: (*1*) shadow; (*2*) multipath; (*3*) radio noise; (*4*) sporadic E reflections; (*5*) bursts; and (*6*) F-2 layer reflections. In view of all these factors, said Mr. Engstrom, television should start at, as near to 45 mc, as possible.



Oscilloscope response at 400-mc, receiver gain of 1, antenna pointed 90° from transmitter.



(Above) Oscilloscope response at 400 mc, receiver gain of 10, antenna pointed 90° from transmitter. An echo practically as large as the main response, delayed approximately 3 microseconds, was noticed in these tests. (Below) Photograph of pulse pattern at 51.25 mc.



Dr. Goldmark's Statement . . .

U-H-F in Television

THE position of u-h-f in television was discussed by Dr. Peter C. Goldmark, chief television engineer of CBS, at the hearings. According to Dr. Goldmark, television in the ultrahigh frequencies will give a more satisfactory and permanent service than it can in the frequencies presently assigned to it.

The use of u-h-f would permit widening the present 4-mc video band to 10 mc, which would require a maximum channel of 16 mc, he said. This would be utilized for transmission in black-and-white at 735 lines per picture or in color with 525 lines. According to Dr. Goldmark, the 10-mc bandwidth proposal is based on data and calculations showing that the average 16-mm professional film will produce a picture with a texture which is equivalent to about 680 lines or 750 lines if we allow for blanking. The proposed 735-line black-and-white system, which actually give 660 lines per picture, he said, is thus almost identical in definition to the average professional 16-mm film.

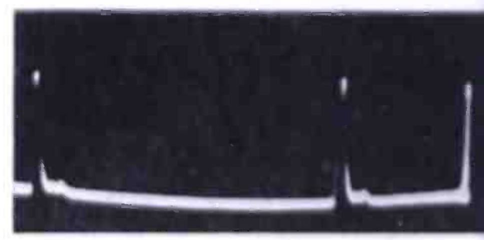
Discussing the discrepancy in pure geometrical definition that exists between the 735-line monochrome and the 525-line color pictures, he said that the added information resulting from color more than offsets that difference.

Dr. Goldmark pointed out that two u-h-f television transmitters to operate between 460 and 476 mc have been ordered from Federal Telephone and Radio Corporation and General Electric Company. He said that these transmitters will be capable of handling modulation in excess of 10 mc. Dr. Goldmark said that the Federal transmitter would provide combined audio and video transmission on the same carrier. No further details were offered.

Analyzing the advantages which the u-h-f region appears to offer to receiver design, Dr. Goldmark said that u-h-f carrier frequencies are high compared to the width of the transmission band, making it possible to have a large number of wide channels within a relatively narrow spectrum.

He said: "In the prefar television allocation structure the useful spectrum extended from 50 mc to 294 mc, thus covering something like 2½ octaves. The highest television carrier frequency in the band is nearly six times the lowest car-

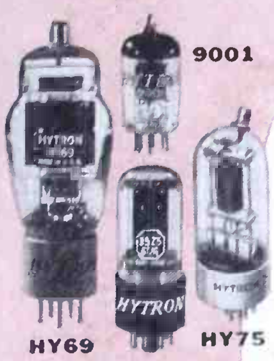
(*Continued on page 78*)



Oscilloscope response at 51.25 mc, receiver gain of 1, antenna pointed 90° from transmitter. Here and in response shown below, two multipath responses in the order of 8% of the amplitude of the main response as well as small echos, with amplitudes of 1% to 2% are shown.

(Above) Oscilloscope response at 51.25 mc, receiver gain of 10, antenna pointed 90° from transmitter. (Below) A photograph of test pattern at 51.25 mc, with antenna pointed 90° transmitter.

Some INTERESTING FACTS ABOUT HYTRON



- Hytron is the oldest manufacturer in the United States specializing on radio receiving tubes. The first Hytron tube was made by hand in 1921.
- The now standard BANTAM GT receiving tube is a Hytron origination. Hytron designed and developed over 70 of the popular GT types. These small glass receiving tubes contributed to the development of the miniature table radio and to large scale production of radio and radar equipment for the Services.
- The tiny BANTAM JR. tubes originated by Hytron were the first sub-miniatures. They made possible hearing aids and pocket radio sets. Similar Hytron tubes serve in wartime electronic devices.
- Hytron has pioneered transmitting and special purpose tubes for the radio amateur and for police radio. Its very-high-frequency tubes and its instant-heating r.f. beam tetrodes for mobile communications, have also become extremely popular with the Services.
- Hytron combines long experience in high-speed receiving tube techniques with the know-how of special purpose tube engineering. The result is economical mass production of special tubes.
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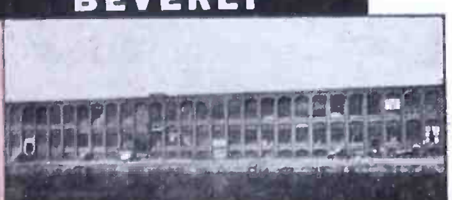

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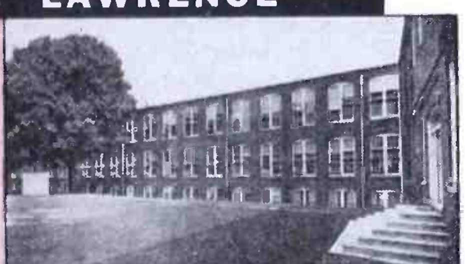

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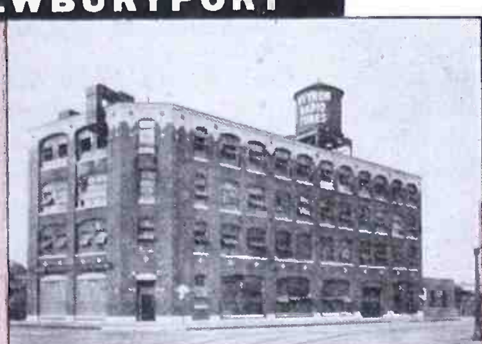

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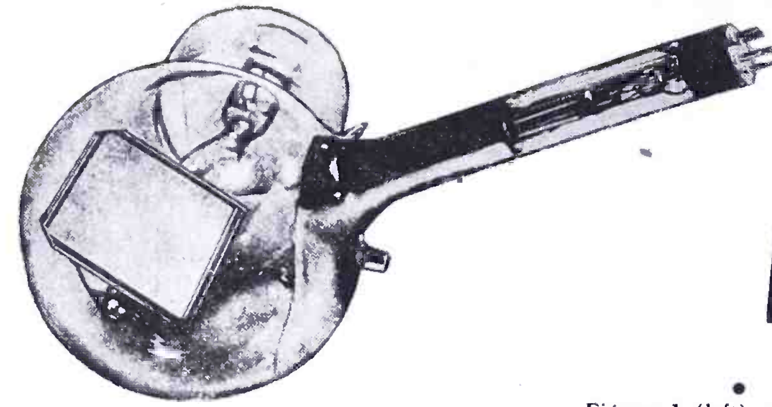
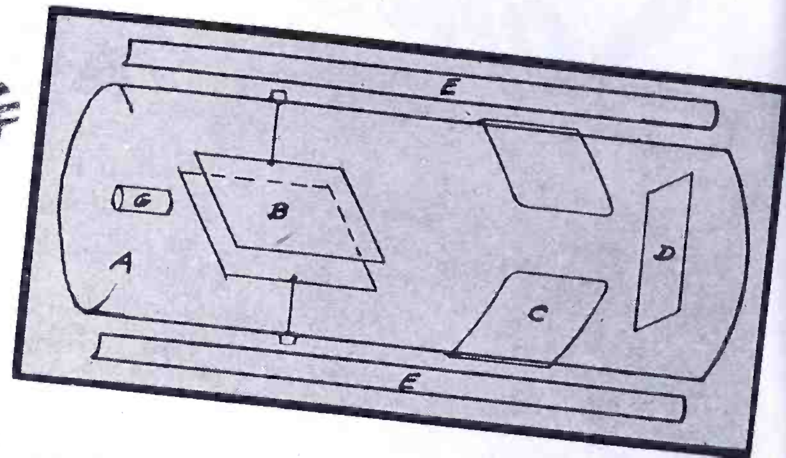




Figures 1 (left) and 2 (right)
Figure 1, the iconoscope, one of the first camera tubes to be developed. Figure 2, constructional details for orthicon: A, glass envelope; B, static deflection plates; C, magnetic deflection coils; D, translucent mosaic screen; E, field coils, and G, electron gun.

C-R TUBES...SPECIAL DESIGNS

by J. R. BEERS
Development Engineer
North American Philips Co., Inc.

THERE are several types of video type tubes that are based on the application of cathode rays and cathode-ray guns. Among these are iconoscope, orthicon, and image dissector which come under the classification of camera tubes.

In the inocoscope the gun is basically the same as that used to activate the fluorescent screen of the tubes analyzed in previous papers. In this application, however, the cathode ray is used as a means for discharging electrical energy. This energy is generated on a light sensitive mosaic upon which a picture (to be transmitted) is focused by means of a conventional lens system. Figure 1 shows one of the first tubes used for this purpose.

The target plate consists of an extremely thin and uniform mica sheet, backed by a metal plate. The surface of the mica facing the gun is sensitized by deposition of caesium metal upon a base of silver oxide. This is applied so as to form tiny photoelectric cells each insulated from the other. The mosaic surface may be charged by visible light rays, as in the television application, or it may be designed to respond to normally invisible rays, such as infrared.

Information gathered by the sensitized plate is translated into electrical impulses, when scanned by the electron beam from the c-r gun. Scanning, in this case, is accomplished by magnetic fields.

In this type of tube, the electron beam used for the discharge is necessarily of high speed, due to gun design and the small spot-size required. Because of this, more secondary electrons are released at the mosaic than can be collected. These excess secondaries fall back on the mosaic, causing unwanted localized charging.

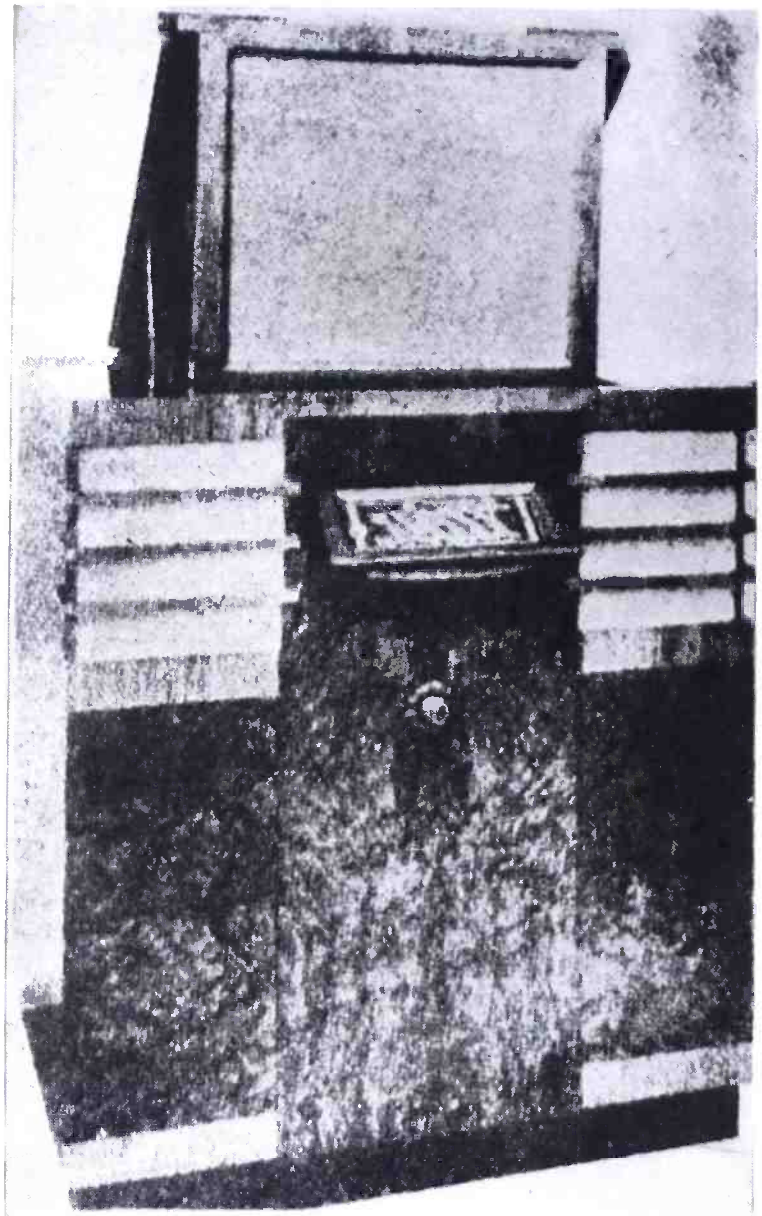
The orthicon tube, using slow speed electrons for scanning, was subsequently developed to overcome this condition. Construction of the tube is shown in Figure 2. It employs both electrostatic and magnetic deflection of the electron beam and utilizes the same type of mosaic screen.

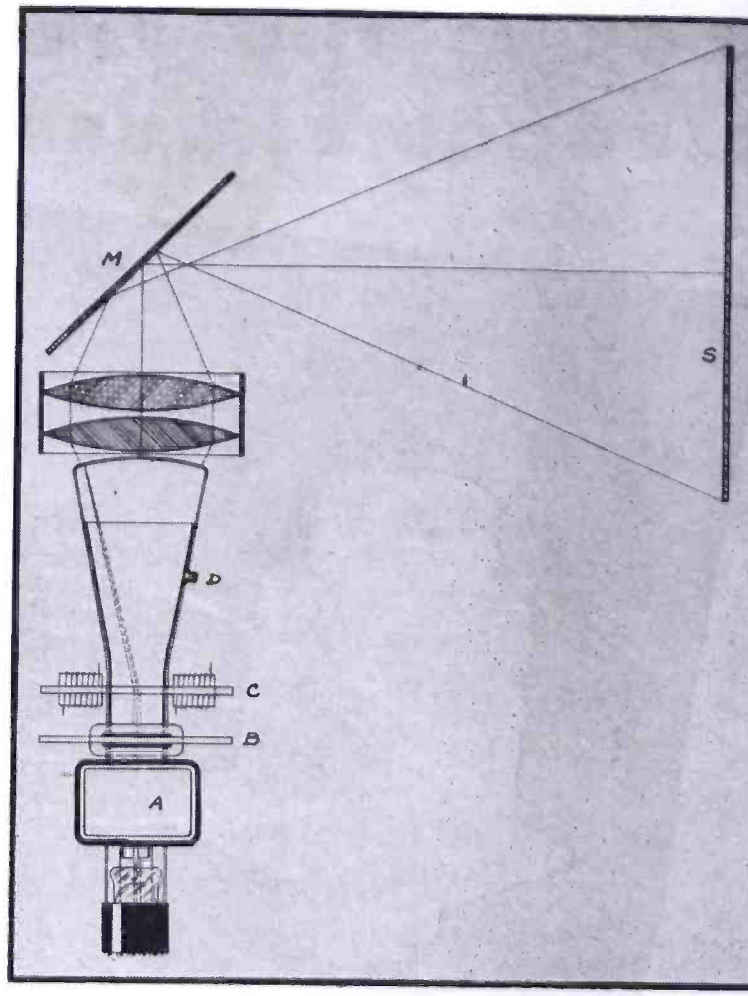
The image dissector tube serves all of the similar purposes as previously mentioned tubes. However, it does not possess the same memory features. Signals produced are much weaker, so electron multipliers are frequently built in as an integral part of the tube. An early form of the tube used a mosaic film that was translucent. Here, the screen acts as a cold cathode from which electrons are emitted in direct proportion to the light intensity of the image focused upon it. These electrons are attracted to the anode at the opposite end of the tube. A small aperture in its center permits electrons to pass through the anode to a target. This produces a signal corresponding to the emission resulting from light focused on the cathode at that point. By means of magnetic fields, the entire electron image is made to pass before the aperture in a fixed scanning pattern. Thus, electrons from every segment of the cathode are systematically collected by the target. In this manner the cathode image is dissected, and the picture information transmitted as electrical fluctuations. In newer designs the cathode consists of an opaque surface which is excited through a window at opposite ends of the tube.

In present-day television these tubes are the basis for picture transmission just as the fluorescent screen type are a basis for picture reception. However, at the present stage of television development there appears to be a greater field for possible changes and improvements in picture tubes than in camera tubes.

Foremost among reception improvements is the subject of projection. In Figure 3 is shown a projection type receiver. This receiver uses a projection type c-r tube having a 4″ face diameter which projects a picture 16″x20″ on a translucent screen. A top voltage of 25,000 is used in this receiver. Method of projection is shown in Figure 4.

Although such a receiver appears to answer the requirement for larger





Figures 3 (left) and 4 (above)
Figure 3, Philips type projection receiver using trans-lux screen; picture size is 16" x 20". Figure 4, projection method used in this receiver: A, focusing coil; B, vertical deflection coil; C, horizontal deflection coil; D, high potential anode; M, mirror; and S, translucent screen.

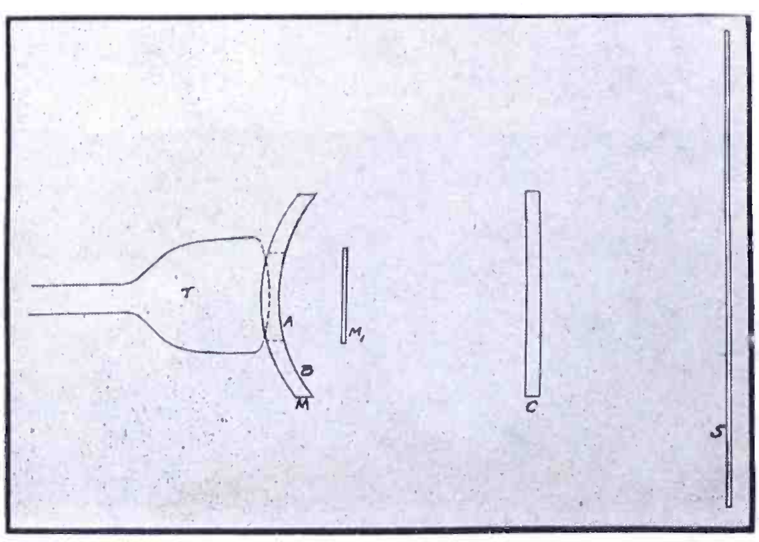
pictures there is still a considerable problem in light level and tube life as compared to direct-viewing tubes. Many experiments have been made with dark-trace screens and various types of electronic light shutters or valves. However, thus far the fluorescent type screen appears to be the most practical. Since this material has definite limitations as a light source when operated at outputs consistent with satisfactory life, it becomes necessary to increase efficiency of projection system to highest possible degree.

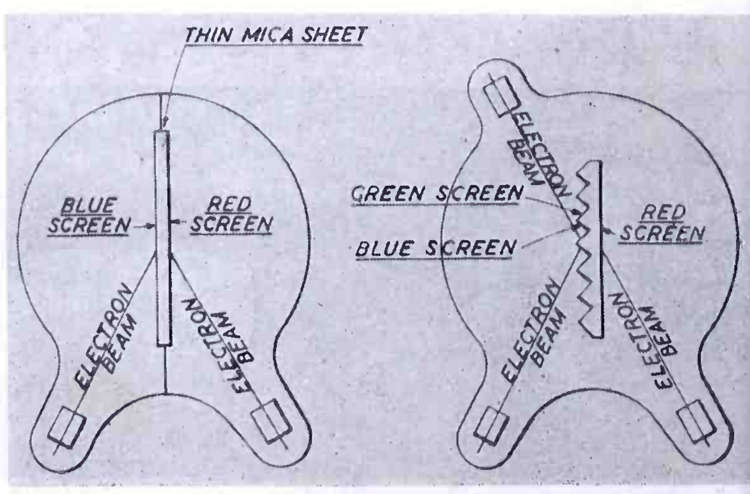
An adaptation of Schmidt optics for projection appears to have initial efficiencies considerably in excess of the conventional lens systems. Figure 5 shows one arrangement of this system. A relative aperture of F/.6 as compared to F/1.5 in the conventional systems as well as fewer reflecting surfaces favor the Schmidt system. Although at first glance it would appear that final decision might be made in favor of this system, experience has shown that there are other critical factors to be considered. Since the mirror surfaces of the reflectors are metallic and exposed to atmospheric action they are subject to a certain degree of corrosion. The problem of dust deposits on the mirror surfaces also has to be considered. Either of the above difficulties may reduce the efficiency of the system to below that of a conventional system whose light losses have been reduced by non-reflective treatment of the lens surfaces.

Another factor in determining final light level is the efficiency of projec-

(*Continued on page* 80)

Figures 5 (below) and 6 (below, right)
Figure 5, one arrangement of Schmidt optical system for television projection: A, apertures; B, metallic surface of mirror; C, correction lens; M, concave mirror; M_1, plane mirror-reflecting surface on side toward tube; S, screen; and T, projection c-r tube. Figure 6, the new Baird electronic color television tubes.





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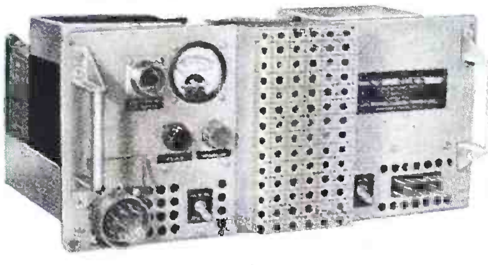

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QUARTER-WAVELENGTH INSULATORS

by LAWRENCE A. WARE
Associate Professor
Electrical Engineering Dept.
State University of Iowa

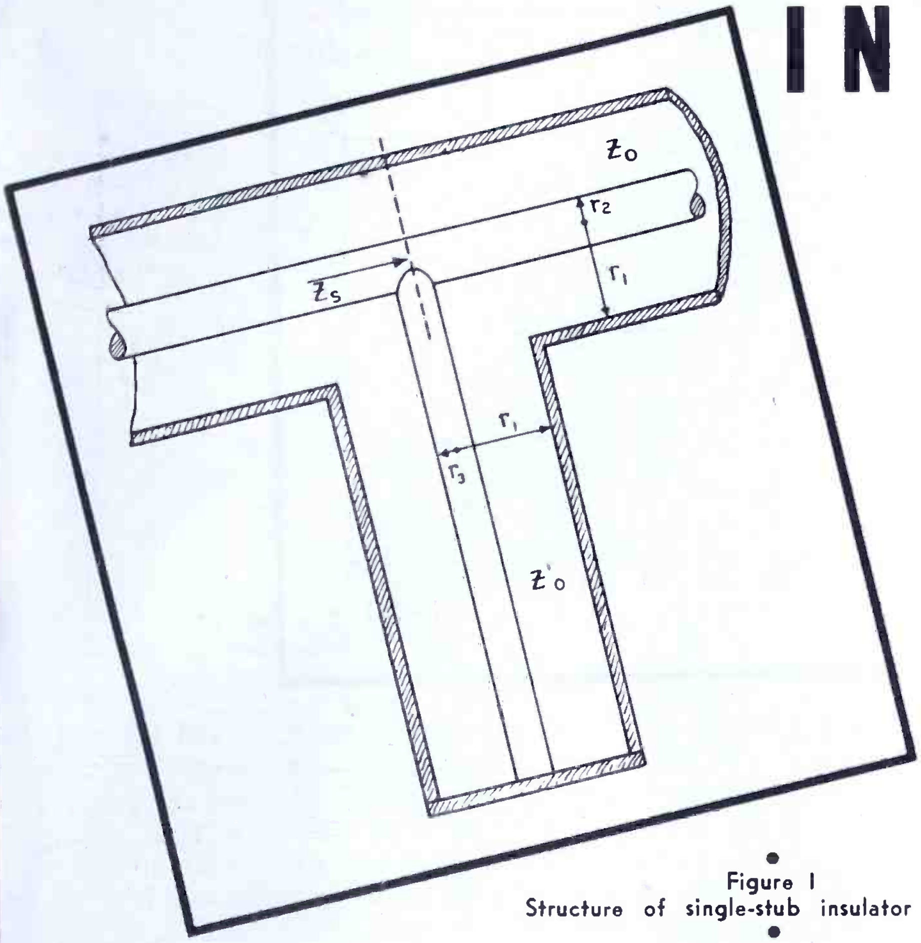

Figure 1
Structure of single-stub insulator support.

The short-circuited quarter-wavelength line used as a support for the inner conductor of high-frequency coaxial lines is considered in this paper. Three cases are treated specifically: a—The single stub support; b and c—Two special cases of the double stub support. It is shown that, by making appropriate adjustments of the characteristic impedances in these elements, *broad-banding* is improved, i.e., a broader band of frequencies may be transmitted with less loss due to mismatching. As an illustration a design of a double-stub support to operate at 750 megacycles is presented.

IN the use of coaxial lines at ultra-high frequencies it is often convenient to make use of quarter-wave short-circuited stubs to support the inner conductor. As long as only a single frequency is to be transmitted this method offers no particular difficulty, as the stub can be adjusted to be one-quarter wavelength long at the given frequency, to which it will offer infinite impedance. However, if a band of frequencies is to be transmitted there will be reflection loss at all frequencies except the one for which the stub has been designed. As an introduction to this problem let us consider the simple single-stub support represented in Figure 1. Later we will analyze the problem of broadening the band, over which low attenuation will occur.

(A)—The Single Stub Support

In Figure 1, we have the main transmission line represented as having a characteristic impedance Z_0 given by the usual equation, $Z_0 = 138 \log(r_1/r_2)$. Suppose we design the stub for a frequency f_0 which will be called the midfrequency. The stub will differ in general from the line itself by having a different characteristic impedance, Z_0', brought about by adjusting the radius r_3 of the inner conductor. The length of the stub will be such that at f_0 it is one quarter-wavelength long and its angular length will be designated by b given by $b = (f/f_0)90°$, where f is the frequency of operation and will not be considered to differ from the midfrequency by more than about 10%. Neglecting the resistance of the conductors, the input impedance to the stub is

$$Z = j\,Z_0' \tan b$$

and Z_s can easily be calculated as follows:

$$Z_s = \frac{ZZ_0}{Z + Z_0} = \frac{jZ_0'\,Z_0 \tan b}{Z_0 + jZ_0' \tan b}$$

$$= \frac{Z_0 \tan b}{\sqrt{\tan^2 b + n^2}}\ \underline{/\tan^{-1}(n/\tan b)} \quad (1)$$

$$\text{where } n = \frac{Z_0}{Z_0'}\,. \quad (2)$$

It is convenient in the following material to work with the ratio of Z_s/Z_0.

$$\frac{Z_s}{Z_0} = \frac{\tan b}{\sqrt{\tan^2 b + n^2}}\ \underline{/\tan^{-1}(n/\tan b)} \quad (3)$$

$$= \frac{1}{\sqrt{1 + \left(\dfrac{n}{\tan b}\right)^2}}\ \underline{/\tan^{-1}(n/\tan b)} \quad (4)$$

$$= A\ \underline{/\theta°} \quad (4')$$

The ratio given by equation *4* will give an indication of the amount of mismatch caused by the stub and from it the resultant loss can be determined as f is varied away from f_0. It is readily seen from equation *4* that as n is decreased, A in equation 4′ approaches unity and θ approaches zero for fixed values of frequency or of b. It is clear then, in this simple case, that if an improvement in *broad-banding* is to be obtained, n must be made as small as practicable. This decrease in n however involves an increase in Z_0' and thus a decrease in the radius r_3. There may exist, in practical cases, a lower limit to r_3 owing to the possible breakdown of the air around the inner conductor if the transmitted power is very high. Curves for A and θ are plotted in Figure 2 for three values of n. In Figure 3 are plotted two curves of attenuation caused by such a stub for values of $n = 1.0$ and 0.8. It is to be noted for future reference that at $b = 80°$ and 100° and for $n = 0.8$, the loss of about 0.02 db, which is an im-

(Continued from page 51)

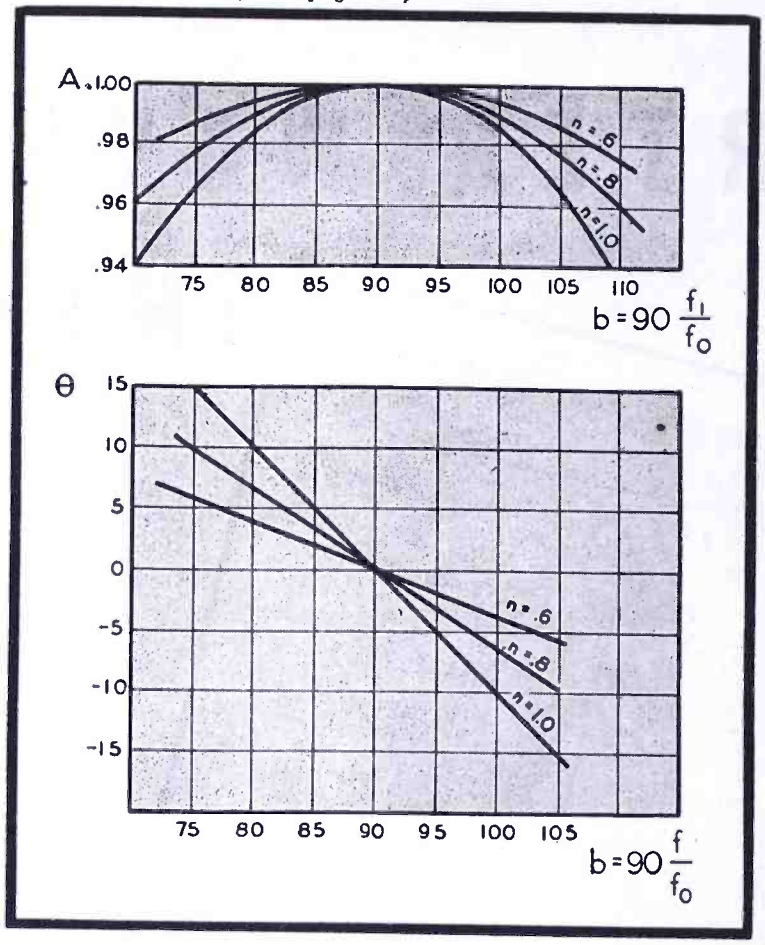

Figure 2
Curves for A and θ for a single-stub with variable n.

provement over that for $n = 1.0$ of roughly 0.01 db. If it be assumed that $r_1/r_2 = 3.6$ then $n = 0.8$ would give a value for r_1/r_3, for the stub, of 4.95. Also if the midfrequency, f_0, is 750 megacycles, then the band from $b = 80°$ to $100°$, representing a range of about 22% of f_0, is 167,000,000 cycles per second wide.

Thus far it is seen that decreasing n will produce broadbanding but it is, of course, advisable to decrease the loss, over the operating range, to a much lower value if possible. A further improvement in matching can be realized without decreasing n to any lower value by using two quarter-wavelength stubs separated by a quarter wavelength as shown in Figure 4. Here the characteristic impedance of the main line is, as before, Z_0; that of the stubs is Z_0', and that of the section a-b between the stubs is Z_0''. The ratio of Z_0/Z_0' will again be designated by n and the ratio of Z_0/Z_0'' will be represented by a. The problem is divided into two parts. The first in part (B) will make $a = 1$ and $n = 0.8$ and the second in part (C) will take $a = 1.035$ and $n = 0.8$ for reasons to be considered later.

(B)—The Two-Stub Support With $a = 7.0$ and $n = 0.8$

To obtain information concerning the degree of mismatching in this two-stub structure it is first necessary to calculate the impedance Z_1 in Figure 4. This impedance is the resultant of combining the stub impedance with the Z_0 of the line as in part (A). Then Z_1 is used as the terminating impedance of the short section of line a-b and its input impedance is calculated. This impedance in turn is combined in parallel with that of the stub c giving a value for Z_2. This pro-

(Continued on page 54)

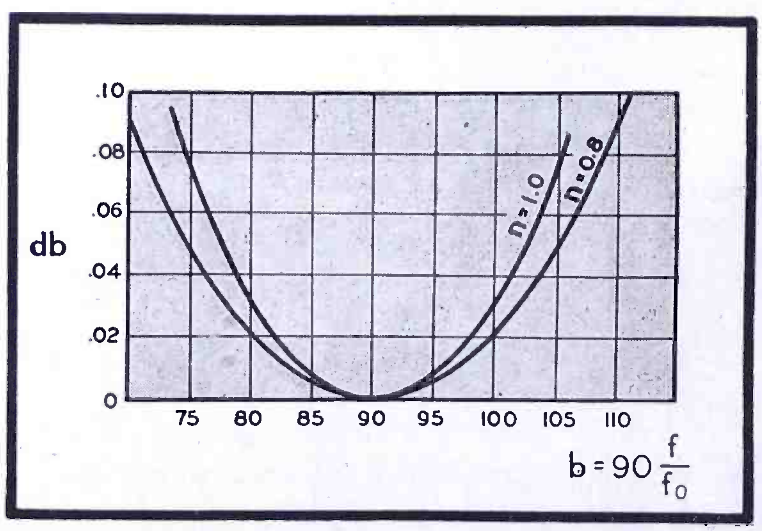

Figure 3
Loss in db for single stub for $n = 1.0$ and 0.8.

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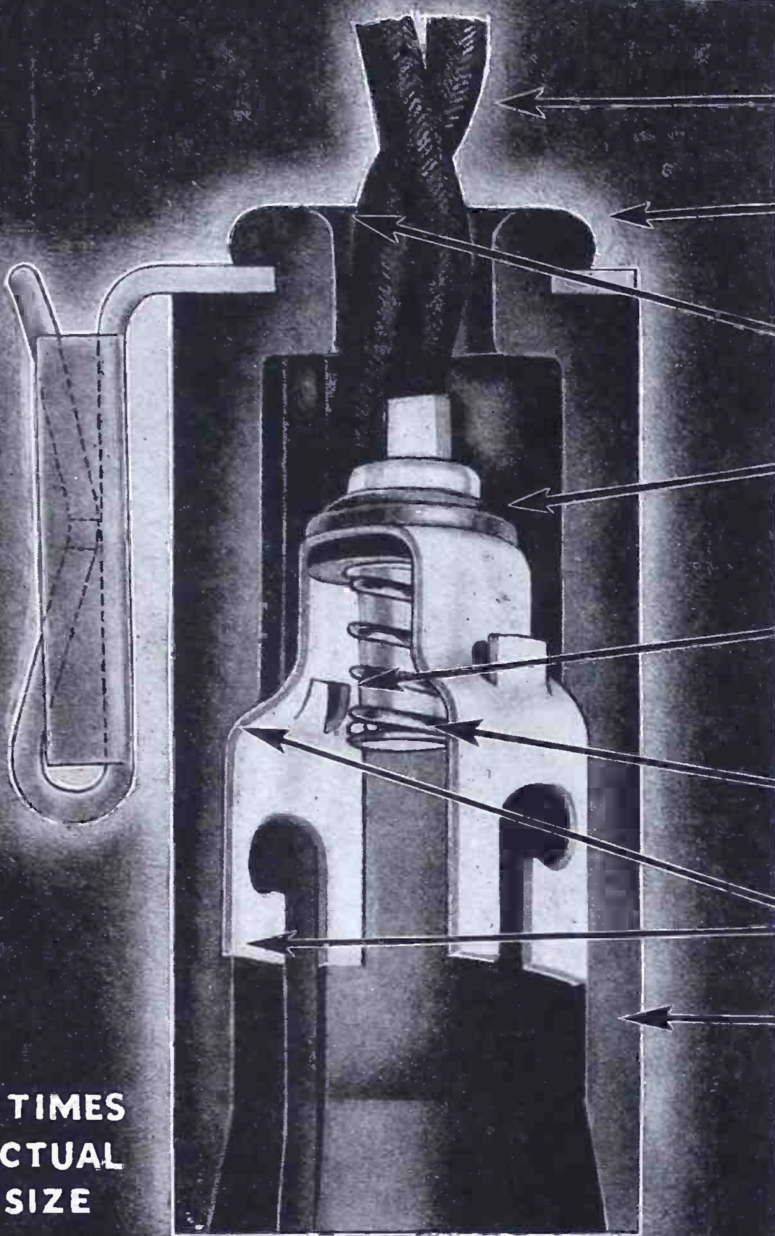

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(Continued from page 52)

cedure allows the employment of two variable impedances Z_0' and Z_0'' thus permitting more opportunity to make adjustments which will improve the matching conditions. The principal results are as follows:

The ratio of the input impedance Z_a to Z_0 at the point a can be easily calculated to be

$$\frac{Z_a}{Z_0} = \frac{(a+n)\tan b + j\tan^2 b}{(a+n)\tan b + j\,(a^2\tan^2 b - n^2 - 2an)} \tag{5}$$

$$= A\,\underline{/\theta^\circ} \tag{6}$$

where

$$A = \sqrt{\frac{1 + \dfrac{(a+n)^2}{\tan^2 b}}{a^4 + \dfrac{(a+n)^2 - 2a^2 n\,(n+2a)}{\tan^2 b} + \dfrac{n^2\,(n+2a)}{\tan^4 b}}} \tag{7}$$

and

$$\theta = \tan^{-1}\frac{a+n}{a^2} \qquad \frac{n(n+2a) - (a^2-1)\tan^2 b}{\tan b + \tan^3 b} \tag{8}$$

Through a knowledge of A and θ in general the loss may be calculated for various values of b. In this section $a = 1$ and $n = 0.8$, which substituted into equations 7 and 8, make it possible to plot the curves of Figure 5. It is noted that the phase curve tends to cross the axis with a much lower slope than in the case of the single stub and it may be expected that the attenuation curve will show much lower values in this region. The corresponding attenuation curve is plotted in Figure 9, where it is noted that a great improvement has been made at the reference points of $b = 80^\circ$ and 100°. The value is now about 0.005 db instead of 0.02. A further decrease in n will improve this condition.

(C)—Double Stub Support With a and n Arbitrary

In the treatment of the more general case it is first necessary to inspect equation 5 with the purpose of determining the relation which must exist among n, a and b in order to ob-

(Continued on page 84)

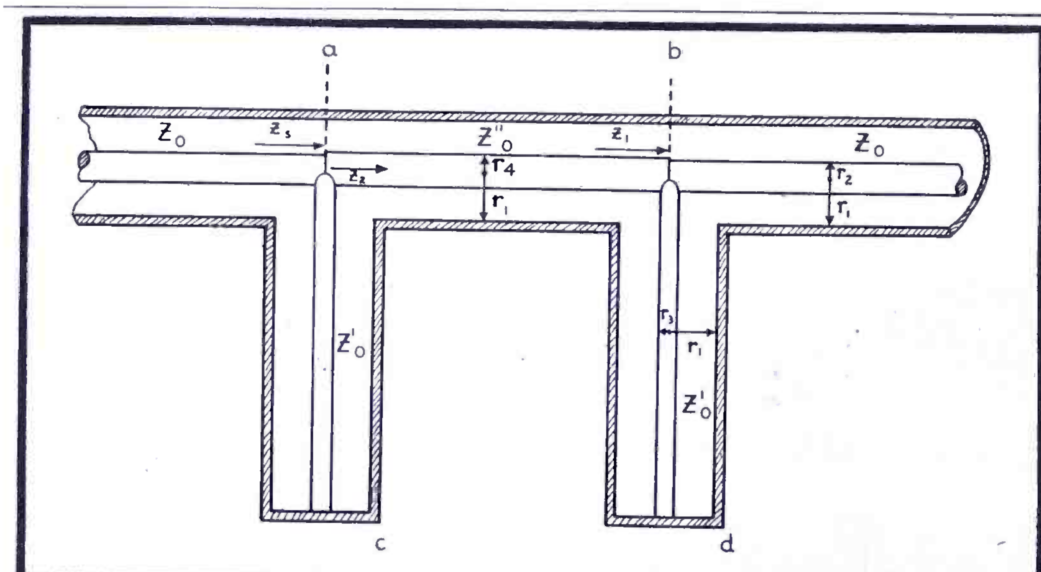
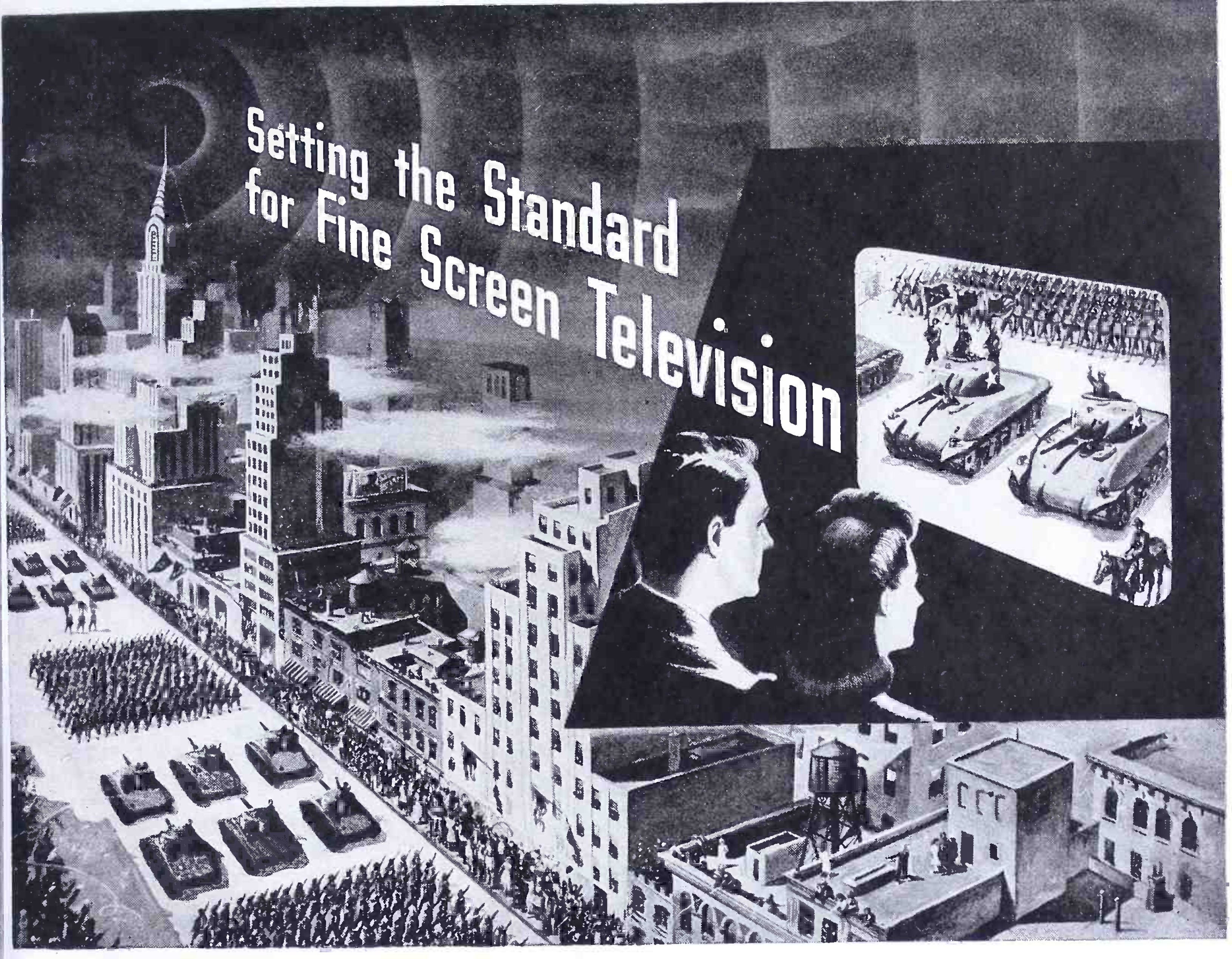


Figure 4
Structure of a double-stub support.



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OWI TRANSMITTERS

(*Continued from page* 36)

ment, is centrally located in the control room.

R-F Generator

The r-f signal is initiated in the r-f generator units. A battery of these run continuously. All units are identical, consisting of a 6V6 crystal-oscillator stage, two 6V6 multiplier-buffer stages and a final 807 amplifier.

The crystal-oscillator stage is of conventional design, using broadcast-type temperature controlled ovens. The plate circuit is tuned to crystal frequency. The first buffer stage operates either at crystal frequency of second, third or fourth harmonic, and the second buffer stage operates in some cases as a multiplier and in other cases as a straight amplifier, depending on the multiplication of crystal frequency required.

In all cases the 807 stage operates as a straight amplifier. The output is coupled to three parallel sets of coaxial jacks. Operating conditions are such that from one to three transmitters may be connected without affecting the drive.

Each unit is assembled on a rack-mounting 12 x 20″ chassis all of which are identical. Thus any unit can operate on any frequency, when proper coils and crystals are plugged in.

Tuning the crystal oscillator and buffer amplifier stages is accomplished by midget variable condensers mounted inside the coil forms. The tuning condenser for the plate circuit of the 807 stage is mounted in the chassis, and is adjustable from the front panel. Thus, to set up any unit on a given frequency, it is necessary only to plug in the proper coils and crystal, and peak the tuning of the 807 stage. Figure 5 shows a rear view of one of the r-f generator units. The shield has been removed from the second buffer stage coil to show the construction.

A partial view of the equipment bays in which these generators are mounted appears in Figure 6, showing the coaxial patching panels by means of which the outputs of the generators may be patched to the inputs of the transmitter drivers. Immediately above and below the patching panels are the r-f generator unit front panels (one of which has been removed to show internal construction) with the final tuning knob to the right, tube metering push buttons grouped at the center, and crystal heat indicator at the left.

Audio monitoring of the transmitters is accomplished by speakers concealed above each transmitter. Each speaker is driven from its own amplifier. The input to this amplifier is normally fed from a diode monitor coupled to the transmitter output. By means of a switch located on the hand rail in front of the transmitter, speakers may be switched to the audio line so that comparison may be made between the signal as it enters the modulator input, and as it leaves the transmitter. Duplicate speakers are similarly located in the control room above the control desk, where monitoring is accomplished in the same manner. In addition, there are monitor level controls on the desk.

Cathode-ray oscilloscopes, which may

(*Continued on page* 66)

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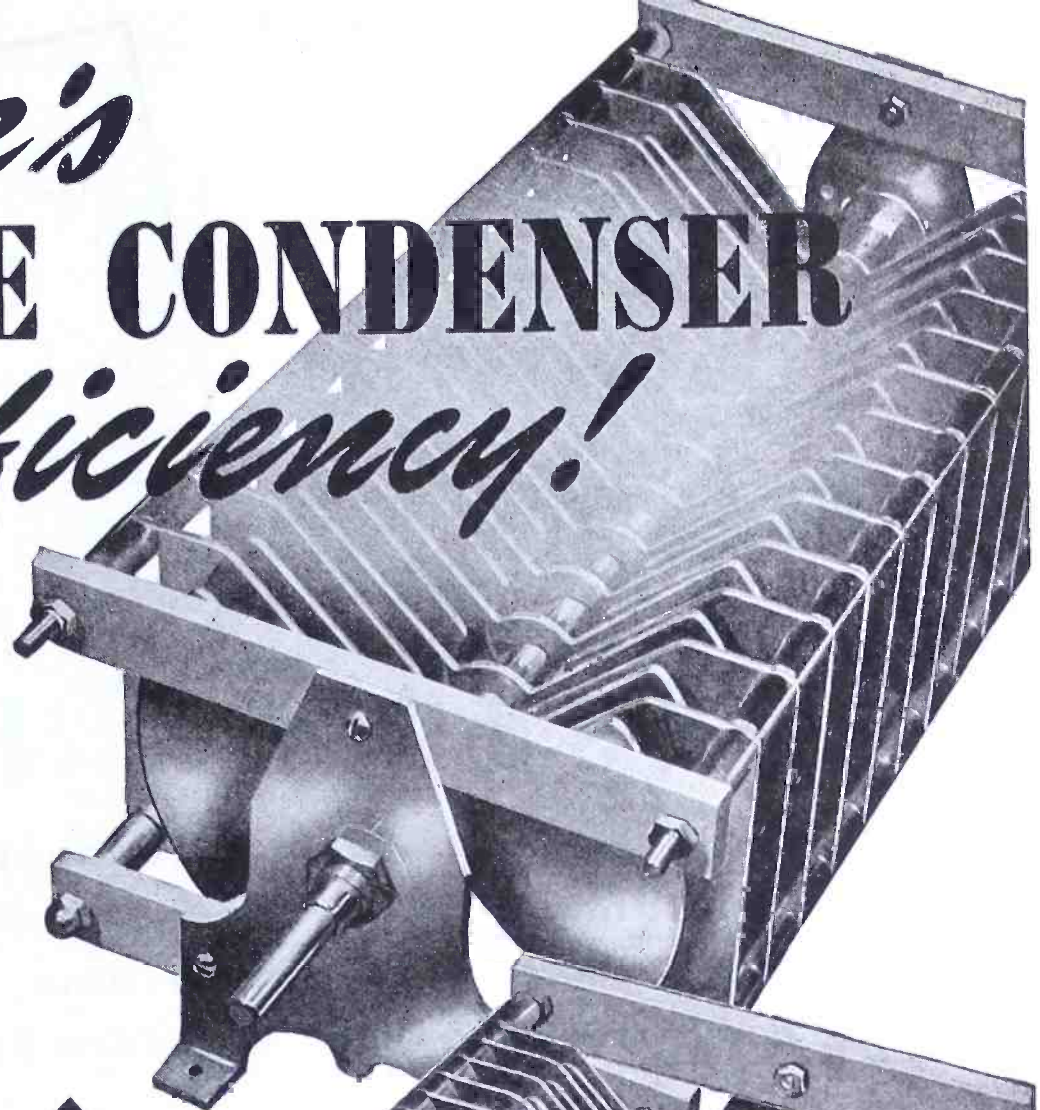

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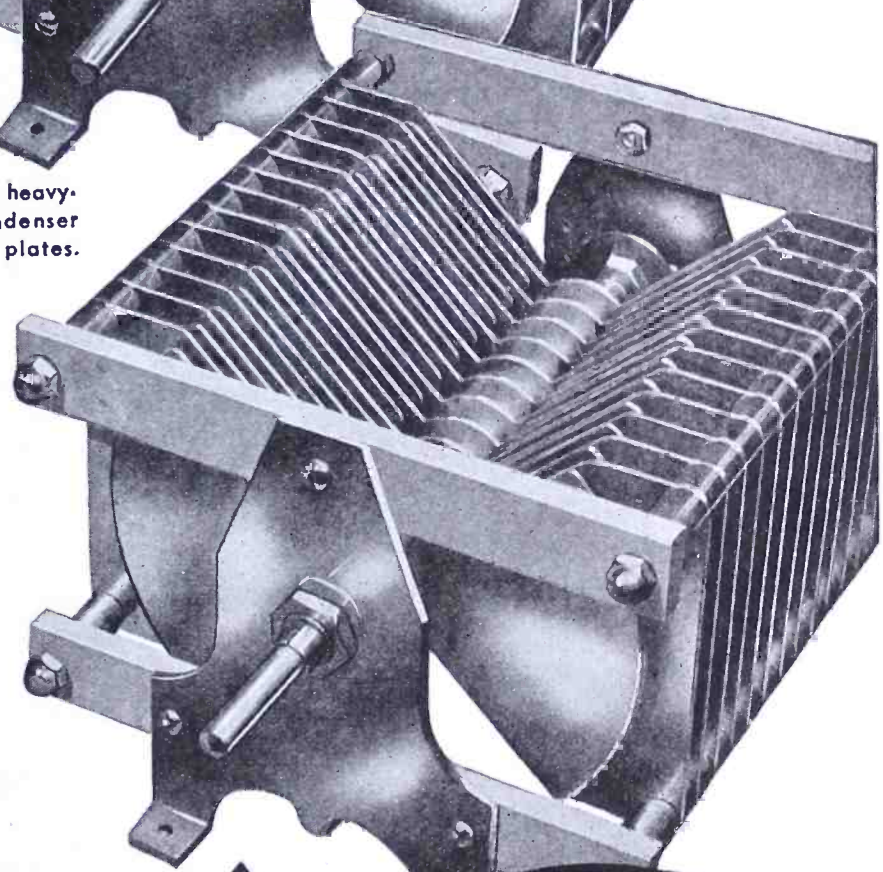
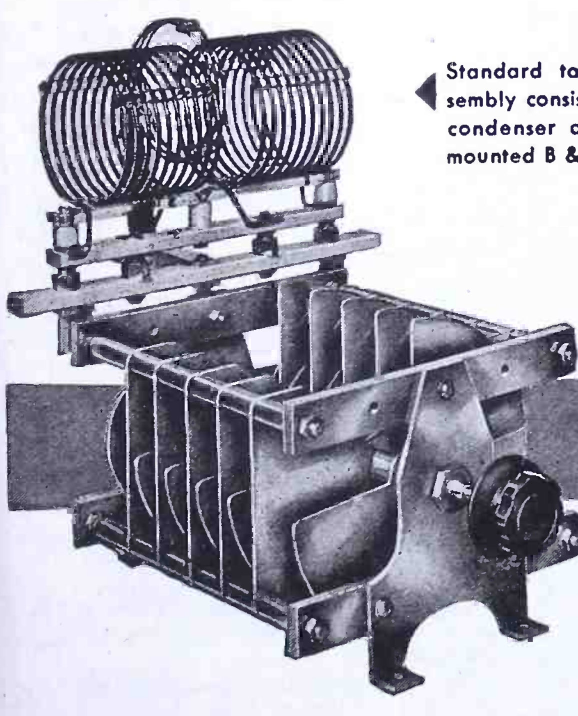


Typical standard Type CX Condenser with 1/16" plates.



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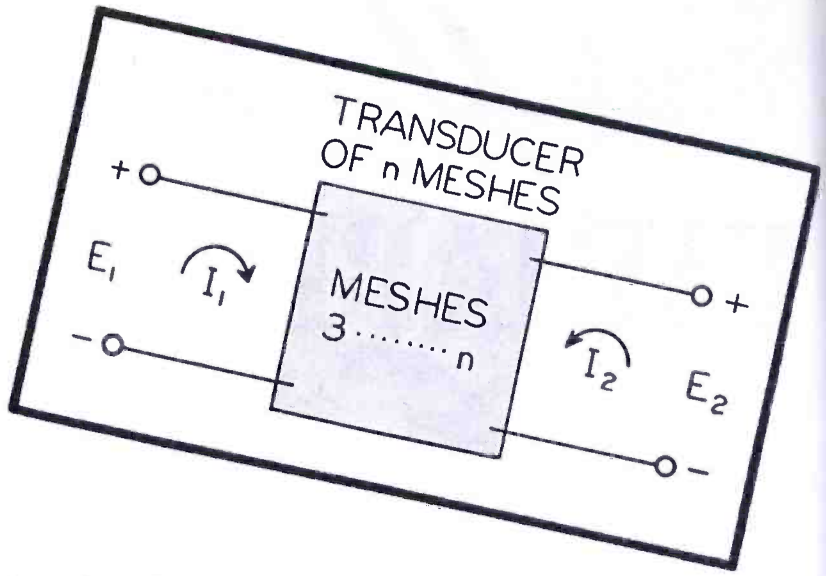

Figure 1

The nominally positive directions of voltage and current at the two pairs of terminals.

A COMPILATION OF TRANSDUCER FORMULAE

Relations Between π-Section Elements, T-Section Elements, Open-Circuit Impedances, Short-Circuit Admittances, Iterative and Image Parameters and Others, Are Tabulated In All Possible Combinations So That Any Set Can Be Found From Any Other Set

by W. R. MacLEAN

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AN electrical transducer, sometimes called a *four-pole,* is a network with two pairs of accessible terminals. Here the designation *four-pole* is not precisely what is meant, since it is essential that the four terminals be associated in two fixed pairs. Into one of the two pair, we send energy and from the other pair we receive. The networks considered in the presentation are the simple linear passive ones. That is, they contain only coils, resistors, and condensers.

The complete performance characteristics of such a transducer is, of course, known if its internal structure is specified. The structure would consist of any number of meshes, *n*, each containing *L*, *R*, *C*, and coupled together in any manner. We designate one of the pairs of accessible terminals as *1*, and the other as *2*, and identify the meshes of the internal structure so that the circuit through terminals *1* is contained in mesh *1* and in that only. Similarly, terminals *2* are contained only in mesh *2*.

By the standard method of solving polymesh networks for the various steady-state currents under the action of single frequency driving forces, we have *n* equations in the *n* unknown currents, involving the terminal voltage E_1, at terminals *1*, and E_2 at *2*. There are no other emf's to consider since the internal structure is passive. In Figure 1 appears the nominally positive directions of voltage and current at the two pairs of terminals.

The *n* simultaneous equations could be solved for the *n* currents by the regular process of determinants. In general, however, we are not interested in the currents in the internal meshes, but only those in meshes *1* and *2*. To determine these for given terminal voltages, we would have to compute the determinant, Δ, and certain of its minors[1], Δ_{11}, Δ_{12}, etc.

If now at any single frequency, it is desired to know the *external* behavior of the transducer to varying conditions of loading, it is not necessary to return to *n* simultaneous equations, or even to the *n*-rowed determinant, Δ. A complete description of this external behavior can be obtained from *three* quantities; for instance, from the three impedances which make up the equivalent *T* section. In general, these *T*-section impedances will be functions of the frequency.

The *T*-section impedances are not the only set which describe the behavior of a transducer under varying load; there are the π-section impedances also. In all there are eight or more sets of such quantities which are useful in communications engineering. The relations that exist between the eight most useful sets are presented in a chart in this paper, and in such a tabular form that one can observe immediately how any set may be expressed in terms of any other set or in terms of the system determinant, Δ, and its various minors. For those doing any amount of work involving transducers, such a chart is quite useful. A portion of the chart (using somewhat different designations) was first presented by G. A. Campbell in his famous article *Cisoidal Oscillations*[2]. The rest of the formulae are, of course, to be found in some texts[3], but not usually as a convenient tabulation.

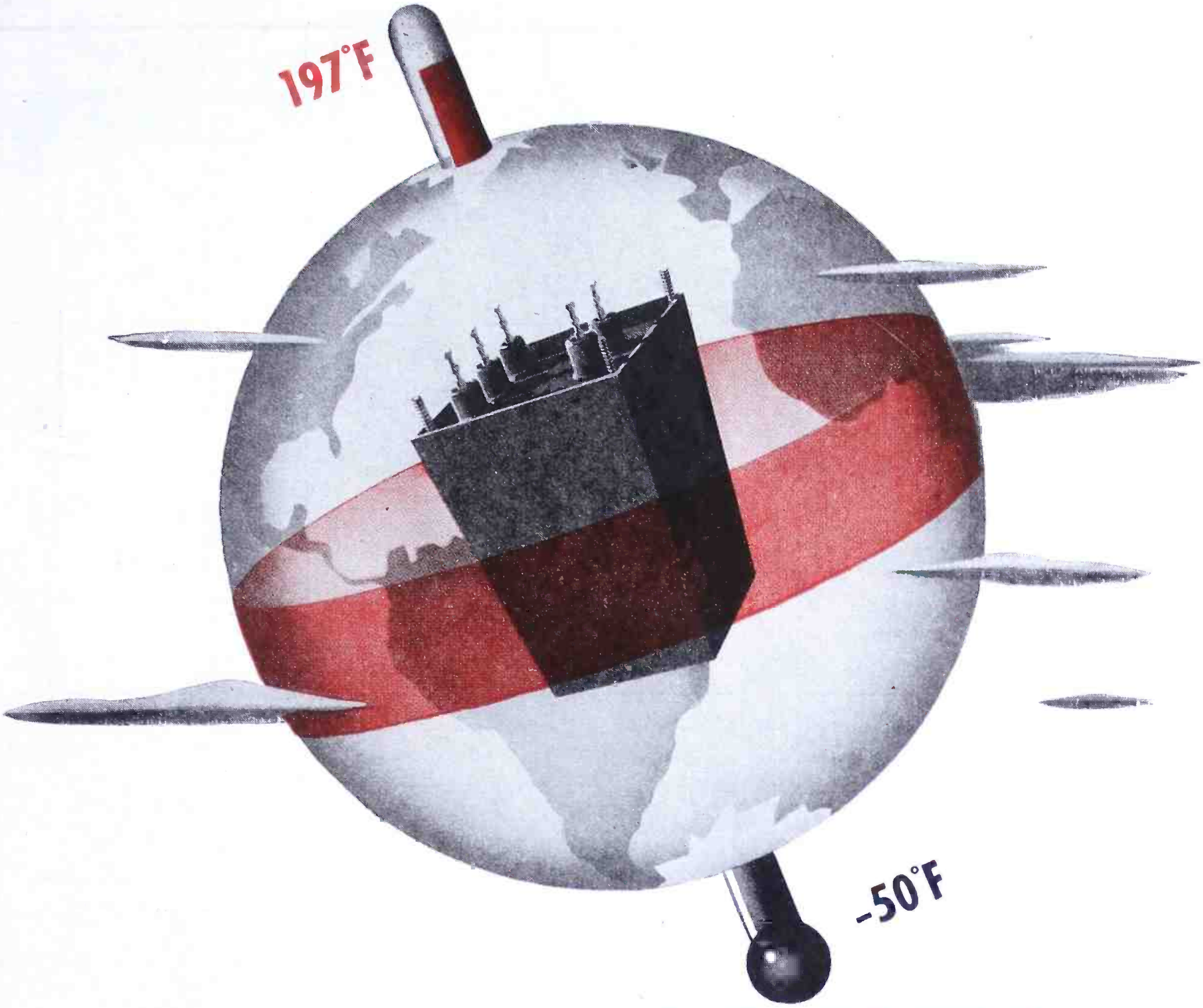
Chart Use Guide

As a guide to the use of the chart,

[1]The minor Δ_{12}, for instance, is the determinant that remains when the first row and second column are stricken from Δ. Similarly $\Delta_{11;22}$ is obtained by deleting the first two rows and columns.

[2]Trans. AIEE, *30*, pp. 873-909 (1911); or *Collected Papers*, an A. T. & T. publication.

[3]E. A. Guillemin, *Communication Networks*, J. Wiley & Sons.



Torture Test—DOUBLED!

The story of a transformer yanked back and forth from Pole to Equator

Men of the U. S. Army Signal Corps say that no matter where they run their lines, "It's either too hot or too cold." To make sure equipment can take it, the Corps runs the five-cycle humidity test.

They were giving this test to a Thermador transformer. They put it into a chamber, pressed a button to get the bleak 50° below. They pressed another button, the thermometer shot to the 197° of a blazing equatorial noon. Five times they raised and lowered the temperature. They watched, through the glass doors, water dripping onto the transformers—condensation.

After forty-eight hours they took an ice pick to get at the terminals.

They wiped them dry, connected the current, threw on the switch. If, after this torture, the transformer could take 2,000 volts it would pass the test. They gave it not 2,000 but 4,000 volts, doubling the test—and, of course, it took it!

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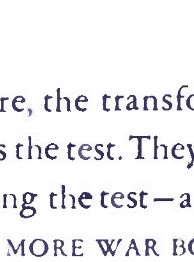


	SHORT CIRCUIT ADMITTANCES	OPEN CIRCUIT IMPEDANCES	T-SECTION ELEMENTS	Π-SECTION ELEMENTS
	Y_{11} Y_{22} Y_{12}	Z_{11} Z_{22} Z_{12}	T_1 T_2 T_{12}	Π_1 Π_2 Π_{12}
$Y_{11}=$	$\frac{\Delta_{11}}{\Delta}$	$\frac{Z_{22}}{Z_{11}Z_{22}-Z_{12}^2}$	$\frac{T_2+T_{12}}{T_1T_2+T_1T_{12}+T_2T_{12}}$	$\frac{\Pi_1+\Pi_{12}}{\Pi_1\Pi_{12}}$
$Y_{22}=$	$\frac{\Delta_{22}}{\Delta}$	$\frac{Z_{11}}{Z_{11}Z_{22}-Z_{12}^2}$	$\frac{T_1+T_{12}}{T_1T_2+T_1T_{12}+T_2T_{12}}$	$\frac{\Pi_2+\Pi_{12}}{\Pi_2\Pi_{12}}$
$Y_{12}=$	$\frac{-\Delta_{12}}{\Delta}$	$\frac{-Z_{12}}{Z_{11}Z_{22}-Z_{12}^2}$	$\frac{-T_{12}}{T_1T_2+T_1T_{12}+T_2T_{12}}$	$\frac{-1}{\Pi_{12}}$
$Z_{11}=$	$\frac{Y_{22}}{Y_{11}Y_{22}-Y_{12}^2}$	$\frac{\Delta_{22}}{\Delta_{11:22}}$	T_1+T_{12}	$\frac{\Pi_1(\Pi_2+\Pi_{12})}{\Pi_1+\Pi_2+\Pi_{12}}$
$Z_{22}=$	$\frac{Y_{11}}{Y_{11}Y_{22}-Y_{12}^2}$	$\frac{\Delta_{11}}{\Delta_{11:22}}$	T_2+T_{12}	$\frac{\Pi_2(\Pi_1+\Pi_{12})}{\Pi_1+\Pi_2+\Pi_{12}}$
$Z_{12}=$	$\frac{-Y_{12}}{Y_{11}Y_{22}-Y_{12}^2}$	$\frac{\Delta_{12}}{\Delta_{11:22}}$	T_{12}	$\frac{\Pi_1\Pi_2}{\Pi_1+\Pi_2+\Pi_{12}}$
$T_1=$	$\frac{Y_{22}+Y_{12}}{Y_{11}Y_{22}-Y_{12}^2}$	$Z_{11}-Z_{12}$	$\frac{\Delta_{22}-\Delta_{12}}{\Delta_{11:22}}$	$\frac{\Pi_1\Pi_{12}}{\Pi_1+\Pi_2+\Pi_{12}}$
$T_2=$	$\frac{Y_{11}+Y_{12}}{Y_{11}Y_{22}-Y_{12}^2}$	$Z_{22}-Z_{12}$	$\frac{\Delta_{11}-\Delta_{12}}{\Delta_{11\,22}}$	$\frac{\Pi_2\Pi_{12}}{\Pi_1+\Pi_2+\Pi_{12}}$
$T_{12}=$	$\frac{-Y_{12}}{Y_{11}Y_{22}-Y_{12}^2}$	Z_{12}	$\frac{\Delta_{12}}{\Delta_{11:22}}$	$\frac{\Pi_1\Pi_2}{\Pi_1+\Pi_2+\Pi_{12}}$
$\Pi_1=$	$\frac{1}{Y_{11}+Y_{12}}$	$\frac{Z_{11}Z_{22}-Z_{12}^2}{Z_{22}-Z_{12}}$	$\frac{T_1T_2+T_1T_{12}+T_2T_{12}}{T_2}$	$\frac{\Delta}{\Delta_{11}-\Delta_{12}}$
$\Pi_2=$	$\frac{1}{Y_{22}+Y_{12}}$	$\frac{Z_{11}Z_{22}-Z_{12}^2}{Z_{11}-Z_{12}}$	$\frac{T_1T_2+T_1T_{12}+T_2T_{12}}{T_1}$	$\frac{\Delta}{\Delta_{22}-\Delta_{12}}$
$\Pi_{12}=$	$\frac{-1}{Y_{12}}$	$\frac{Z_{11}Z_{22}-Z_{12}^2}{Z_{12}}$	$\frac{T_1T_2+T_1T_{12}+T_2T_{12}}{T_{12}}$	$\frac{\Delta}{\Delta_{12}}$
$K_1=$	$\sqrt{\frac{1}{Y_{11}Y_{22}-Y_{12}^2}+\left[\frac{Y_{22}-Y_{11}}{2(Y_{11}Y_{22}-Y_{12}^2)}\right]^2}+\frac{Y_{22}-Y_{11}}{2(Y_{11}Y_{22}-Y_{12}^2)}$	$\sqrt{\left(\frac{Z_{11}+Z_{22}}{2}\right)^2-Z_{12}^2}+\frac{Z_{11}-Z_{22}}{2}$	$\sqrt{\frac{(T_1+T_2)(T_1+T_2+4T_{12})}{4}}+\frac{T_1-T_2}{2}$	$\frac{\sqrt{\Pi_{12}(\Pi_1+\Pi_2)(\Pi_1\Pi_{12}+\Pi_2\Pi_{12}+4\Pi_1\Pi_2)}+(\Pi_1-\Pi_2)\Pi_{12}}{2(\Pi_1+\Pi_2+\Pi_{12})}$
$K_2=$	$\sqrt{\frac{1}{Y_{11}Y_{22}-Y_{12}^2}+\left[\frac{Y_{11}-Y_{22}}{2(Y_{11}Y_{22}-Y_{12}^2)}\right]^2}+\frac{Y_{11}-Y_{22}}{2(Y_{11}Y_{22}-Y_{12}^2)}$	$\sqrt{\left(\frac{Z_{11}+Z_{22}}{2}\right)^2-Z_{12}^2}+\frac{Z_{22}-Z_{11}}{2}$	$\sqrt{\frac{(T_1+T_2)(T_1+T_2+4T_{12})}{4}}+\frac{T_2-T_1}{2}$	$\frac{\sqrt{\Pi_{12}(\Pi_1+\Pi_2)(\Pi_1\Pi_{12}+\Pi_2\Pi_{12}+4\Pi_1\Pi_2)}+(\Pi_2-\Pi_1)\Pi_{12}}{2(\Pi_1+\Pi_2+\Pi_{12})}$
$\Gamma=$	$\cosh^{-1}\frac{Y_{11}+Y_{22}}{2Y_{12}}$	$\cosh^{-1}\frac{Z_{11}+Z_{22}}{2Z_{12}}$	$\cosh^{-1}\frac{T_1+T_2+2T_{12}}{2T_{12}}$	$\cosh^{-1}\left(1+\frac{(\Pi_1+\Pi_2)\Pi_{12}}{2\Pi_1\Pi_2}\right)$
$W_1=$	$\frac{1}{Y_{11}}\sqrt{\frac{Y_{11}Y_{22}}{Y_{11}Y_{22}-Y_{12}^2}}$	$Z_{11}\sqrt{1-\frac{Z_{12}^2}{Z_{11}Z_{22}}}$	$\sqrt{\frac{(T_1+T_{12})(T_1T_{12}+T_2T_{12}+T_1T_2)}{T_2+T_{12}}}$	$\Pi_1\sqrt{\frac{\Pi_{12}(\Pi_2+\Pi_{12})}{(\Pi_1+\Pi_{12})(\Pi_1+\Pi_2+\Pi_{12})}}$
$W_2=$	$\frac{1}{Y_{22}}\sqrt{\frac{Y_{11}Y_{22}}{Y_{11}Y_{22}-Y_{12}^2}}$	$Z_{22}\sqrt{1-\frac{Z_{12}^2}{Z_{11}Z_{22}}}$	$\sqrt{\frac{(T_2+T_{12})(T_1T_{12}+T_2T_{12}+T_1T_2)}{T_1+T_{12}}}$	$\Pi_2\sqrt{\frac{\Pi_{12}(\Pi_1+\Pi_{12})}{(\Pi_2+\Pi_{12})(\Pi_1+\Pi_2+\Pi_{12})}}$
$\Theta=$	$\cosh^{-1}\frac{\sqrt{Y_{11}Y_{22}}}{Y_{12}}$	$\cosh^{-1}\sqrt{\frac{Z_{11}Z_{22}}{Z_{12}^2}}$	$\cosh^{-1}\sqrt{\frac{(T_1+T_{12})(T_2+T_{12})}{T_{12}^2}}$	$\cosh^{-1}\sqrt{\frac{(\Pi_2+\Pi_{12})(\Pi_1+\Pi_{12})}{\Pi_1\Pi_2}}$
$A=$	$\frac{-Y_{22}}{Y_{12}}$	$\frac{Z_{11}}{Z_{12}}$	$\frac{T_1+T_{12}}{T_{12}}$	$\frac{\Pi_2+\Pi_{12}}{\Pi_2}$
$B=$	$\frac{-1}{Y_{12}}$	$\frac{Z_{11}Z_{22}-Z_{12}^2}{Z_{12}}$	$\frac{T_1T_2+T_1T_{12}+T_2T_{12}}{T_{12}}$	Π_{12}
$C=$	$-\frac{Y_{11}Y_{22}-Y_{12}^2}{Y_{12}}$	$\frac{1}{Z_{12}}$	$\frac{1}{T_{12}}$	$\frac{\Pi_1+\Pi_2+\Pi_{12}}{\Pi_1\Pi_2}$
$D=$	$\frac{-Y_{11}}{Y_{12}}$	$\frac{Z_{22}}{Z_{12}}$	$\frac{T_2+T_{12}}{T_{12}}$	$\frac{\Pi_1+\Pi_{12}}{\Pi_1}$

Chart of transducer formulæ (other portion appears on page 62). In rows 5 and 6, one has a choice of two impedances for each K or W. Corresponding these are two values of Θ and Γ.

the following definitions of the quantities that appear are presented:

Short-Circuit Admittances: Y_{11}, Y_{22}, Y_{12}

Y_{11}: admittance at *1*, with *2* shorted
Y_{22}: admittance at *2*, with *1* shorted
Y_{12}: ratio of receiving current at *1* shorted to driving voltage at *2*

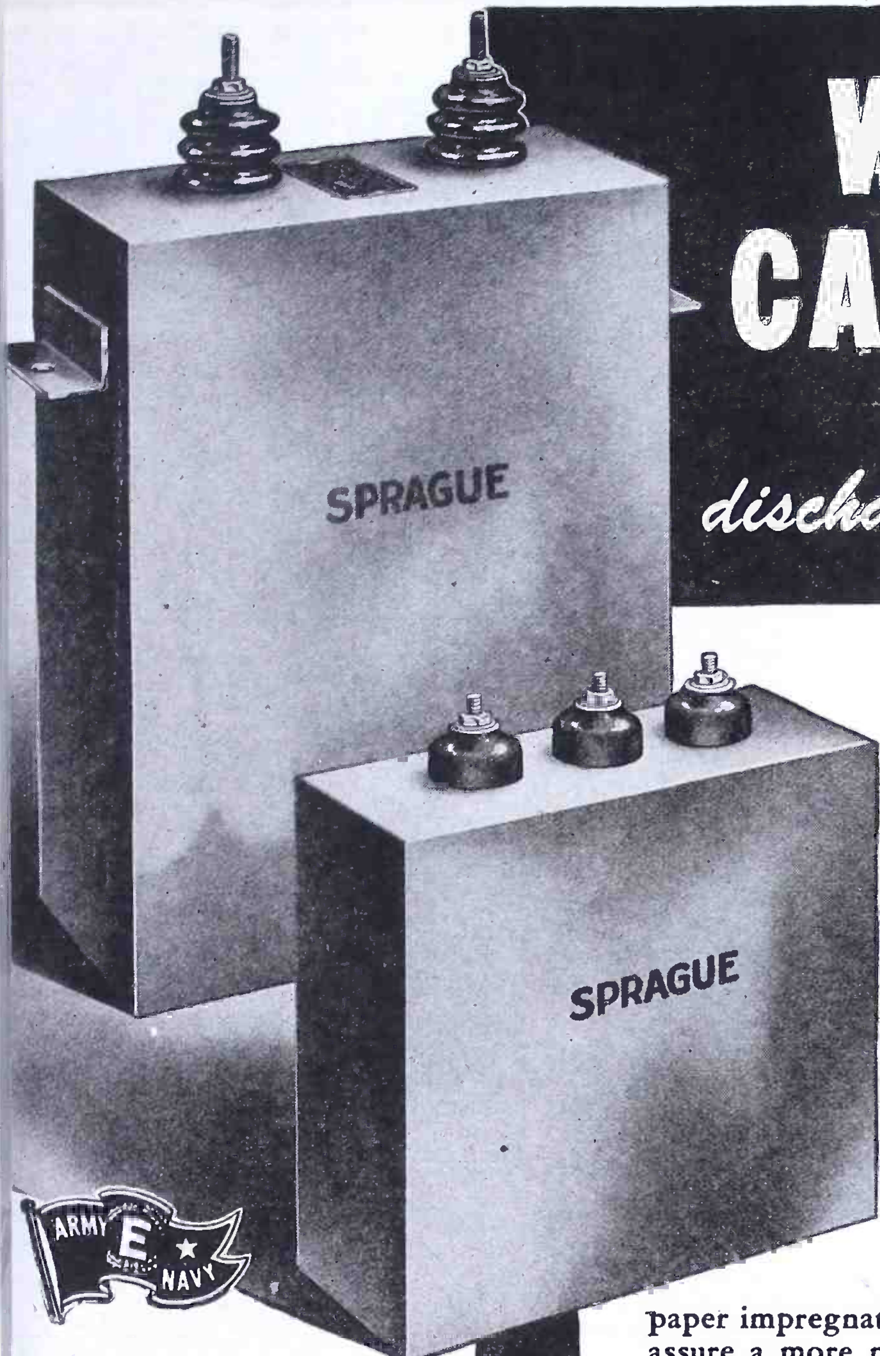
Due to the linear nature of the network, the quantity Y_{21} is the same as Y_{12}. This is true for all double index quantities which follow; hence it is only necessary to mention one of them. The voltage and current at the two ends are related by a pair of linear equations involving these admittances

$$\left.\begin{array}{l} I_1 = Y_{11}E_1 + Y_{12}E_2 \\ I_2 = Y_{21}E_1 + Y_{22}E_2 \end{array}\right\} \quad (1)$$

Open-Circuit Impedances: Z_{11}, Z_{22}, Z_{12}

Z_{11}: impedance at *1*, with *2* open
Z_{22}: impedance at *2*, with *1* open
Z_{12}: ratio of receiving voltage at *1* open to driving current at *2*

These quantities also relate the two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ITERATIVE PARAMETERS	IMAGE PARAMETERS	TANDEM PARAMETERS	REALIZABLE IMPEDANCES	
$K_1 \quad K_2 \quad \Gamma$	$W_1 \quad W_2 \quad \theta$	$A \quad B \quad C \quad D$	$S_1 \quad S_2 \quad O_1 \quad O_2$	
$\frac{(K_1+K_2)\coth\Gamma+(K_2-K_1)}{2K_1K_2}$	$\frac{\pm}{W_1\tanh\theta}$	$\frac{D}{B}$	$\frac{1}{S_1}$	$=Y_{11}$
$\frac{(K_1+K_2)\coth\Gamma+(K_1-K_2)}{2K_1K_2}$	$\frac{\pm}{W_2\tanh\theta}$	$\frac{A}{B}$	$\frac{1}{S_2}$	$=Y_{22}$
$-\frac{K_1+K_2}{2K_1K_2\sinh\Gamma}$	$\frac{-1}{\sqrt{W_1W_2}\sinh\theta}$	$\frac{-1}{B}$	$\frac{-\sqrt{O_1(O_2-S_2)}}{S_2O_1}$	$=Y_{12}$
$\frac{K_1+K_2}{2}\coth\Gamma+\frac{K_1-K_2}{2}$	$\pm W_1\coth\theta$	$\frac{A}{C}$	O_1	$=Z_{11}$
$\frac{K_1+K_2}{2}\coth\Gamma+\frac{K_2-K_1}{2}$	$\pm W_2\coth\theta$	$\frac{D}{C}$	O_2	$=Z_{22}$
$\frac{K_1+K_2}{2\sinh\Gamma}$	$\frac{\sqrt{W_1W_2}}{\sinh\theta}$	$\frac{1}{C}$	$\sqrt{O_1(O_2-S_2)}$	$=Z_{12}$
$\frac{K_1+K_2}{2}\tanh\frac{\Gamma}{2}+\frac{K_1-K_2}{2}$	$\sqrt{W_1W_2}\ \frac{\sqrt{W_1/W_2}\cosh\theta-1}{\sinh\theta}$	$\frac{A-1}{C}$	$O_1-\sqrt{O_1(O_2-S_2)}$	$=T_1$
$\frac{K_1+K_2}{2}\tanh\frac{\Gamma}{2}+\frac{K_2-K_1}{2}$	$\sqrt{W_1W_2}\ \frac{\sqrt{W_2/W_1}\cosh\theta-1}{\sinh\theta}$	$\frac{D-1}{C}$	$O_2-\sqrt{O_2(O_1-S_1)}$	$=T_2$
$\frac{K_1+K_2}{2\sinh\Gamma}$	$\sqrt{W_1W_2}\ \frac{1}{\sinh\theta}$	$\frac{1}{C}$	$\sqrt{O_1(O_2-S_2)}$	$=T_{12}$
$\frac{2K_1K_2}{(K_1+K_2)\tanh\Gamma/2+(K_2-K_1)}$	$\sqrt{W_1W_2}\ \frac{\sinh\theta}{\sqrt{W_2/W_1}\cosh\theta-1}$	$\frac{B}{D-1}$	$\frac{S_1O_2}{O_2-\sqrt{O_1(O_2-S_2)}}$	$=\pi_1$
$\frac{2K_1K_2}{(K_1+K_2)\tanh\Gamma/2-(K_2-K_1)}$	$\sqrt{W_1W_2}\ \frac{\sinh\theta}{\sqrt{W_1/W_2}\cosh\theta-1}$	$\frac{B}{A-1}$	$\frac{S_2O_1}{O_1-\sqrt{O_2(O_1-S_1)}}$	$=\pi_2$
$\frac{2K_1K_2}{K_1+K_2}\sinh\Gamma$	$\sqrt{W_1W_2}\ \sinh\theta$	B	$\frac{S_2O_1}{\sqrt{O_1(O_2-S_2)}}$	$=\pi_{12}$
$\sqrt{\frac{\Delta}{\Delta_{11:22}}+\left(\frac{\Delta_{22}-\Delta_{11}}{2\Delta_{11:22}}\right)^2}+\frac{\Delta_{22}-\Delta_{11}}{2\Delta_{11:22}}$	$\frac{\sqrt{(W_1+W_2)^2\cosh^2\theta-4W_1W_2}\pm(W_1-W_2)\cosh\theta}{2\sinh\theta}$	$\frac{A-D}{2C}+\frac{1}{C}\sqrt{\left(\frac{A+D}{2}\right)^2-1}$	$\sqrt{\left(\frac{O_1-O_2}{2}\right)^2+O_1S_2}+\frac{O_1-O_2}{2}$	$=K_1$
$\sqrt{\frac{\Delta}{\Delta_{11:22}}+\left(\frac{\Delta_{22}-\Delta_{11}}{2\Delta_{11:22}}\right)^2}+\frac{\Delta_{11}-\Delta_{22}}{2\Delta_{11:22}}$	$\frac{\sqrt{(W_1+W_2)^2\cosh^2\theta-4W_1W_2}\mp(W_1-W_2)\cosh\theta}{2\sinh\theta}$	$\frac{D-A}{2C}+\frac{1}{C}\sqrt{\left(\frac{A+D}{2}\right)^2-1}$	$\sqrt{\left(\frac{O_1-O_2}{2}\right)^2+O_1S_2}-\frac{O_1-O_2}{2}$	$=K_2$
$\cosh^{-1}\frac{\Delta_{11}+\Delta_{22}}{2\Delta_{12}}$	$\cosh^{-1}\left\{\frac{W_1+W_2}{2\sqrt{W_1W_2}}\cosh\theta\right\}$	$\cosh^{-1}\frac{A+D}{2}$	$\cosh^{-1}\frac{O_1+O_2}{2\sqrt{O_1(O_2-S_2)}}$	$=\Gamma$
$\sqrt{K_1K_2\frac{(K_1+K_2)\cosh\Gamma+(K_1-K_2)\sinh\Gamma}{(K_1+K_2)\cosh\Gamma-(K_1-K_2)\sinh\Gamma}}$	$\sqrt{\frac{\Delta\Delta_{22}}{\Delta_{11}\Delta_{11:12}}}$	$\sqrt{\frac{AB}{CD}}$	$\sqrt{O_1S_1}$	$=W_1$
$\sqrt{K_1K_2\frac{(K_1+K_2)\cosh\Gamma-(K_1-K_2)\sinh\Gamma}{(K_1+K_2)\cosh\Gamma+(K_1-K_2)\sinh\Gamma}}$	$\sqrt{\frac{\Delta\Delta_{11}}{\Delta_{22}\Delta_{11:22}}}$	$\sqrt{\frac{DB}{CA}}$	$\sqrt{O_2S_2}$	$=W_2$
$\cosh^{-1}\sqrt{\cosh^2\Gamma-\left(\frac{K_1-K_2}{K_1+K_2}\right)^2\sinh^2\Gamma}$	$\cosh^{-1}\frac{\sqrt{\Delta_{22}\Delta_{11}}}{\Delta_{12}}=\tanh^{-1}\sqrt{\frac{\Delta\Delta_{11:22}}{\Delta_{22}\Delta_{11}}}$	$\cosh^{-1}\sqrt{AD}$	$\tanh^{-1}\sqrt{\frac{S_1}{O_1}}$	$=\theta$
$\cosh\Gamma+\frac{K_1-K_2}{K_1+K_2}\sinh\Gamma$	$\sqrt{\frac{W_1}{W_2}}\cosh\theta$	$\frac{\Delta_{22}}{\Delta_{12}}$	$\frac{O_1}{\sqrt{O_1(O_2-S_2)}}$	$=A$
$\frac{2K_1K_2}{K_1+K_2}\sinh\Gamma$	$\sqrt{W_1W_2}\sinh\theta$	$\frac{\Delta}{\Delta_{12}}$	$\frac{S_1O_2}{\sqrt{O_1(O_2-S_2)}}$	$=B$
$\frac{2}{K_1+K_2}\sinh\Gamma$	$\frac{1}{\sqrt{W_1W_2}}\sinh\theta$	$\frac{\Delta_{11:22}}{\Delta_{12}}$	$\frac{1}{\sqrt{O_1(O_2-S_2)}}$	$=C$
$\cosh\Gamma-\frac{K_1-K_2}{K_1+K_2}\sinh\Gamma$	$\sqrt{\frac{W_2}{W_1}}\cosh\theta$	$\frac{\Delta_{11}}{\Delta_{12}}$	$\frac{O_2}{\sqrt{O_1(O_2-S_2)}}$	$=D$

Chart of transducer formulæ (other portion appears on page 60). In column 6, within each square, one should use a consistent determination of any square root or ± sign appearing.

ends by equations which are the solution of (*1*)

$$\left.\begin{array}{l} E_1 = Z_{11}I_1 + Z_{12}I_2 \\ E_2 = Z_{21}I_1 + Z_{22}I_2 \end{array}\right\} \qquad (2)$$

T-Section Impedances: T_1, T_2, T_{12}

T_1: impedance of series arm near *1*
T_2: impedance of series arm near *2*
T_{12}: impedance of shunt arm

π-Section Impedances: π_1, π_2, π_{12}

π_1: impedance of shunt arm near *1*
π_2: impedance of shunt arm near *2*
π_{12}: impedance of series arm

Iterative Parameters: K_1, K_2, Γ

K_1: interative impedance at *1*, i.e., such a value of impedance which if connected to *2* as a load would equal the input impedance at *1*. Or, the impedance at *1* of the transducer followed by an infinite chain of identical transducers in tandem.

K_2: same definition as for K_1, with *1* and *2* interchanged

Γ: natural logarithm of the ratio of one terminal voltage to the preceding one in the infinite chain just mentioned. Γ has the same value for transmission either way and is called the *propagation*

(*Continued on page 64*)

TRANSDUCER FORMULAE

(*Continued from page* 62)

constant. The real part of Γ is the *attenuation constant* and the imaginary part is the *phase constant*.

Image Parameters: W_1, W_2, Θ

W_1, W_2: Image impedances at *1* and *2*. We find two values of impedance, W_1, W_2, so that with W_2 as load on *2* the impedance into *1* is W_1 and with W_1 as load on *1* the impedance into *2* is W_2. Or, W_1 is the impedance looking into *1* when the transducer is followed by an infinity of identical transducers alternately reversed so that like numbered terminals are connected together. W_2 is an impedance into *2* in a similar arrangement.

Θ: half the natural logarithm of the ratio of voltage at one terminal to the preceding like numbered terminal in one of the infinite chains. The result is the same for terminals of either number and both directions of transmission. Θ is called the *transfer constant*. Its real and imaginary parts are *image attenuation constant* and *image phase constant.*

Tandem Parameters

We can set up a bilinear relationship between input and output voltage and current, valid for any condition of loading by formulae, such as

$$\left.\begin{aligned} E_1 &= AE_2 - BI_2 \\ I_1 &= CE_2 - LI_2 \end{aligned}\right\} \quad (3)$$

The quantities *A, B, C,* and *D* then describe the transducer. Here there are four quantities instead of three as previously, so one would not expect them to be entirely independent. This is correct, for the determinantal equation

$$\begin{vmatrix} A & B \\ C & D \end{vmatrix} = 1 \quad (4)$$

always holds.

The full usefulness of these parameters only becomes apparent when one employs matrix multiplication[4]. In terms of matrix multiplication, (*3*) becomes:

$$\begin{pmatrix} E_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} E_2 \\ -I_2 \end{pmatrix} \quad (5)$$

Suppose now a network $\begin{pmatrix} A & B \\ C & D \end{pmatrix}$ is followed by a second one. $\begin{pmatrix} A' & B' \\ C' & D' \end{pmatrix}$, then in addition to (*5*), there would be another equation exactly like it but with primed letters.

n such a tandem arrangement, however, $E_2 = E'_1$ and $-I_2 = I'_1$. Therefore

$$\begin{pmatrix} E_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} A' & B' \\ C' & D' \end{pmatrix} \begin{pmatrix} E'_2 \\ -I'_2 \end{pmatrix}$$

)r, the ABCD matrix of two transucers in tandem is the *product of ɩe individual ones.* This is a very seful relation for some applications. (5) can be solved and written as

$$\begin{pmatrix} E_2 \\ I_2 \end{pmatrix} = \begin{pmatrix} D & B \\ C & A \end{pmatrix} \begin{pmatrix} E_1 \\ -I_1 \end{pmatrix}$$

e., for the reversed transducer, *A* ıd *D* change places.

It is not always possible to build a vo-terminal network out of a finite umber of elements whose impedance ould coincide at all frequencies with ıy of the impedances, $1/Y_{12}$, Z_{12}, W_1, V_2, K_1, K_2. That is, the latter are ot physically realizable. It is somemes convenient to express network arameters in terms of physically alizable impedances. Z_{11}, Z_{22}, $1/Y_{11}$, $/Y_{22}$ are four such impedances. The st column gives expressions for all ther network quantities in terms of ıese, but for this formulation, it is onvenient to introduce the letters

$$\begin{cases} 0_1 = Z_{11} \\ 0_2 = Z_{22} \\ S_1 = 1/Y_{11} \\ S_2 = 1/Y_{22} \end{cases}$$

'he 0_1 and 0_2 are the open-circuit ıpedances looking into the two ends, ıd S_1, S_2, the corresponding shortrcuit impedances.

Here again there are four instead f three quantities, and hence a retion must exist between them. This elation is

$$\begin{vmatrix} 0_1 & 0_2 \\ S_1 & S_2 \end{vmatrix} = 0$$

In several cases the relationships etween the various sets of parameters re not unique. This is seen in the mbiguity of sign of the square roots nd of branch of the multiple valued ıverse hyperbolic functions. These mbiguities are not accidental and ınnot be removed.

A specification of one of the sets of arameters: *Y, Z, T, π, A,* defines

See any book on matrices. Rules sufficient r this application can be deduced from the two amples.

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} \alpha \\ \beta \end{pmatrix} = \begin{pmatrix} a\alpha + b\beta \\ c\alpha + d\beta \end{pmatrix} \text{ and}$$

$$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} u & v \\ w & x \end{pmatrix} = \begin{pmatrix} (au + bw) & (av + bx) \\ (cu + dw) & (cv + dx) \end{pmatrix}$$

(*Continued on page 66*)

TRANSDUCER FORMULAE

(*Continued from page 65*)

the performance of a network uniquely. Consequently, all the relations between this group are single valued. On the other hand, specification of the *Realizeable Impedance* group leaves an ambiguity: for instance, an interchange of output wires would not change this set. Since certain changes in elements are equivalent to an inversion of leads, we have two networks for each such set. In the case of the *Image Parameter* set, there are four networks corresponding to each. Changing the sign of every element or inverting leads does not change the *Image Parameters.* Hence in column *6* of the chart there is a total of four choices in each square.

Finally every network has two image and two iterative impedances on each end. The Γ or θ corresponding to one is the negative of that corresponding to the other. This is the other value of $\cosh^{-1}$ or $\tanh^{-1}$.

•

OWI TRANSMITTERS

(*Continued from page 56*)

be seen in Figure 7, are provided for monitoring the carrier of each transmitter, and are located in the control desk. These have a 60-cycle sweep voltage on the horizontal plates; the vertical plates are fed from pre-tuned circuits, coupled by coaxial lines to the transmitter output. These tuned circuits are selected by band switch from the front of the oscilloscope. The coil assembly on each has 10 resonant circuits, each with a midget variable condenser for resonating the circuit to any of 10 frequencies on which the associated transmitter may be operating.

Immediately below each oscilloscope panel is a small panel bearing the audio level control, the *carrier-on* light, the *emergency-off* button for each of the transmitters, and a key which, when thrown, drops the studio line, and picks up the output of a pre-set electrical transcription machine, and simultaneously, through relays, starts the transcription machine motor. To the right of the public address speaker on the center panel is a master key, which operates *all* the pre-set electrical transcription machines simultaneously.

At the center of the desk are the general controls common to all transmitters. Immediately above is the public address speaker, which also serves as a microphone, and which may be switched to a two-way f-m transmitter, communicating with the antenna service car, without being disconnected from the regular building intercommunication system. Immediately below the speaker is a volume level indicator, with its range switch and channel selector switch. Below these are the level control and selector switches for the monitoring speakers.

The frequency monitoring system is also included in the control room equipment, and consists of a secondary frequency standard, a fixed-tuned 5-mc WWV receiver, a frequency counter, and an r-f signal mixing panel.

All components of the 100-kc oscilla-

(*Continued on page 70*)

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGONIGLE, President RCA BUILDING, 30 Rockefeller Plaza, New York, N. Y. GEORGE H. CLARK, Secretary

At the 77th Division Club meeting, October 25, 1944

Personals

A ROUSING round of applause and congratulations to Morris Pierce for his epic deed on the western front. Thanks to his ingenuity we captured powerful Radio Luxembourg before its German occupants could destroy it.

Mr. Pierce, chief engineer of WGAR, who was serving as chief engineer of the Physchological Warfare Branch of OWI, won the plaudits of the world last year, too, by securing the surrender of the entire Italian fleet without the firing of a single shot. An old transmitter retuned from 1,100 to 500 kc did the job, and what a job!

Glad to see John W. Swanson recently. JWS started in wireless with the United Wireless Telegraph Company in 1909. He then went with the Marconi Wireless Company of America. A position with the United Fruit Company (Tropical Radio) followed. Today he is an executive in the Marine Department of the Standard Oil Company. . . . VWOA welcomes Edward J. Oberle of Allwood, N. J., who has seen service in the Navy and at WODA of Paterson, N. J. . . . We were sorry to learn of the illness of Charles E. Drew, a genuine oldtimer, who recently entered the Veterans Hospital at Northport, L. I., after suffering a nervous breakdown. His most recent book, *How to Pass Radio License Examinations,* was published April 1, 1944. We hope that we may see him around again very soon. . . . Commander Fred Muller would like to receive mail from his old friends. Contact headquarters for his address.

The VWOA Fall Meeting

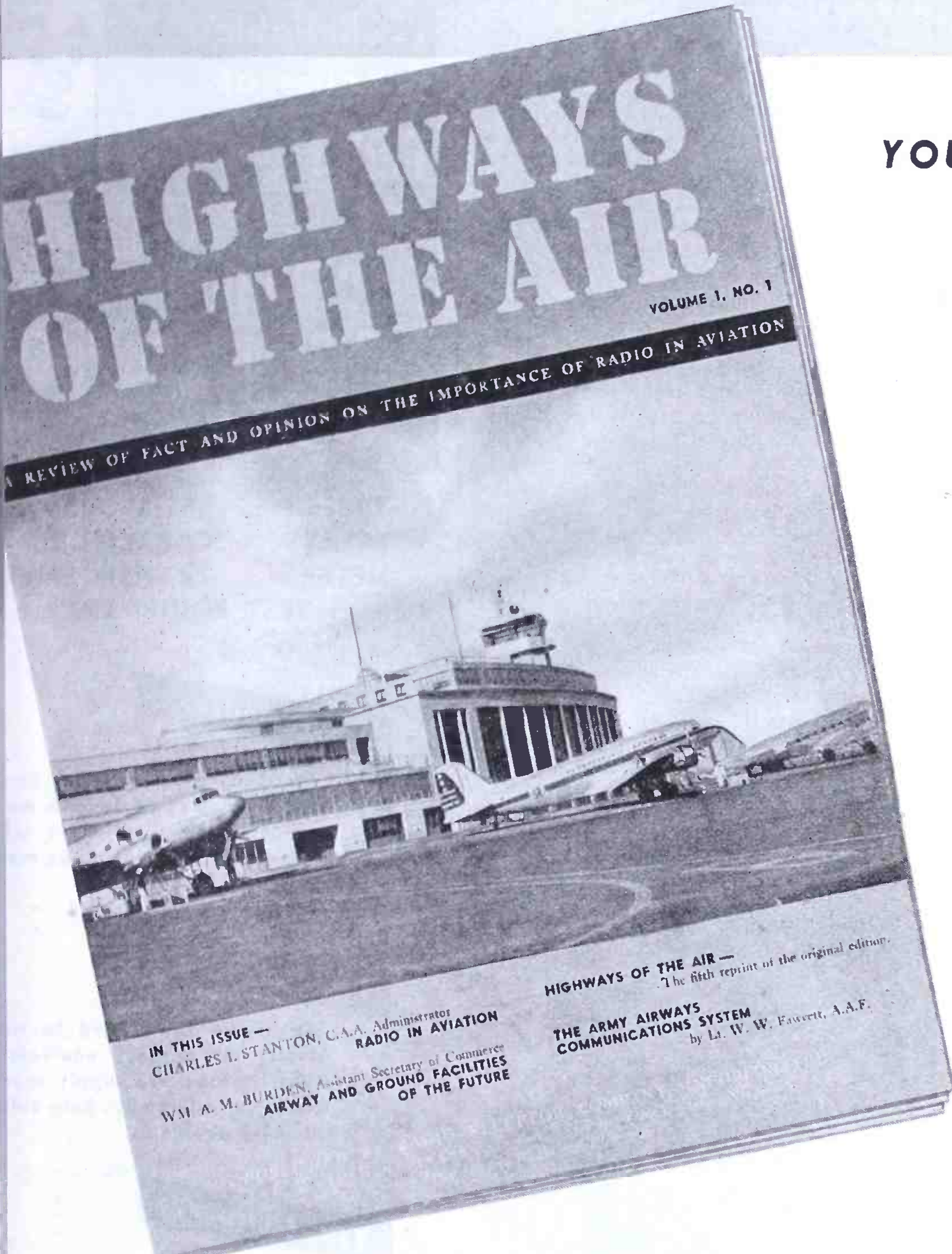
THE 77th Division Club meeting on October 25, 1944, was well attended. Among those present were: Ludwig Arnson, president of Radio Receptor Company; Col. Tom Mitchell, vice president and general manager of RCA Communications, and J. F. Rigby, personnel director of RCAC; C. D. Guthrie, radio supervisor of the War Shipping Administration, and Mr. Campbell of the same office; Ed Carroll, who always comes up from Philadelphia for these parties to relate those interesting stories; Carl Nelson, publisher of *Telephone and Telegraph Age;* a large delegation from the marine department of the Mackay Radio and Telegraph Company with E. H. Price, marine superintendent, and A. F. Wallis in the lead; V. P. Villandre, war services supervisor of the Radiomarine Corporation of America and our very diligent ticket committee chairman these many years; Peter Podell, one of our founders, now in the motor sales field; Frank Orth, technical supervisor of CBS; Arthur H. Lynch, eastern representative of the National Company and general sales manager for Erc[illegible] Radio Laboratories, and chairman o[illegible] our ways and means committee; A. I[illegible] Yuter, one of our most constant mem[illegible]bers; George Duvall, now with th[illegible] Army Signal Corps; Bill Stedman who seldom misses a meeting; Henry Hayden, Ward Leonard representative; Roscoe Kent, one of the earlies[illegible] of oldtimers, now with the Geme[illegible] Company; Martell Montgomery o[illegible] Federal Telephone and Radio Corporation; Henry Steinberg, eastern representative of Cornell Dubilier[illegible] Bob Frey, radio supervisor of the Bul[illegible] Steamship Lines; J. A. Bossen; and R. J. Iverson of the New York *Times* radio staff.

In Memoriam

TWO of our veteran wirelessmen have passed away . . . Arthur Cohen, member of the staff of the American Embassy, Rio de Janeiro, and John H. Cose, assistant superintendent of RCA Institutes. Mr. Cohen was a wireless officer on the largest of American passenger vessels. He also served aboard some of the larger American Yachts. Mr. Cose served on the staff of RCA Institutes as a code instructor, and head of the Physics Department. In 193[illegible] he assumed the position of Assistant Superintendent. . . . To the families and friends of these veteran wirelessmen we extend our deepest condolences.

"HIGHWAYS OF THE AIR"

Important to everyone interested in airports and aviation



YOU SHOULD KNOW- - -

What is the "bottle-neck" in post-war expansion of civil aviation . . . . *See page 8*

Why CAA is installing Ultra High Frequency radio ranges. *See page 8*

What anti-collision devices are being developed . . *See page 9*

What electronic aircraft detectors are . . . . *See page 9*

What can civil aviation learn from the A.A.C.S. . . *See page 2*

What goes into an instrument landing system . . *See page 11*

What is approach control. *See page 11*

These questions and dozens of others of vital import to all those interested in the development of radio in aviation for increased safety of human life and property are discussed in the pages of

"HIGHWAYS OF THE AIR"

This issue is No. 1, Volume 1 — others will follow if you request them. Contents are authoritative—but non-technical—designed to inform the layman on a subject which is becoming of increasing importance.

Send for your copy on your letterhead—we are glad to send it as our contribution to a greater Air-America.

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SINCE 1922 IN RADIO AND ELECTRONICS

OWI TRANSMITTERS

(*Continued from page* 66)

tor circuit are enclosed in a temperature controlled oven, including the tuned circuit, the crystal, the oscillator tube, and a voltage regulator. The oscillator is electron coupled to an isolating amplifier, which feeds the output to the multivibrator and the fixed tuned WWV receiver.

The WWV receiver is a three-stage t-r-f type, fed from a tuned loop. A detector stage mixes the 100-kc signal with the WWV signal. An audio amplifier is included to drive the monitoring speaker.

The multivibrator is of conventional design, with operating frequencies at 10, 20 and 50 kc. It is preceded and followed by isolating amplifiers. The output amplifier is of cathode-follower type, feeding one stator of two signal-balancing variocouplers, in tandem, driven from a common shaft, and completely shielded from each other. A faraday shield eliminates capacity coupling between rotor and stator of each variocoupler. The rotors are so oriented on the common shaft that when coupling is at minimum in one unit, it is at maximum in the other. Multivibrator output is fed to one stator, the unknown signal is fed to the other, and the two rotors in series are fed to the input of the communications receiver. This provides a means of balancing the amplitudes of the unknown and the standard signals, so that a good beat note is obtained.

The unknown signal input to the signal balancing variocouplers may, by means of a jack panel, be obtained from one of the r-f generators, or from an antenna. The multiple-band communication receiver and frequency counter complete the equipment of the frequency-monitoring unit.

R-F Driver

A front view of the r-f driver, which is composed of three stages, is shown in

Figure 10
Interior of the power amplifier cabinet. Small cabinet between two tubes provides shielding for grid circuits of amplifier.

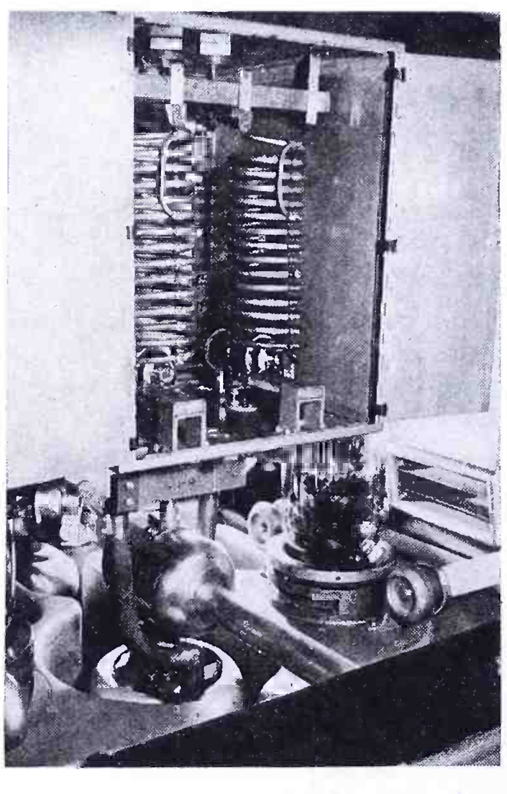


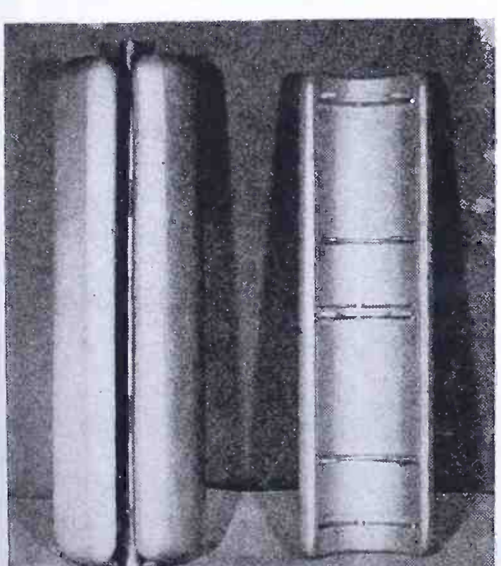
Fig. 8. Each stage is separately tuned in both grid and plate circuits, and is link-coupled to the succeeding stage. Both the grid and plate circuits of the first stage, a single 807, have eight pre-tuned, plug-in coils. Each grid coil is provided with an input winding which is selectively connected to the double coaxial transmission line terminating on the r-f exciter patching panel. The push-pull 813 second stage has two sets of tapped coils in both grid and plate circuits.. The F129B driver third stage is push-pull, and has two sets of tapped coils in its grid. Both these stages have adjustable tuning capacities, controlled from the front of the cabinet. The 129B plate circuit consists of a copper tubing inductance with adjustable taps and shorting bars, and a variable air condenser, visible from center front of Figure 8, controlled from front of cabinet. A ganged band switch is mounted vertically and operated from the rear of the cabinet, by means of a horizontal handwheel, accessible from the top shelf. This mechanism switches all circuits except the 129B plate circuit, which must be changed manually. Other front controls include the third stage neutralizing, and the output coupling adjustment, which is accomplished by swinging a small link coil into the field of the center of the driver plate inductance, Figure 9.

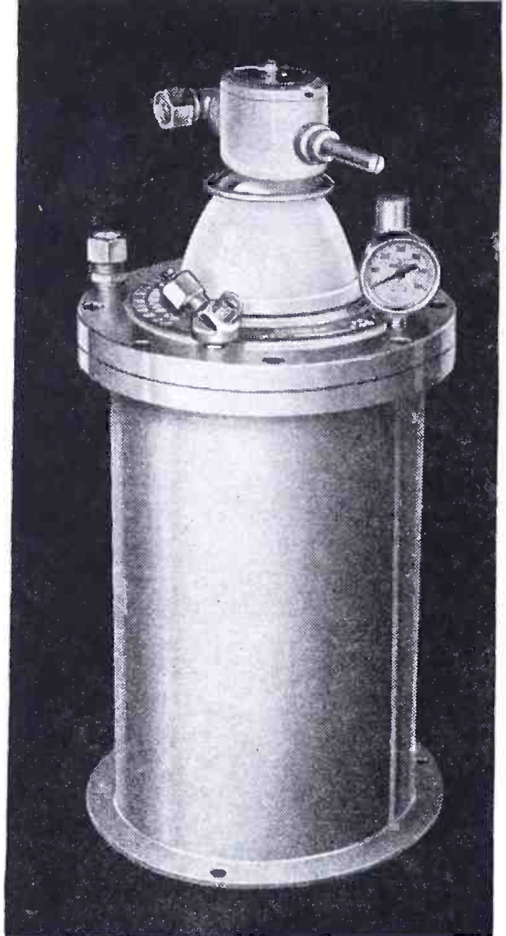
Final Amplifier Unit

The final amplifier of each transmitter is designed to deliver 250-kw 100% plate modulated, on frequencies between 6 mc and 21.65 mc, with plate voltage up to 15 kv. Figure 10 shows a view of the interior of the power amplifier cabinet. Mounted between the two tubes is a small cabinet which provides shielding for the grid circuits of the amplifier. The grids of these tubes are driven through a pi network, fed through coaxial transmission lines from the driver cabinet, where it is inductively coupled to the tank circuit of the driver. The doors of the grid cabinet are shown open, so that grid coils may be observed. These coils are so proportioned that the circuit is tuned at 6 mc, when the entire coil is in the circuit. By placing shorting straps across turns of the coils, higher frequencies are obtained,

(*Continued on page* 72)

Figure 11
Neutralizing condenser, which consists of two semi-cylindrical sections, rotated in the cylindrical space formed by tube jacket housings.





(Continued from page 71)

until at 21.65 mc the entire coil is short circuited. The pi network uses the tube capacities and inductances in its circuit.

The grid circuit of the final amplifier has a fixed bias which protects the tubes to a safe value of plate dissipation, in case of failure of drive. This is accomplished by obtaining bias voltage through a high resistance from one of the low voltage rectifiers. The voltage is applied continuously, and in case of failure of drive, the tubes are automatically protected from overloads without the operation of any relays. When tubes are being driven, the bias becomes negligible.

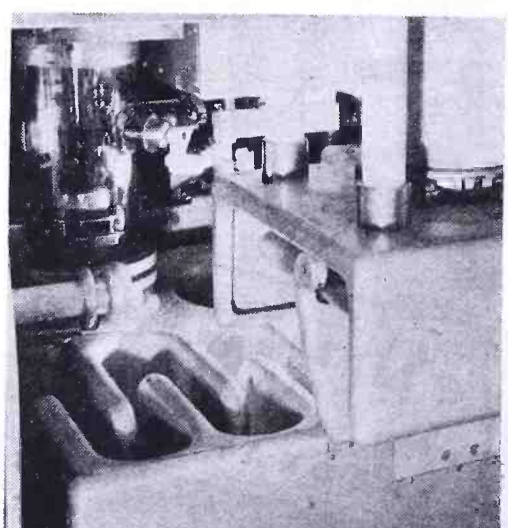
On each side of the cabinet interior, cooling air is provided through a vertical duct, connecting with the header duct above the entire transmitter unit, and providing a blast of air on the glass of the power amplifier tubes, of sufficient velocity for effective cooling over the entire periphery of the glass.

In Figure 10, the arrangement of the neutralizing condenser and the plate tank condenser may also be seen. In the center of the picture, three concentric shafts run toward the rear of the cabinet, through a corona shield, housing bevel gears. This mechanism, operating by chain drive from controls on front of the cabinet, adjusts the plate tank condenser, the antenna coupling loop, and the neutralizing condenser.

The neutralizing condenser consists of two semi-cylindrical sections (Figure 11) rotated in the cylindrical space formed by the tube jacket housings. This design provides a balanced-bridge circuit, with essentially no detuning of grid or plate circuits during neutralization adjustments.

The plate tank circuit of the power amplifier (Figure 12) consists of a variable air condenser and a transmission line inductance with movable shorting bar. The constants of this circuit are such that a frequency range of 6 to 21.65 mc is covered by adjustment of the capacity and inductance. The moving portion of the plate tank condenser is suspended from a carriage which rides on three brass pipes. In addition, this condenser is bypassed to the shield at practically the same point to which the filaments of the tubes are bypassed. The grid cabinet is also connected to this same point. This serves to hold the circulating currents in the shielding to a minimum, and pro-

Figure 12
Variable air condenser and transmission line inductance, with movable shorting bar in plate tank circuit of the power amplifier.



vides stable operation at powers in excess of 200 kw.

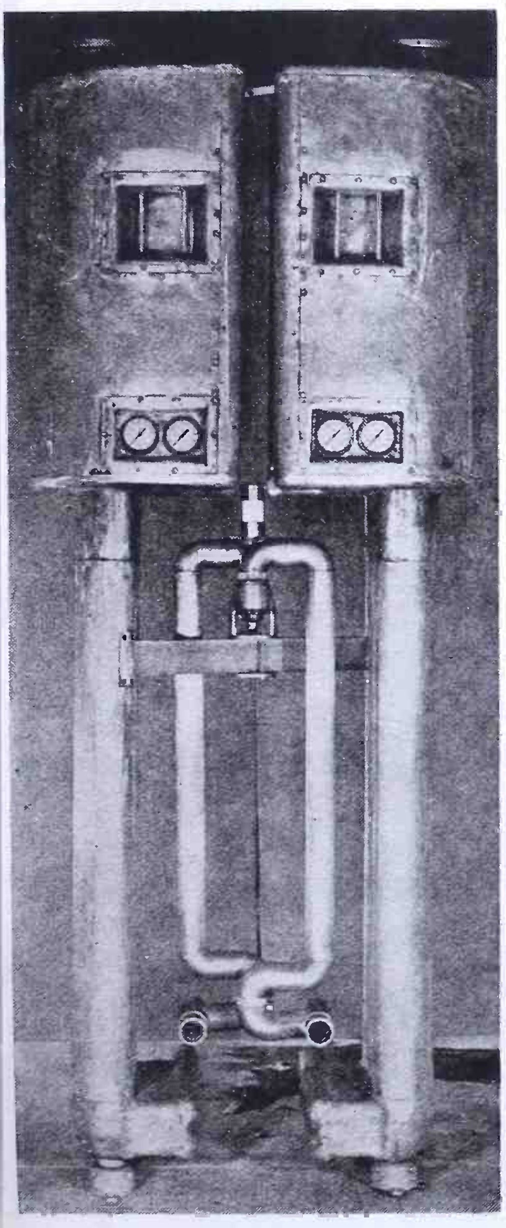
The stationary plates of the plate condenser are carried directly on the housings which contain the tube jackets. Figure 13 shows an assembly of tube jackets in housings, incorporating thermometers and water pressure gauges. Also shown are the antenna coupling loop, vertical section of the transmission line, and the bottom header castings to which are to be connected the horizontal four-pipe transmission line, on which the shorting bar slides. These horizontal pipes also carry cooling water to the tubes.

The transmission line tank is housed in a metal shielding duct, which is a continuation of a shield within the cabinet, but which is insulated from the metal of the cabinet itself. The vertical section of the transmission line consists of a pair of large copper pipes on each side, each pair encased in a copper sleeve. This offers an exceptionally low impedance circuit, and makes it possible to obtain a high distributed capacity, even though the conductors are separated from each other far enough to permit mounting of a coupling loop between them.

The coupling loop is in two portions: a vertical adjustable portion shown in Figure 13, and a horizontal fixed portion which runs parallel to the horizontal portion of the transmission line tank circuit,

(*Continued on page* 74)

Figure 13
Vertical adjustable portion of the coupling loop, which also has a horizontal fixed portion, running parallel to the horizontal portion of the transmission line tank circuit.



(Continued from page 73)

and which is automatically coupled or decoupled, depending on the position of the transmission line shorting bar. Tuning of this coupled circuit is accomplished by vacuum condensers, either at the bottom of the vertical coupling loop, or at the rear of its horizontal portion, depending on frequency. The vertical portion of the coupling loop is so arranged that it can be rotated into a bucking position with respect to the horizontal section, during operation at lower frequencies.

All of the foregoing adjustments for frequency change can be made from the front of the cabinet in a few seconds.

Low Level Audio and Control Room Equipment

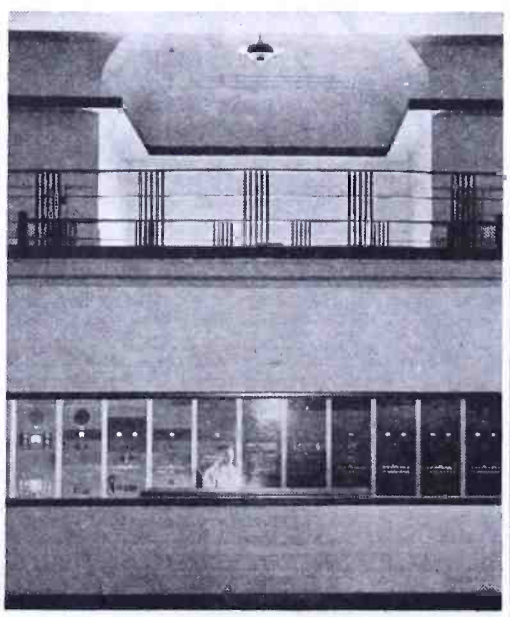
All program material is supplied to the transmitters either by telephone circuits, or by electrical transcriptions. No provisions are made for live pick-ups at the transmitter building. At present the OWI and CIAA programs originate in studios in the East, and are fed through the WLW master control room at Crosley Square in downtown Cincinnati, to the transmitter audio equipment. Figure 14 shows a panoramic view of the equipment bays in the control room. A separate amplifier channel is provided for each modulator input, plus one spare. Each channel is installed in a separate equipment bay.

The incoming lines are terminated in matching networks which provide a means of feeding one to three amplifier channels from any one line. The output of the matching network may be patched directly to the desired amplifier input, or it may be patched through a selector switch, affording a quick means of transfer from one program channel to another. This switch affords a selection of either of two circuits, and is set up by patch cord, so that the selection may be between any two telephone lines, or between telephone line and electrical transcription output.

The signal then is routed to one of four equipment bays which contain the amplifier channels associated with the particular transmitter inputs, and passes through a variable attenuator and an

Figure 14

View of the equipment bays in the control room.



electrical transcription switching relay to the line amplifier. The volume indicator, mounted in the bay, monitors the level at the output of the line amplifier. From this point, the signal passes through a peak clipper, and out of the amplifier bay to the transmitter input attenuator, located on the control desk.

The electrical transcription switching relay mentioned, is controlled by keys on the control desk, as previously described. Monitoring speaker amplifiers and switching equipment are also located in the control room equipment bays. Each program channel has a monitoring take-off at the output of the line amplifier, and this signal is fed through speaker selector switches so arranged that the operator is able to pre-set levels before the signal is fed to the modulator input. The e-t machine output is fed through a pre-amplifier and variable attenuator to the switching relay, and to the selector switches of the monitoring speaker, so that here again the level may be pre-adjusted before the signal is fed to the modulator.

Throughout all of the speach equipment in the control room, complete flexibility is maintained by use of jacks and patch cords, by which any elements, from amplifiers to fixed pads, may be isolated. In most cases, back contacts on the jacks route the signal through its normal channel, but the presence of the jacks in the circuit makes it possible to lift a defective element quickly, and patch in a spare.

Modulator

The modulator (Figure 15) consists of a three-stage voltage amplifier, followed by a 2- to 6-tube class *B* power stage. The first two stages are push-pull 807 and 813 tubes, respectively, and are resistance coupled. These stages are mounted horizontally on a vertical panel in the upper center of the unit, while the circuit components are mounted on the rear. The 813s are resistance coupled to push-pull 891s, located slightly above the main group of tubes, and operating class *A* as the third voltage amplifier. The 891 stage is coupled with a 1:1 ratio transformer, to 2, 4, or 6 F125 tubes, operating class *B* with zero-grid current, as the power stage. In the 4 or 6 tube

(*Continued on page* 76)

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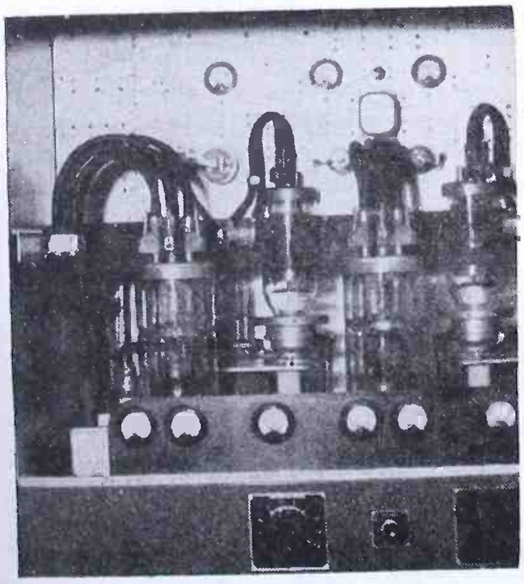
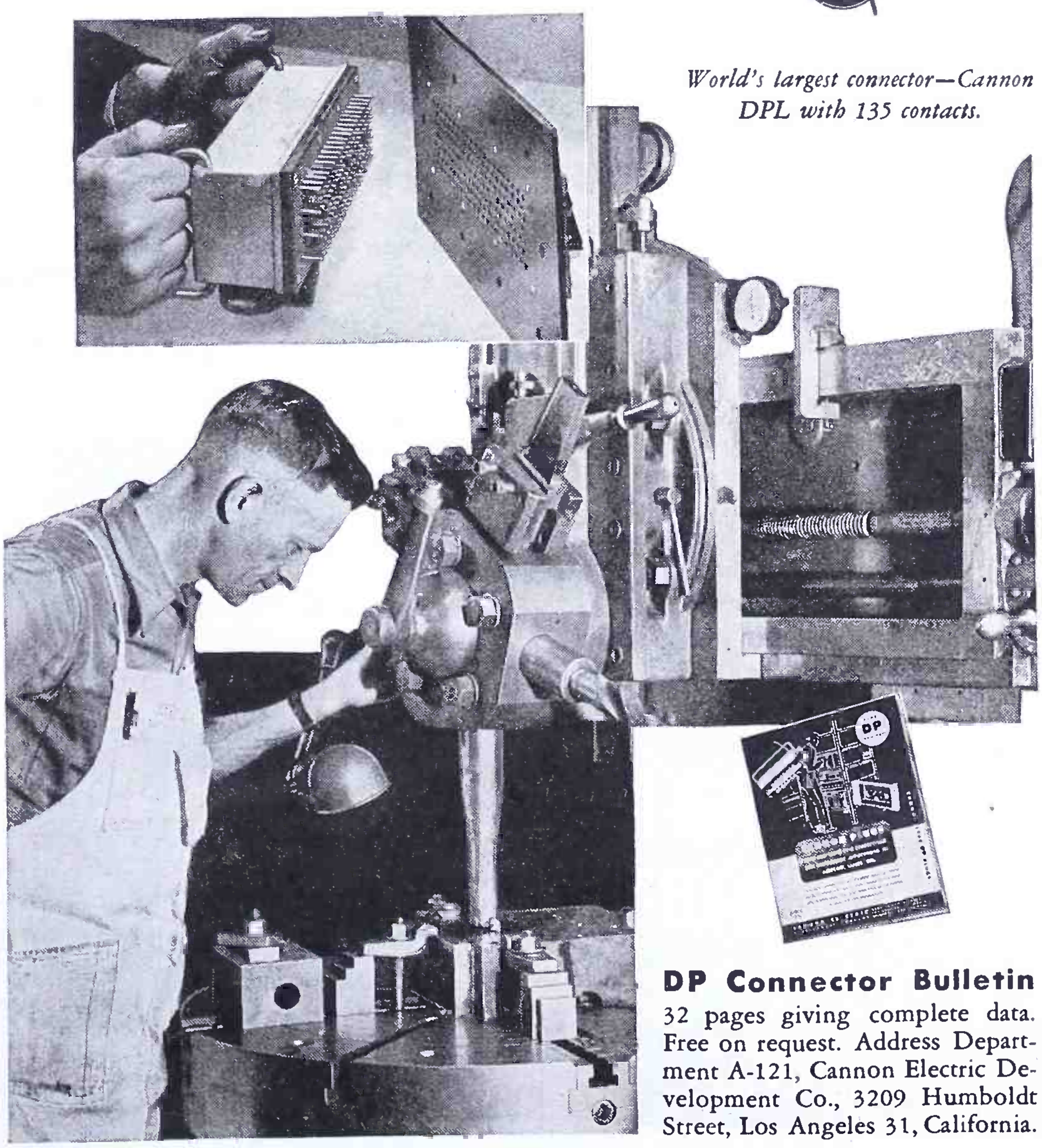
Figure 15
Modulator unit which consists of three-stage voltage amplifier and a two to six-tube class *B* amplifier.





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arrangement, 2 or 3 tubes operate in parallel on each side of the push-pull circuit. Three 125s in the front constitute one side of the class *B* stage, while three more in the rear constitute the other side.

In order to accommodate tubes of normal differences in characteristics, each tube has individually combined bias and drive adjustment. The circuit is such that these two adjustments are accomplished simultaneously, with one potentiometer in each grid circuit. Each modulator tube plate circuit has a 42-ohm surge limiting resistor in series, which may be seen at bottom of unit in Figure 16.

The modulation transformer, weighing more than 24,000 pounds, and its reactor and d-c blocking condenser, are located in the transformer vault. This combination was designed to cover a frequency range of from 30 to 10,000 cycles, at a power output of 180-kw maximum.

Power Supply Substation

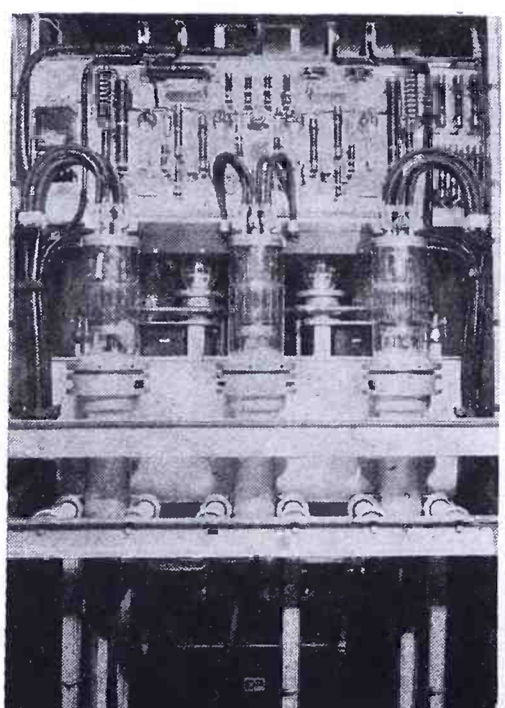
Power is supplied to the plant from a 33-kv loop circuit, with remote controlled disconnect switches on each side of the take-off point. These switches, both normally closed, may be opened by push-button controls in the transmitter control room, in case of a fault on either line.

At the substation a 3000-kva transformer bank provides 3-phase, 2400-v service, divided into six main circuits to the transmitters, each equipped with fused disconnect switches. Three of these are for the high-voltage plate-supply transformers, and the other three are fed through an induction regulator, and supply a 200-kva, 2400/240-v, 3-phase transformer in each vault. All 240-v power for operating filament transformers, pump and blower motors, low voltage supplies, etc., is obtained from these transformers. Each transmitter becomes an independent unit from the substation to the antenna switching station.

Transformer Vault

All high voltage transformers, filter reactors, filter condensers, and high-volt-

Figure 16
The 42-ohm surge limiting resistors, which are in series with each modulator plate circuit, at bottom of unit in view below.



age control components are located in three fireproof vaults within the building, one for each of the three transmitters, built into the bay directly behind each transmitter unit. In the floor plan (Figure 2) the location of the vaults, and the major components of one vault, may be seen.

The high-voltage plate transformer is a 750-kva, three-phase unit, with a special high speed motor-operated tap switch, connected in its secondary winding, which operates under load. The transformer windings and taps are such as to provide variable d-c voltages at the load from 5500 to 15,000-v in 32 steps. Incorporated in the transformer is a voltage regulating control, to operate the tap switch motor, and thus maintain the voltage at any selected value, regardless of input line variations or load on the transformer. Voltage adjustment is accomplished from the transmitter control panel, by means of a rheostat, which is the series calibrating resistor for the contact-making voltmeter in the control unit. The shaft of the rheostat is connected to the panel control through a torque switch, which causes the tap changer to become instantly responsive to adjustments of the control. At all other times, a half-minute time delay is automatically operative, as the tap changer corrects for line voltage fluctuations. The transformer also returns automatically to its lowest voltage tap each time primary voltage is removed for periods in excess of a few seconds in order that reapplication of power may occur at minimum voltage.

The unregulated three-phase power for the high voltage system from the substation is fed through manual disconnect switches in the vaults, and then through series line reactors for limiting fault, or rectifier arc-back currents, through a magnetically operated contactor, and the ignitron interrupter (*see high voltage controls*) before reaching the tap changing transformer. Normally, the magnetic contactor remains closed, and the power interruption is accomplished by the ignitron unit. But if an a-c line overload should occur or a transmitter door should be opened, this contactor operates, following the ignitron interruption, to provide additional protection.

[To Be Concluded in December]

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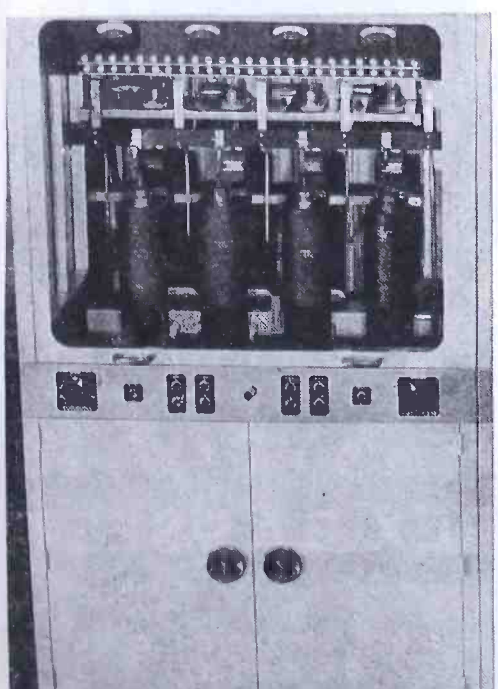
Figure 17
The rectifier cabinet.



GOLDMARK ON U-H-F TELEVISION

(*Continued from page* 44)

rier frequency. It would be difficult to build a receiver and receiving antenna to cover this range and still sell at reasonable price. Now consider the case of a television band providing for thirty 16-mc channels and starting, say, around 450 mc. Such a band would extend from 450 to 950 mc, which is barely more than one octave. As a result the requirements of receiving antennas, of receiver tuning circuits, etc., are considerably simplified and much more easily met. There are indications that the proposed new standards can be fitted into a channel less than 16 mc wide.

"The power requirements for the new u-h-f television transmitters were based on coverage at the present 60-mc channel, and we have not taken into account the appreciable increase in field strength which the higher frequencies offer."

Dr. Goldmark cited that in the report of Dr. R. A. Norton, prepared on behalf of the FCC for the 1940 and 1941 television hearings, propagation data evaluated u-h-f advantages. These data revealed, he said, that, progressing toward the boundaries of the service area, the horizon, field strength from a 5-kw transmitter at 500 mc is approximately equal to that from a 125-kw transmitter at 60 mc.

Analyzing this point, Dr. Goldmark said:

"Simple computation based on Dr. Norton's 1941 report furnished the following interesting data: assuming two transmitters, one operating at 60 mc, the other at 500 mc, both with 1-kw power, and further assuming a transmitting antenna 1000-feet high and receiving antenna 30-feet high, the service area (500 μv/m contour) at 60 mc will be 2340 square miles, whereas at 500 mc the coverage increases to 6560 square miles. In contrast to this, the interference area (5 μv/m contour) at 60 mc is 25,100 square miles, but is reduced to 19,800 square miles at 500 mc. Stating it differently, the interference to service area ratio at 60 mc is 11 to 1 but only 3 to 1 at 500 mc."

Dr. Goldmark also discussed u-h-f noise conditions. He said that according to a RTPB report the daytime and nighttime atmospheric noise is negligible at 500 mc as well as at 100 mc.

And for any given bandwidth, he pointed out, most man-made noise at 500 mc has a peak amplitude which is only half of that which is present at 100 mc.

The report also reveals that the ratio of the peak amplitude of man-made noise in a receiver having a 16-mc bandwidth to that of man-made noise in a 6-mc receiver is 1.9 to 1. Assuming an urban location, the peak noise amplitude will therefore be ($\frac{1}{2}$x1.9) = .8 times as great in the 16-mc u-h-f receivers as in a 6-mc receiver operating in the v-h-f spectrum, explained Dr. Goldmark.

The annoying receiver hiss, which would introduce a salt and pepper effect in the presence of a weak signal, is proportional to the square root of the bandwidth only. Thus, he said, noise due to receiver hiss would be only 1.6 times as intense in a 16-mc receiver as in a 6-mc receiver; a negligible amount with respect to the 500 microvolt-per-meter contour.

Highly-directional receiving antennas will not respond to all the noise-energy perceptible at a given receiver location, said Dr. Goldmark. He pointed out that normally noise can be assumed to come from all directions at once, but the narrow beam antenna will receive only that part of the noise which originates within its beam. At 500 mc, he explained, the improvement in the signal-to-noise ratio will easily amount to 6 or 8 db or more, as compared with that which is obtained with the customary double dipole array around 100 mc.

Therefore, he said, the increase in signal-to-noise ratio, coupled with the predicted increase in field strength in effect would cause a 5-kw transmitter operating at 500 mc to provide a service comparable to that of 100-kw transmitter operating at 60 mc.

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G. L. Beers Statement

ANSWERING questions relating to stability of transmitters and receivers, color television and channel assignments, G. L. Beers, staff assistant to the chief engineer of RCA Victor division, RCA, said that in general it can be stated that the stability of television transmitters for frequencies of 50 mc, 300 mc, and 500-1000 mc will probably be a definite percentage of the carrier frequency. He explained that it is believed that a transmitter stability of .005% can be achieved throughout this entire frequency region unless some new technique for the generation of power in the region of 500-1000 mc is required. This would impose lower limits on frequency stability. He said that the minimum drift which can be achieved with arrangements which are suitable for broadcast receivers will result in a percentage drift which remains substantially constant throughout the frequency range considered. According to Mr. Beers the best frequency stability which can probably be obtained in a commercial product would be approximately .05%.

Analyzing this problem further, Mr. Beers said: "The primary effect of transmitter instability and receiver drift upon a 6-mc television channel for frequencies in the region between 50 mc and 300 mc is to limit the deviation which can be used for a 200-kc frequency modulation television sound channel. The RTPB committee which considered this subject adopted a maximum deviation of plus or minus 25 kc.

"It is our belief that the effect of transmitter and receiver instability for 6 mc channels at frequencies up to 300 mc will not impose material limitations on the resolution which can be obtained from television receivers. No frequency stability difficulty is anticipated with a 20-mc channel at 300 mc. The frequency stability which can be obtained in the region between 500 and 1000 mc will not permit the use of a 200 kc-television sound channel. The channel width required for the transmission of the sound at carrier frequencies in this region must either be increased materially or some other method of sound transmission must be employed. Frequency stability limitations from the standpoint of both picture and sound will not permit the use of 6-mc channels at 1000 mc. It is believed that the benefits which can be realized from automatic frequency control in re-

(Continued on page 80)

(*Continued from page* 79)

ceivers designed for the television frequencies under consideration do not justify the additional circuit complications and the resultant increase in costs to the customer."

Fidelity standards were also discussed by Mr. Beers. He said that the subject of the adequacy of a 60-mc channel in the frequency region between 50 and 300 mc was considered by committee 1 of RTPB panel 6. He offered a resolution adopted by the committee, which, he said, expressed his opinion on this subject. The resolution read:

"It is the opinion of the committee that the present television bandwidth of 6 megacycles renders an adequate monochrome television service having acceptable entertainment value. An increase in the bandwidth would not add to the value of picture commensurate with efficient spectrum utilization in the existing bands below about 200 megacycles. A reduction in bandwidth would not provide gains in the form of possibilities for increase in number of channels or more economical use of the space available, commensurate with the resulting degradation of the picture."

Mr. Beers pointed out that practical television receivers which will select any one of 20 to 30 six-mc channels in the 50-300 mc band can be constructed.

SPECIAL C-R TUBES

(*Continued from page* 48)

tion screen. While a perfectly diffusing reflective screen is the most satisfactory from the standpoint of viewing angle, it is considerably less efficient than a screen having directive characteristics. However, the greatest efficiency is obtained by using a translucent screen, but again the viewing angle becomes a limiting factor.

Another problem of considerable interest is the development of tubes and methods for the transmission and reception of colored pictures. Considerable work has been done along this line by Dr. Goldmark of CBS in which mechanically operated color filters are used. This system requires direct-viewing picture tubes which must be operated at a light output considerably above that of the presently used direct viewing tubes for black and white. This brings up the problem of tube life which may be materially shortened at higher intensities, as well as picture size which again depends upon tube-face diameter.

Several other methods for producing colored pictures have been suggested. Latest among these is the Baird tube employing a three-color fluorescent screen which is excited by three separate cathode-ray guns all assembled in the same envelope. The elimination of mechanical color filters as well as light losses due to them would be in favor of such a tube design. However, such a tube could present some rather serious manufacturing problems which might make its cost prohibitive. At the same time there would be a definite limitation to picture size since the envelope diameter must be considerably greater in diameter than the fluorescent screen.

During the past three years many new applications for cathode-ray tubes have been found in the prosecution of the war. Various types of screens have been developed including high speed, dark trace, long persistence, and photo-emissive types used for detection and combat purposes, which can only be mentioned here, but which will have many and varied postwar applications.

Looking toward postwar applications of c-r tubes and possible markets, the uses might be classified as television, aviation, industrial, radio servicing, laboratory and medical applications in the order of their importance.

By far the most important of the above markets will be television.

Television has, as a possible market, every home in our larger cities, with direct viewing and limited projection type tubes for immediate postwar use.

CAA COURSE SOLUTIONS

(*Continued from page* 40)

use of the graphical method as described below and illustrated in Figure 4:

A construction line is drawn perpendicular to the goniometer line from the intersection point *0*. The distance from the center to where this line crosses the goniometer line or its extension, to the same scale as used for vectors *V*, is the value of L_G and is always positive. Angle A is the angle between the negative portion of the goniometer line and the closer adjacent course. (That part of the goniometer line on the opposite side of the center from the vector L_G is referred to as the negative portion of the goniometer line.

[*To Be Concluded In December*]

FIRST ANNUAL CONFERENCE

TELEVISION BROADCASTERS ASSOCIATION, INC.

Hotel Commodore, New York City
December 11 and 12, 1944

Monday, December 11, 1944

10:00 A. M. Opening remarks: *Dr. Allen B. Du Mont, TBA president*
Report on arrangements; *O. B. Hanson, vice-president, NBC, chairman of conference*

"New Horizons in Television": *Dr. W. R. G. Baker*, vice president in charge of electronics, G. E. and *E. W. Engstrom*, in charge of the RCA Laboratories.

"Television Programming": *John F. Royal*, vice president in charge of television of NBC; *Robert L. Gibson*, assistant to vice president in charge of advertising and publicity at G.E., and *Thomas H. Hutchinson*, in charge of production for RKO Television Corporation.

"Establishing Television Networks"; *Harold S. Osborne*, chief engineer of A. T. & T.

12:30 P. M. Luncheon session.
"Television and the Broadcaster"; *Lewis Allen Weiss*, Don Lee Network.

2.00 P. M. Panel meetings, *Dorman D. Israel, presiding.*
Panel meetings will be conducted by: *C. A. Priest*, G.E. (manufacturers); *Samuel H. Cuff*, DuMont (broadcasters); *Thomas H. Hutchinson*, RKO Television (program producers); *William H. Weintraub* (advertising agencies); *Clifford Denton*, New York *Daily News* (newspapers); *Paul Larsen*, SMPE (theatres and motion pictures); and *William Morris* (talent).

Topics:
"Broadcast Television Licenses"
"Television and the Theatre"
"Program Production and Advertising Agencies"
"Television Receiver Manufacture"
"Television Transmitters."

7:30 P. M. Banquet. *"Seeing Our Neighbors." Large screen television demonstration with special telecast to ballroom.

Tuesday, December 12, 1944

9:30 A.M. *"What I See in Television"

10:30 A. M. Round-table discussions: *Dr. Alfred N. Goldsmith*, chairman. Experts who will handle question and answer session, will include *O. B. Hanson*, NBC; *Allen B. DuMont*, president of TBA; *Dr. C. F. Jolliffe*, RCA; *F. J. Bingley*, Philco; *J. E. Keister*, G.E.; *Harry Lubcke*, Don Lee; *Jack R. Poppele*, WOR; *A. H. Brolly*, Balaban and Katz; and *Klaus Landsberg*, Television Productions, Inc.

12:30 P. M. Luncheon session. *"The Motion Picture and Television."

3:30 P. M. to 8:00 P. M. Visits to N. Y. City television stations.

***Speakers to be announced.**

NEWS BRIEFS

2-WAY EQUIPMENT STILL ON PRIORITY, SAYS WPB

WPB has announced that there has been no relaxation of restrictions that would allow the sale of two-way equipment on unrated purchase orders. Certain manufacturers who have erroneously informed their customers that they could make deliveries on unrated orders have been asked to correct this impression.

Two-way emergency radio communication equipment is available only in limited quantities for essential use by police departments, public utilities, railroads and other essential industries when the equipment is vital to their operation, WPB said.

* * *

F. E. WALTERS GOES TO MECK INDUSTRIES

Fred E. Walters has been appointed plant manager of the John Meck Industries, Plymouth, Indiana. Mr. Walters was formerly with International Detrola Corporation as production manager.

* * *

ILLINOIS U. NAMES EVERITT E.E. DEPT. HEAD

Dr. W. L. Everitt has been named professor and head of the department of electrical engineering at the University of Illinois.

Dr. Everett will take up his duties at the University immediately on release from war service, in Washington.

Dr. Everitt succeeds Ellery B. Paine, whose retirement was announced recently.

* * *

A. J. HALL NOW U. M. C. RESEARCH ENGINEER

A. J. Hall has been appointed production and research engineer for the Universal Microphone Co., Inglewood, Cal.

He was formerly with the Kellogg Switchboard and Supply Co., Chicago, as engineer in charge of design, research and development laboratories.

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NBC AND COLUMBIA UNIVERSITY SPONSOR TELEVISION COURSE

The first television course to be recognized for credit toward a university degree was inaugurated recently by the University Extension of Columbia University in cooperation with the NBC University of the Air.

Forty persons are enrolled in this 15-week course, representing one-tenth of the total applications for admission.

Twenty guest experts in various fields of television are expected to address the class during the 15 weekly sessions.

* * *

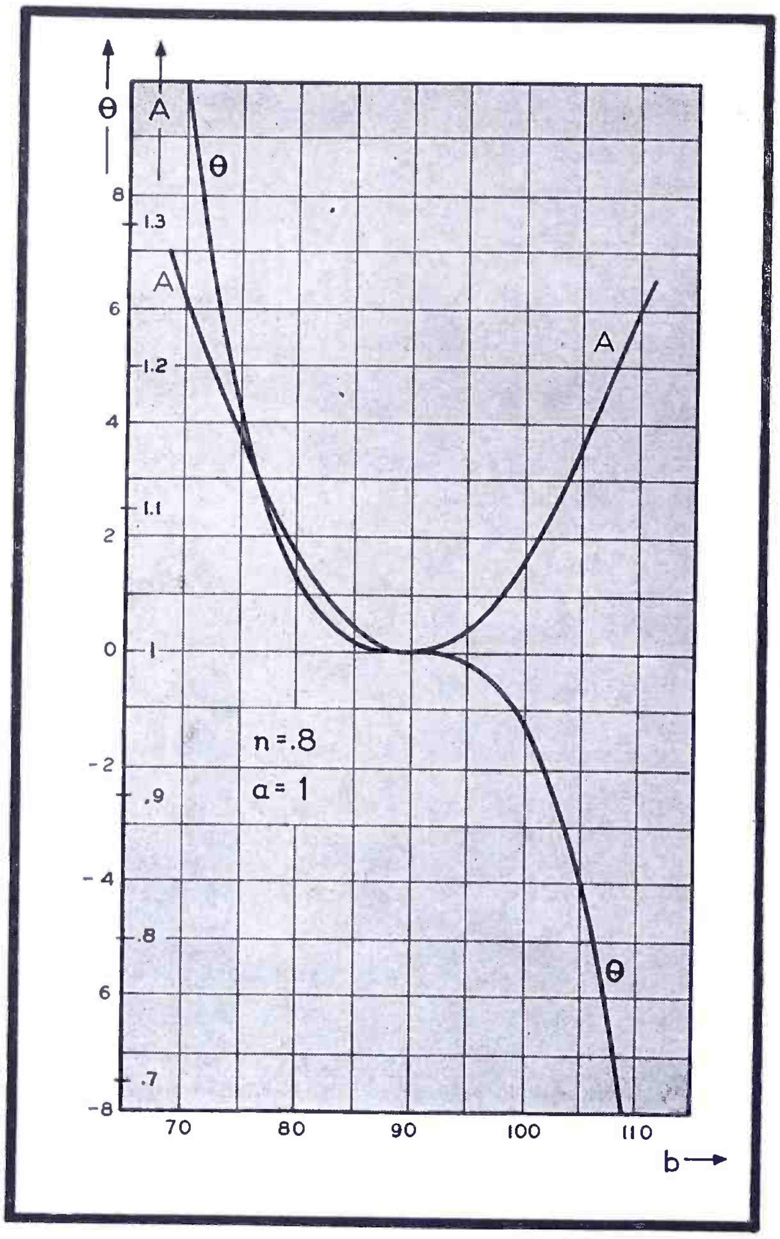
KOBAK BECOMES MBS PRESIDENT

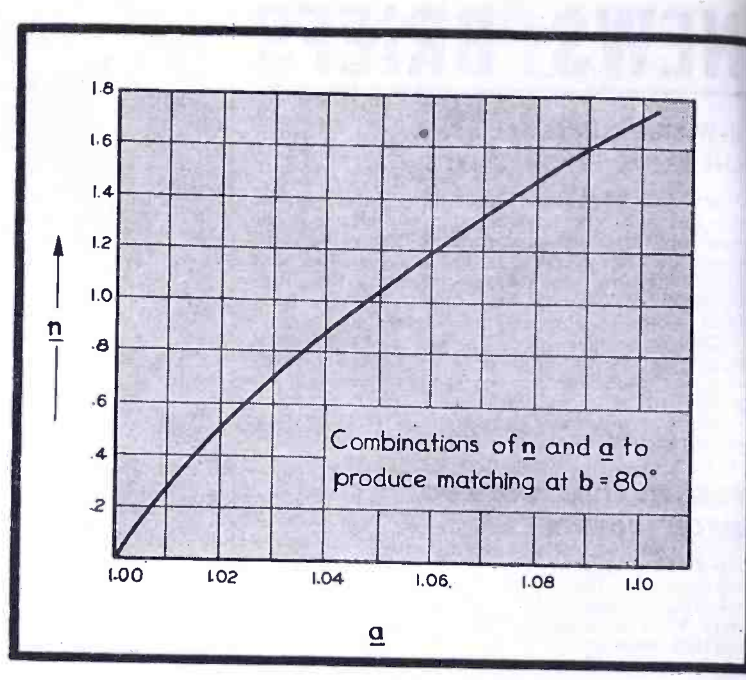
Edgar Kobak has been elected president of the Mutual Broadcasting System. He suc-

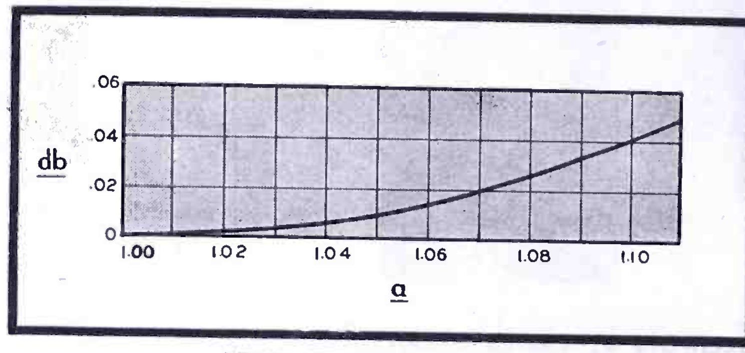
(*Continued on page* 89)

QUARTER-WAVELENGTH INSULATORS

(*Continued from page* 54)







Figures 5 (left), 6 (top, right) and 7 (above, right)
Figure 5, *A* and *θ* for a double-stub support with a = 1.0 and n = 0.8. Figure 6, relation of *n* and *a* to produce matching at b = 80° and 100°. Figure 7, loss at b = 90° as a function of *a*.

tain perfect matching. This is easily seen to be the following equation

$$\tan^2 b = a^2 \tan^2 b - n^2 - 2an \qquad (9)$$

or solved for *n*, it becomes

$$n = a \left[\sqrt{1 + \frac{a^2 - 1}{a^2} \tan^2 b} - 1 \right] \qquad (10)$$

Equation *10* thus gives combinations of values of *a* and *n* which will produce zero loss at given values of *b*. Using $b = 80°$ and $100°$ as points at which we wish to have zero loss a curve relating *n* to *a* is plotted in Figure 6. This gives pairs of values which may be used to obtain perfect matching at 80° and 100°. Again re-

(*Continued on page* 86)

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933, OF COMMUNICATIONS

Published monthly at New York, N. Y., for October 1, 1944.

State of New York }
County of New York } ss.:

Before me, a Notary Public, in and for the State and county aforesaid, personally appeared B. S. Davis, who, having been duly sworn according to law, deposes and says that he is the Business Manager of COMMUNICATIONS, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit: 1. That the names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, Bryan Davis Publishing Co., Inc., 19 East 47th Street, New York, N. Y.; Editor, Lewis Winner, New York, N. Y.; Managing Editor, None. Business Manager, B. S. Davis, Ghent, N. Y.; 2. That the owners are: Bryan Davis Publishing Co., Inc., 19 E. 47th St., New York 17, N. Y.; B. S. Davis, Ghent, N. Y.; J. C. Munn, Union City, Pa.; A. B. Goodenough, Port Chester, N. Y.; P. S. Weil, Great Neck, N. Y.; F. Walen, Union City, N. J.; G. Weil, Great Neck, N. Y.; L. Winner, New York, N. Y. 3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities, are: None. 4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock, and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) B. S. DAVIS, Business Manager.

Sworn to and subscribed before me, this 19th day of September, 1944.

(Seal) FRANKLIN B. GOOLD, Notary Public.
Commission expires March, 1946.

INSULATORS

(*Continued from page* 84)

ferring to equation *5* it is seen that at $b = 90°$

$$\frac{Z_s}{Z_0} = \frac{1}{a^2} \qquad (11)$$

which means, of course, that if a is not equal to unity there will be a mismatch at the midfrequency and a consequent loss. From equation *8* it is seen that at $b = 90°$ the angle of Z_s/Z_0 is zero. Thus by selecting appropriate values of a the loss at $b=90°$ can be set arbitrarily within certain practical limits. A curve relating the db loss at $b = 90°$ to values of a is presented in Figure 7. If it be required that the loss at the mid-frequency not exceed 0.005 db, a is seen to be about 1.035 and from Figure 6 the corresponding value of n is seen to be 0.8.

Before any calculations are made, then, one may expect an attenuation curve showing about 0.005 db loss at $b = 90°$, decreasing to zero at $b = 80°$ and 100° and then, as distance from the midfrequency increases, a loss which increases again to values above the allowable amount. The frequency range in this case over which the attenuation is equal to or less than 0.005 db will be wider than for the case where $a = 1.00$.

Curves for A and θ for the case of $a = 1.035$ and $n = 0.8$ are plotted in Figure 8. The attenuation curve is plotted in Figure 9. Figure 8 clearly indicates the effect of the change of a from 1.00 to 1.035. It is seen, from the attenuation curve, that 0.005 db is not exceeded until $b = 76°$ and 104° which represents an improvement in frequency range of about 40% over the case for $a = 1.00$ and $n = 0.8$.

The actual values which have been used above are selected arbitrarily and of course a similar elementary analysis can be carried out using other frequency ranges, values of allowable attenuation, and the corresponding values of a and n. In conclusion, a design of a double-stub support is offered, to operate about a midfrequency of $f_0 = 750$ megacycles. Let us assume $r_1 = 1.5$ cm., $a = 1.035$, $n = 0.8$ and $Z_0 = 77$ ohms. The wavelength is

$$\lambda = c/f_0 = \frac{3 \times 10^{10}}{750 \times 10^6} = 40 \text{ cm}$$

The length of the stubs then must be about 10 cm, preferably with adjustable plugs at the ends c and d for allowing adjustments. (See Figure 4). The distance between a and b

should also be 10 cm. The various radii are as follows:

$r_1 = 1.5$ cm, $r_2 = 0.416$, $r_3 = 0.302$, and $r_4 = 0.435$ cm

The frequencies between which the loss will be about 0.005 db or less will be given by $(f/f_0)90 = 76$ and 104. Thus $f = 634$ and 866 megacycles are the limits of the band.

In the design of this double-stub support it may be advantageous to place the stubs at right angles to each other in order to increase the rigidity of the structure.

Appendix: Calculation of Small Losses

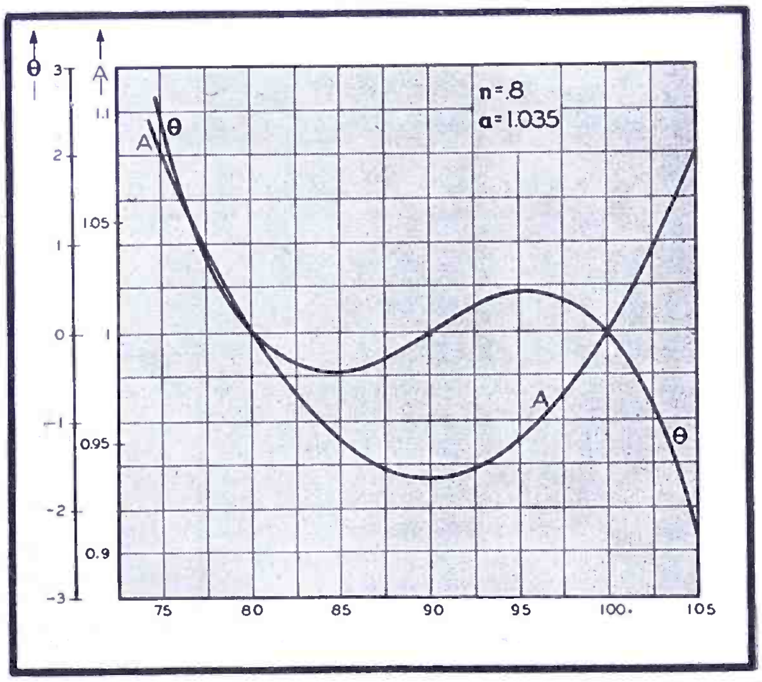
For the purpose of calculating losses which are the result of a very slight mismatch of impedances, the following development is presented. Let us assume a generator of unit emf, and an impedance $Z_0\underline{/0^\circ}$. This generator works into an impedance $Z_s\underline{/\theta^\circ}$ where Z_s differs very little from Z_0 and θ is small. The condition is as shown in Figure 10.

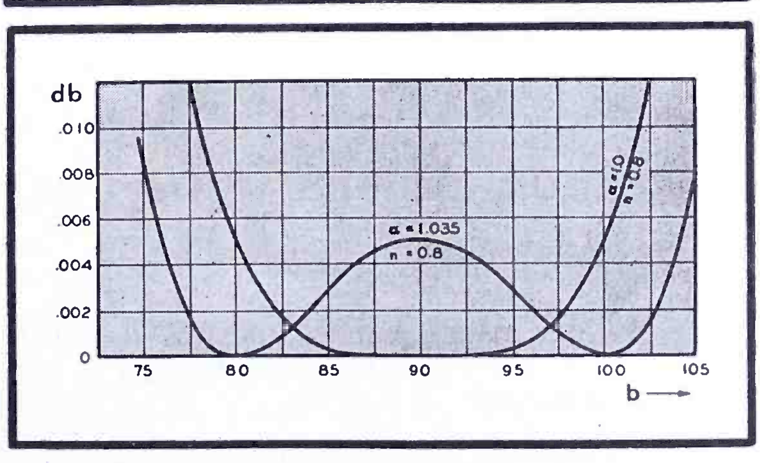
The power delivered in the case where $Z_s\underline{/\theta} = Z_0\underline{/0^\circ}$ is

$$P_1 = \frac{1}{4Z_0} \qquad \text{(a)}$$

The power in the mismatched case

(*Continued on page* 88)





Figures 8 (right) and 9 (right, below)
Figure 8, A and Θ for a double-stub support with a = 1.035 and n = 0.8. Figure 9, loss in a double-stub support for two cases: a = 1.0, n = 0.8, and a = 1.035, n = 0.8.

is determined below.

$$I = \frac{1}{Z_0 + Z_s\cos\theta + jZ_s\sin\theta} \qquad (b)$$

$$|I|^2 = \frac{1}{Z_0^2 + 2Z_0Z_s\cos\theta + Z_s^2} \qquad (c)$$

and the power is

$$P_2 = \frac{Z_s\cos\theta}{Z_0^2 + 2Z_0Z_s\cos\theta + Z_s^2} \qquad (d)$$

The ratio of powers is then

$$\frac{P_1}{P_2} = \frac{1}{4Z_0}\cdot\frac{Z_0^2 + Z_s^2 + 2Z_0Z_s\cos\theta}{Z_s\cos\theta} = \frac{\frac{Z_s}{Z_0} + \frac{Z_0}{Z_s} + 2\cos\theta}{4\cos\theta} \equiv \rho \qquad (e)$$

Now let $Z_s/Z_0 = 1 + a$, and $\cos\theta = 1 - (\theta^2/2)$. Substituting into equation *e*:

$$\rho = \frac{1 + a + \frac{1}{1+a} + (2 - \theta^2)}{4 - 2\theta^2} = \frac{4 + 4a + a^2 - \theta^2}{4 + 4a - 2\theta^2} \qquad (f)$$

neglecting terms in $\theta^2 a$. When equation *f* is divided out, the following approximate equation is obtained:

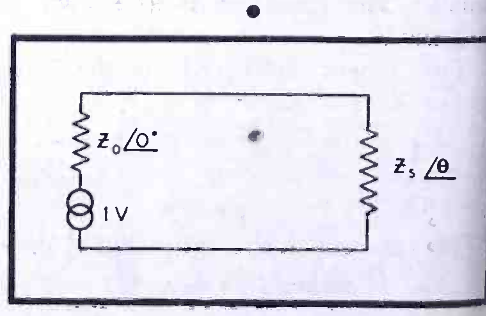
$$\rho \doteq 1 + \frac{a^2 + \theta^2}{4\frac{Z_s}{Z_0}} \qquad (g)$$

The db loss is given by $10\log\rho = (10\ln\rho)/2.3$

$$= \frac{10}{2.3}\ln\left(1 + \frac{a^2+\theta^2}{4\frac{Z_s}{Z_0}}\right) \doteq 1.085\,\frac{a^2+\theta^2}{\frac{Z_s}{Z_0}}\ \text{db} \qquad (h)$$

Equation *h* will give the db loss caused by any very slight mismatch. When the mismatch is considerable, however, it is necessary to use equation *e*.

Figure 10
Generator with mismatched impedances



NEWS BRIEFS

(*Continued from page* 83)

eds Miller McClintock, who retired.
Mr. Koback was formerly executive vice esident of the Blue network and before that ce president of NBC.

* * *

/. E. MACFARLANE, IBS EXECUTIVE, DEAD

/. E. Macfarlane, chairman of the executive mmittee of the Mutual Broadcasting System, ce president of WGN, and business manager the "Chicago Tribune," died recently.
Mr. Macfarlane was one of the founders of e Mutual Broadcasting System ten years ago. e was also the first president of the network, d served in that capacity for eight years.

* * *

. TRUMBULL BECOMES UNITED IRLINE RESIDENT REP.

ustin Trumbull, formerly superintendent of rcraft radio electrical equipment for United irlines at Chicago, has been named resident presentative of United at the Douglas Airaft Corporation in Santa Monica. He also is presenting Aeronautical Radio at Douglas.

* * *

ELT NOW FONDA PRESIDENT

ving M. Felt has been named president of the onda Corporation, New York, and Edgar llinger, Jr., was appointed executive viceesident. Both executives hold similar posts the Jefferson-Travis Radio Manufacturing orp. and Union Aircraft Products Corp.
Other officers appointed include Spencer C. nes, vice president; Justin C. Harris, treaser, and Frank Baron, secretary.

* * *

AINES CATALOG

catalog describing wire-wound resistors (ratgs, characteristics, bracket and terminal hematics), has been released by Haines Mfg. orp., 246 McKibbin Street, Brooklyn 6, N. Y.

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VESTINGHOUSE ACQUIRES AZELTINE LICENSE

Hazeltine license for home receiver manucture was obtained recently by the radio vision of the Westinghouse Electric and Manacturing Company.

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TROMBERG-CARLSON TO MAKE VIRE RECORDERS

he Stromberg-Carlson Company have signed contract with the Armour Research Foundaon to manufacture wire recorders.

* * *

DOLF GROSS LEAVES ERMINAL RADIO

dolph L. Gross has resigned as treasurer and ockholder of Terminal Radio Corporation, 85 ortlandt St., New York.
Mr. Gross has been with the government's ectronic Research Supply Agency at 460 ourth Avenue, New York, since May, 1943.

* * *

VHITE STAR AND "E" AWARDS

ntinel Radio Corporation, 2020 Ridge Avenue, vanston, Illinois, recently received the Armyavy "E" award.
A second white star has been added to the " flags of the National Union Radio Corporion, De Jur-Amsco Corporation, and the Rola mpany.
A fourth white star has been added to the " flag of the Hallicrafters Company.

* * *

RO PROCEDURE CHANGE

ovisions for securing priorities assistance in dio communication, broadcasting, commercial cording and public address systems for mainnance, repair and operating have been transrred from WPB Preference Rating Order 133 to Controlled Materials Plan Regulation and Direction 23 to CMP Regulation 5. multaneously Order P-133 was revoked.
In order to insure the adequacy of our forn communications, United States internanal point-to-point radio communication comnies may now secure special maintenance, pair and operating assistance under CMP gulation 5, Direction 23. International pointpoint communication companies are defined WPB as those owning stations licensed by e FCC to handle international communications, including code, voice and pictorial matter.

The special rule allowing international point-to-point radio communication carriers to use MRO preference rating AA-1 for rearranging and modifying their facilities, formerly in P-133, will be continued under CMP-5.

Under CMP Regulation 5, stations will be able to use their MRO rating for the purchase of new equipment such as amplifiers, turntables, microphones, etc., whether for replacement or as additional equipment, provided the total value of the new equipment for any one capital addition does not exceed $500. Another provision of the new ruling deletes the specific limit of spare tubes that can be kept on hand. Hereafter the total amount that may be spent for MRO under CMP-5 in any calendar quarter may not exceed one-fourth of the expenditures in the whole year 1942; except that if the present expenditures do not exceed $5,000 a year, the purchases do not have to be based on 1942 purchases. WPB pointed out, however, that if this limitation works any hardship on a station, an appeal for increased MRO quota may be filed under CMP-5.

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McGIFFIN NOW G-M OF LEWYT

Roy McGiffin has been appointed general manager of Lewyt Corporation, 136 Broadway, Brooklyn 11, N. Y.

* * *

RMA PLANS POSTWAR PARTS STANDARDIZATION

The RMA engineering department and parts divisions have prepared for extensive standardization of radio components for postwar civilian production.

The parts standardization work of the engineering department will be under the immediate jurisdiction of the receiver section. Dorman

(*Continued on page* 90)

NEWS BRIEFS

(*Continued from page 89*)

D. Israel is chairman of this section, and H. C Forbes is vice chairman. The latter will be th coordinator of parts standardization work of the receiver section and its various subcommittees.

The standards committees of the receive components section of the RMA engineerin department have been reorganized and now in clude: fixed capacitors, J. I. Cornell, chairman electrolytic capacitors, H. E. Rice, chairman mica capacitors, A. DiGiacomo, chairman paper capacitors, Louis Kahn, chairman; vari able air capacitors, Henry Sarkis, chairman ceramic dielectric capacitors, J. D. Heibel chairman; volume controls, H. W. Rubinstein chairman; fixed composition resistors, D. S. W Kelly, chairman; wire-wound resistors, Jess Marsden, chairman; plug-in resistors, Georg Mucher, chairman; sockets, S. Del Camp chairman; speakers, W. A. Ellmore, chairman high-frequency cores, no chairman as yet power transformers, Arni Helgason, chairman high-frequency circuit switches, Henry Richte chairman; interruptors and rectifiers, H. M Dressel, chairman; r-f and i-f transformers Monte Cohen, chairman; dry batteries, L. M Temple, chairman; and relay racks, P. K McElroy, chairman.

* * *

NEW CANADIAN DISTRIBUTOR FOR DU MONT

Cyclograph Services, Ltd., 12 Jordon Street Toronto, Ontario, has been appointed distribu tor for Du Mont cathode-ray tubes, oscillo graphs and cyclographs in Canada. The Can adian appointee will function not only as a sale and field engineering organization, but also i the maintenance and repairs of Du Mont equip ment in the Dominion, succeeding Burlec, Ltd

* * *

IRC NAMES BAGGS MERCHANDISING MANAGER

Robert N. Baggs has been appointed manage of the merchandising division of Internationa Resistance Company.

Mr. Baggs was formerly advertising an sales promotion manager of the tube divisio of the Radio Corporation of America.

* * *

FOLSOM HONORED BY NAVY

The Distinguished Civilian Service Award wa recently awarded to Frank M. Folsom, forme chief of the Procurement Branch, Office of Pro curement and Material in the Navy, for excep tional performance in that capacity from Feb ruary, 1942, to December, 1943. Mr. Folsom i now a director and vice president of the Radi Corporation of America, in charge of the RC Victor Division.

* * *

HUDSON AMERICAN CRYSTAL BULLETIN

A six-page illustrated brochure, "Frequenc Etch," has been released by Hudson America Corporation, 25 West 43rd Street, New Yorl

Included in the bulletin are specific hints o etching as well as a series of graphs showin the relation between etching time and the in crease in frequency of BT crystals.

The method used by one of the major cryst manufacturers in bulk etching crystals to fre quency is also described.

* * *

EVERITT ELECTED IRE PRESIDENT

Dr. William L. Everitt has been elected presi dent of the Institute of Radio Engineers fo the coming year. Dr. Everitt, who is chief o the Operational Research Branch, Office of th Chief Signal Officer of the United States Army succeeds Professor Hubert M. Turner of th Department of Electrical Engineering at Yal University, New Haven.

Dr. Hendrik J. Van der Bijl of Johannesburg Union of South Africa, was elected vice presi dent. Dr. Van der Bijl, fellow of the Institut since 1928, is chairman of the Electricity Supply Commission, the S. A. Iron and Steel Industrial Corporation, Ltd., and the Industrial Development Corporation of S. A., Ltd.; chairman and managing director of African Metals Corporation, Ltd.; director of the S. A. Board Barclays Bank; director general of War Supplies, and chancellor of the University of Pretoria, all of Johannesburg, Union of South Africa.

* * *

CLARK CUTTING TOOL CATALOG

A 12-page adjustable cutting tool catalog has been released by Robert H. Clark Company, 9330 Santa Monica Blvd., Beverly Hills, California.

Featured are data on grinding fixtures, hole cutters, counterbores, tool holders, fly cutters, and boring bars.

* * *

RAYTHEON ON NATIONAL NETWORK

The Raytheon Manufacturing Company is now broadcasting weekly over a coast-to-coast hookup on the Blue network. The famous All-Navy program, "Meet Your Navy," is being featured.

Broadcasts are made from the huge Great Lakes Naval Training Center at Great Lakes, Illinois.

* * *

CARTER MOTORS APPOINTS EXPORT AGENTS

Williams & Associates, 540 N. Michigan Blvd., Chicago, have been appointed Carter Motor export agents in Mexico, Central and South America, and the continent of Africa by Robert W. Carter, managing director of Carter Motor Company, 1608 Milwaukee Avenue, Chicago.

Frazar & Hansen, 301 Clay Street, San Francisco, California, will act as Carter Motor export agents for China, Phillipines, and the Far East including Australia, New Zealand and India.

* * *

SHAW BECOMES TAYLOR TUBE CHIEF INSPECTOR

William Shaw, formerly engineer for G. E. X-Ray Company, has been appointed chief inspector of Taylor Tubes, Inc., 2312 Wabansia Avenue, Chicago.

* * *

RADIO CLUB HEARS RAGAZZINI AND SHANK

A paper, on "Fluctuation Noise as a Factor in Receiver Input Circuit Design," was delivered by Dr. John R. Ragazzini, assistant professor in electrical engineering, Columbia University, before the Radio Club of America at Havemeyer Hall, Columbia University.

A discussion of the origin of fluctuation voltages in circuit elements served as the basis for the paper.

Eugene R. Shank, research engineer of the RCA Laboratories, presented a paper on "Controlled and Uncontrolled Multivibrators" at another RC of A meeting at Columbia University.

In the course of the paper an equation relating the natural frequency of the multivibrator to the characteristics of the tubes and circuit components was developed on the basis of simple capacitor-resistor time constants. Information about the natural frequency stability was also given. The synchronizing of the multivibrators was also considered in some detail.

* * *

UNIVERSAL MICROPHONE 16 YEARS OLD

Universal Microphone Co., Inglewood, Cal., observed its 16th birthday in October.

* * *

TEN NATIONAL REPS FOR HAINES

Ten national sales representatives have been appointed by Haines Manufacturing Corp., 248 McKibbin Street, Brooklyn, New York.

The representatives are: R. A. Adams, Detroit 21, Michigan; Hal F. Corry, Dallas, Texas; Jack Heimann, Minneapolis, Minn.; Royal Higgins, Chicago 5, Ill.; Russ Hines, San Francisco, Calif.; J. P. Kay, Kansas City 6, Mo.; Bert Knight, Los Angeles 15, Calif.; John O. Olsen, Cleveland, Ohio; Perry Saftler, New York 7, N. Y.; and Henry P. Segel, Boston 16, Mass.

* * *

CANNON SOLENOID BULLETIN

A 32-page bulletin on d-c solenoids has just been issued by Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, California. Appearing are photographs of direct current solenoids, together with tabu-

(Continued on page 92)

NEWS BRIEFS

(*Continued from page* 91)

lar data, dimensional drawings, wiring diagrams and response characteristic charts.

* * *

BURLEC APPOINTS COMMANDER MILLARD CHIEF ENGINEER

Commander John R. Millard, RCNVR, has been appointed vice president and chief engineer of Burlec, Limited, Toronto 13, Canada.

For the past year Commander Millard has been serving at Naval Service HQ as director of technical research.

* * *

BOSTON FIRE DEPARTMENT USING 2-WAY RADIO

The Fire Department of Boston, Massachusetts, is now using an f-m two-way system, installed by Galvin. Call letters are WEY, operating on a frequency of 37.74 mc.

Thirty-three mobile fire department units, including three fireboats, and the cars of the district and deputy fire chiefs, are equipped with two-way transmitters and receivers.

The central control station antenna is mounted 420 feet above sea level.

* * *

HUBBELL NOW WITH CROSLEY

Richard W. Hubbell has been appointed broadcasting production manager for the Crosley Corporation.

Hubbell is the author of "4,000 Years of Television," and was formerly with WQXR and CBS.

* * *

GUARDIAN RELAY AND SOLENOID FOLDER

A four-page illustrated bulletin offering data on eight relays and eight solenoids has been published by Guardian Electric Mfg. Company, 1623 West Walnut Street, Chicago 12, Illinois. Relay charts show standard voltages, maximum contact capacity, coil resistance, and operating current. Solenoid charts give resistance and operating current at standard voltages and show stroke and lifting capacity of small solenoids.

* * *

AMP CATALOG

A 20-page catalog, 33, describing the design possibilities in solderless wiring systems has been released by Aircraft-Marine Products Inc., 1591 F North Fourth Street, Harrisburg, Penna.

Featured are data and illustrations on connector blocks, multiple connectors, connector strips, bus bars, terminals, etc.

* * *

ELECTRO-VOICE BOOKLET

A six-page booklet covering communications microphones has been issued by the Electro-Voice Corporation, 1239 South Bend Avenue, South Bend 24, Indiana.

Appearing in the booklet are data on the lip-type 245, or differential microphone; the hand-held 205-S, the noise-cancelling microphone; and the dynamic 600-D.

* * *

FTR BULLETINS

Twelve new bulletins on transmitters, coaxial cables, r-f heating units, selectors, and general products, have been released by the Federal Telephone and Radio Corporation. Transmitter bulletins cover 5-kw broadcast, 20-kw h-f, multi-unit and marine units. Coaxial bulletins describe high frequency solid dielectric cables. The megatherm is described in the r-f heating bulletins. Application data also appear in these bulletins.

* * *

C-D FIBRE COMPANY CATALOG

A 12-page catalog, GF-51, with design and application data on dilecto, dilectene, celeron, micabond, vulcoid and vulcanized fibre, has been released by the Continental Diamond Fibre Company, Newark 51, Delaware.

* * *

CRYSTAL PRODUCTS CATALOG

A 32-page illustrated catalog of quartz crystal units has been released by Crystal Products Company, Kansas City, Missouri. The catalog is indexed to include all fields: broadcasting, filter, test, amateur, aircraft, police-marine, multiple crystal units and blanks. Various types of crystals for each of these services are described and illustrated with cross-sectional photos and drawings.

* * *

WESTINGHOUSE NAMES LOHR MARKET DEVELOPMENT HEAD

A. W. Lohr has been appointed acting manager of the market development department at Westinghouse, in East Pittsburgh, during the absence of Donald C. Hooper, who is now in the U. S. Navy.

* * *

BUTTERFLY CIRCUIT DATA IN G.R. BULLETIN

An analysis of the high-frequency butterfly circuit, by Edward Karplus, appears in the October issue of the General Radio Experimenter.

* * *

HARCO ANTENNA CATALOG

An assortment of masts and towers are described in a 24-page catalog released by the Harco Streel Construction Co., Inc., Elizabeth, N. J. Detailed and illustrated are tubular masts, portable tubular masts, straight triangular towers, tapered triangular towers, straight square towers, tapered square towers, mobile masts and towers, and special types.

* * *

ONAN GENERATING PLANT FOLDER

A folder describing a-c and d-c generating units for high and low powers has been released by D. W. Onan & Sons, 39-51 Royalston Avenue, Minneapolis, Minn.

* * *

STERNKOPF NOW WITH UNIVERSAL COIL

B. J. Sternkopf, formerly of Sperry Gyroscope, has joined Universal Coil Manufacturing Company, 1138 Broadway, Brooklyn, as sales manager. Martin L. Green is owner and chief engineer of the company, which was formerly known as Universal Sound Laboratories.

* * *

BENDIX OPENS R.R. RADIO ENG.-SALES-SERVICE UNIT

An engineering, sales and service organization to coordinate expanding activities in railroad radio has been established by the Bendix Radio Division of Bendix Aviation Corporation.

R. B. Edwards has been named engineering coordinator for the group, which will be under the general direction of W. L. Webb and John W. Hammond, chief engineer and sales manager, respectively.

* * *

FINN AND COCKE BECOME RCA REGIONAL MANAGERS

David J. Finn will manage RCA product distribution in the Chicago region. James W Cocke has been named manager of RCA product distribution in the Dallas, Atlanta region.

Mr. Finn was formerly sales manager for the RCA industrial and sound department.

Mr. Cocke has directed sales activities for RCA in Dallas and Atlanta for many years.

* * *

COUGHLIN NOW P-A FOR UNITED ELECTRONICS

Peter J. Coughlin has been named purchasing agent at United Electronics Company, Newark 2, N. J.

Mr. Coughlin was formerly with Titeflex.

* * *

SYLVANIA SPECIAL ELECTRONIC PRODUCTS BULLETIN

Nine types of electronic tubes for specialized applications are described in a 24-page bulletin, 202, published by Sylvania Electric Products, Inc., Special Products Division, 60 Boston Street, Salem, Mass.

Products described include strobotrons for the study of reciprocating and rotating motion; Pirani and thermocouple tubes for measuring vacuum; voltage regulator tubes; facsimile tubes; germicidal tubes; black light and near ultraviolet lamps. Technical sections of the bulletin give specifications, basic circuit diagrams and suggested applications for products and accessories.

THE INDUSTRY OFFERS . . . —

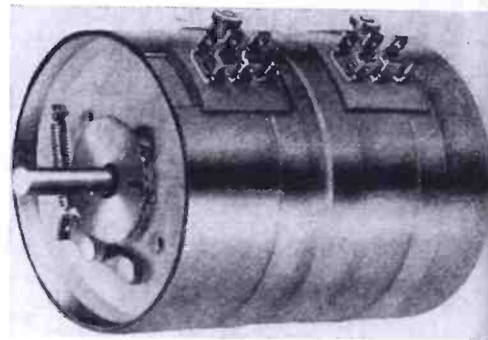
DAVEN DUAL-UNIT ATTENUATOR

Improved model dual-unit attenuators have been developed by the Daven Company, 191 Central Avenue, Newark, New Jersey.

The dual-unit construction is featured in balanced H attenuators, as well as in special multi-circuit controls of the potentiometer, T, ladder, L, and rheostat types.

The new model has fungus and mildew-resisting varnish on all bakelite parts and resistive windings; contact and switch blades are of tarnish resistant, silver alloy. Other features are: separable coupling; new detent device with gear and roller mounted in recessed front end of front unit, separate from resistive network; and extrusion of detent gear and steel attenuator cover for stop to rotation.

Rear of panel depth, 3⅞".



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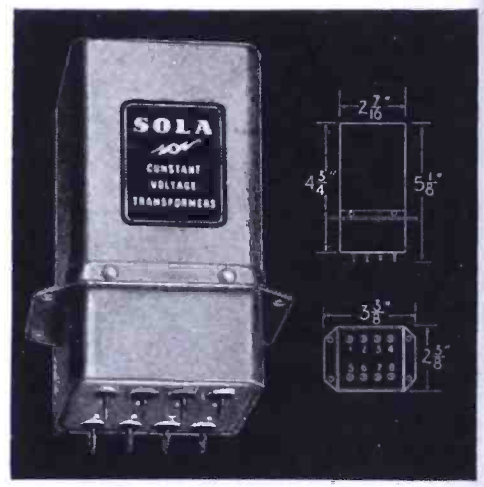
HERMETICALLY SEALED SOLA TRANSFORMERS

Hermetically-sealed constant voltage transformers for through-chassis mounting, and for such applications as heating and refrigeration controls, television and f-m receivers, vacuum tube voltmeters, electronic gauging and inspection equipment, photometric instruments, etc., have been announced by Sola Electric Company, 2525 Clybourn Avenue, Chicago 14, Illinois.



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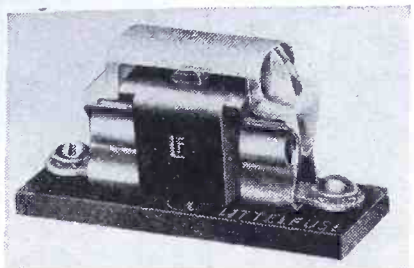
LITTELFUSE BREAKERETTES

Push-breaker type circuit breakers, Breakerette 1561, rated at 32 volts a-c or d-c, interchangeable with all 5 A G fuses, or Navy midget size are being produced by Littelfuse Incorporated, 200 Ong St., El Monte, California; 4757 Ravenswood Ave., Chicago 40, Illinois. Break is snap action capable of interrupting short circuits of 1,000 amperes in ratings up to 5 amperes and 2,500 amperes in ratings over 5 amperes capacity. Time characteristics of the fuses are duplicated electrically. Provided with 5 A G caps to fit into standard 5 A G fuse clips.

In operation, when the bi-metal releases the push-button on which it acts directly, a double break of the circuit is effected. The actual breaking distance is 1/16". To reset, the button is merely pushed into its bottom position with respect to the case. Both trip-free and non-trip free features are provided.

Trip-free shield is thermoplastic to permit visual indication when breaker is tripped. Extreme dimensions 1⅞" long x ¾" wide; overall height with trip-free shield is 1¼". Weight, 15 grams without hood, 18 grams with hood. It fits into clips on ⅞" spacing or more.

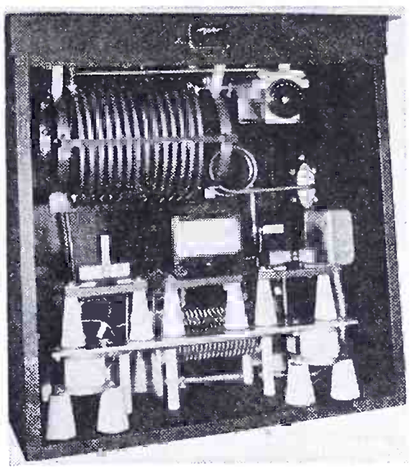


* * *

ANDREW ANTENNA-TUNING UNIT

For coupling a vertical tower antenna to a coaxial transmission line, Andrew Co., 363 E. 75th Street, Chicago 19, have produced an antenna tuning unit, type 48. An L network is used. Elements are variable.

Features are: built-in isolation filter, to permit connecting coaxial transmission line to u-h-f antenna on top of tower. This permits operation of an h-f "talk-back" antenna on top of a low frequency tower. A standard broadcast station would use this feature to connect a coaxial transmission line to a phase sampling loop, or to an f-m antenna; built-in tower lighting filter, to facilitate feeding aircraft warning lights on top of tower; and plug-in meter positions, to facilitate temporary metering in all branches of the circuit during adjustment.



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FTR AUTOMATIC SELECTORS

A high-speed, multi-contact automatic selector, FTR 800, is now being manufactured by Federal Telephone and Radio Corporation, Newark, N. J.

The rotor assembly is operated by a stepping mechanism which responds to impulses of current. After each impulse, a reed suspended pawl engages a ratchet, moving the wipers one step forward over the bank contacts. By this method, connections are made from circuits (connected to wipers) to other circuits (connected to the bank assembly).

The stepping mechanism may be controlled manually by a dial or other means. Automatic control for the stepping magnet may be provided by interrupter springs, electronic circuits or relay circuits.

The wipers on the rotor may be of either of two types: double-ended or single-ended. According to the type of wiper used, this selector can be arranged to have a capacity of from one to three 2-row levels of 22 points each or from one to six single-row levels of 11 points each.

In the case of the double-ended type wiper, one end wipes over a row of 11 contacts during the first half revolution of the rotor and the other end wipes over the same row of contacts during the second half revolution. A single-ended wiper consists of two electrically connected, single-ended units mounted 180 degrees apart and axially staggered. Two rows of bank contacts are wiped over alternately during each revolution by the two staggered ends and are thus equivalent, electrically, to a single row of 22 contacts.

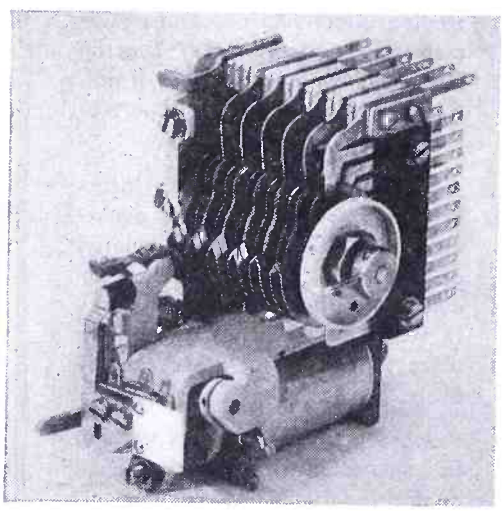
The wipers can be either bridging or non-bridging. The non-bridging wiper passes from one contact to the next without short circuiting the adjacent contacts. A bridging wiper connects with one contact before disconnecting from the adjacent contact. When the step is completed, the wiper is connected to one contact only.

When required, the selector can be arranged

(Continued on page 96)

for homing, that is, the rotor will return automatically to normal position.

Selector is 2½" x 3¼" x 3½". Said to have an operating life of 4,000,000 revolutions at operating speeds up to 60 steps per second.



* * *

GREEN MULTI-RECTIFIERS

Multi-rectifiers with six selenium rectifier sections which may be interconnected by external links to provide four ranges of d-c were recently developed by Green Electric Laboratories, 130 Cedar Street, New York 6, N. Y.

The rectifiers provide: 0-8 volts, maximum capacity 100 amperes; 0-16 volts, maximum capacity 50 amperes; 0-24 volts, maximum capacity 35 amperes; and 0-48 volts, maximum capacity, 18 amperes.

A built-in voltmeter and ammeter indicate d-c output voltage and current. Red line calibrations indicate the maximum current limitation on each range.

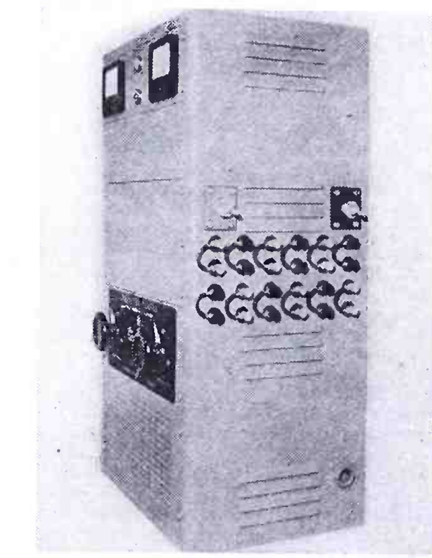
On each side of the rectifier cabinet are wing nut terminals for convenience in connecting loads.

Additional features include a three-phase magnetic contactor in the main power supply

THE INDUSTRY OFFERS . . . —

(*Continued from page 95*)

circuit with on-off push buttons, pilot lamp, monitor lamp, buzzer (overload warning), and an automatic watchman which provides automatic current interruption in case of prolonged overload.



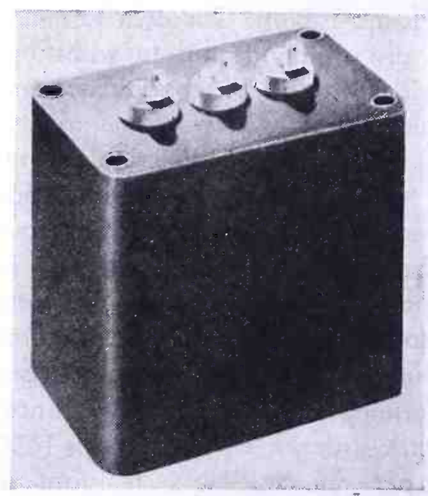
* * *

UTC INTERSTAGE FILTERS

Two interstage filters, types BPI and BPL, for 200 to 10,000 cycles, have been developed by United Transformer Co., 150 Varick Street, New York 13, N. Y. These filters are sharply peaked, having approximately a 2 db attenuation of frequencies plus or minus 3% from the mean frequency, and attenuations of approximately 40 db per octave. They are adjusted to zero phase shift at the mean frequency.

The BPI type has a primary impedance of 10,000 ohms; for operation from the plate of a triode tube to a succeeding grid. Gain is approximately 2 to 1. Type BPL filters are designed to operate from a line impedance of either 500 or 600 ohms to the grid of a tube. The gain is about 9 to 1.

Hermetically sealed case of BPI type, 1½ x 2½ x 2½.

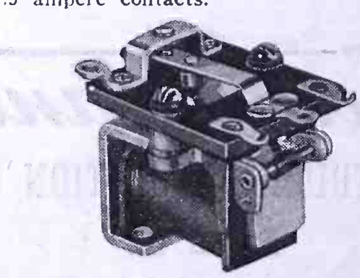


* * *

GUARDIAN MIDGET RELAY

A 1.2-ounce, single-pole single-throw midget relay has been produced by Guardian Electric Manufacturing Company, 1623 West Walnut Street, Chicago 12, Illinois. Measures 1 9/32" x 1 5/32" x 29/32".

Operates on d-c only, and is said to have a switch capacity of double pole, double throw with 1.5 ampere contacts.



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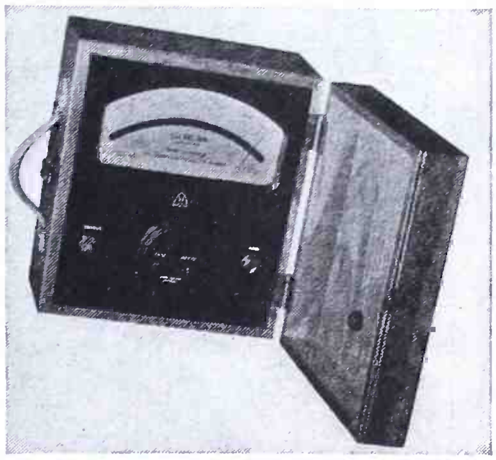
RAWSON ELECTROSTATIC VOLTMETER

Electrostatic voltmeters, type 518, for the measurement of a-c or d-c high voltages have been developed by Rawson Electrical Instrument Co., 113 Potter Street, Cambridge 42, Mass. Exact rms readings on a-c are said to be available with no errors due to frequency or waveform.

For d-c measurements there is said to be no appreciable current drain, as the resistance is guaranteed to be higher than one million megohms.

For a-c measurements the input capacitance is around 10 micromicrofarads, drawing negligible current at low frequencies.

Meters are offered in ranges of 1, 2, 3, 5, 10, and 20 kilovolts full scale; accuracy 1%.



* * *

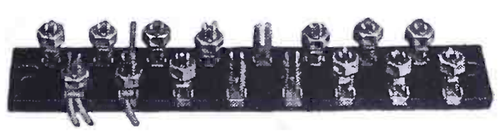
BEE TERMINAL BLOCKS

Solderless, wire-to-wire Bee terminal blocks with slotted-channel binding-post studs, are being produced by L. S. Brach Manufacturing Corporation, Newark 4, N. J. One type, series A-200, has terminal posts staggered in V formations. In another type, series A-300, terminals are set straight in line.

Wires are held in channel between a top clamp or shoe built into the nut, and a lower clamp or shoe which is secured to the base.

Manufacturer claims that average contact resistance of terminal block equals .00031 ohm after 90 hours salt spray.

Block is said to be coated with a hard, moisture-proof, arc-resistant film which contains a fungicidal substance. Base is made of laminated phenolic. Blocks are made under license from the Buchanan Research Laboratories, Inc.



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ROWE MILLISECOND METER

An elapsed milliseconds meter, type MM100, that measures, electronically, small periods of elapsed time directly in milliseconds on a linear scale meter, has been developed by Rowe Radio Research Laboratory Co., 2422 North Pulaski Road, Chicago. The start and finish of the period to be measured is made to initiate and terminate operation of the unit by various mechanical, electrical or photoelectronic means. Start of the period causes the meter to rise and termination stops the meter, at which position it remains for taking the reading.

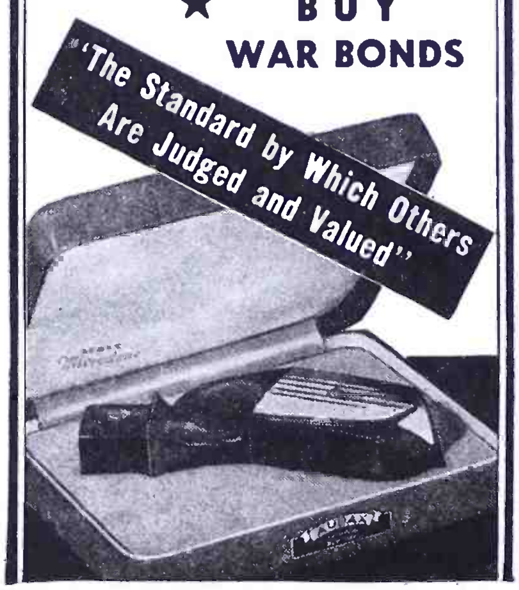
Range is 100 milliseconds. Other ranges can be had covering both higher and lower elapsed periods.

* * *

N. A. PHILIPS SPECTROMETER

A Geiger-counter x-ray spectrometer has been announced by North American Philips Co., Inc., 100 East 42 Street, N. Y. City.

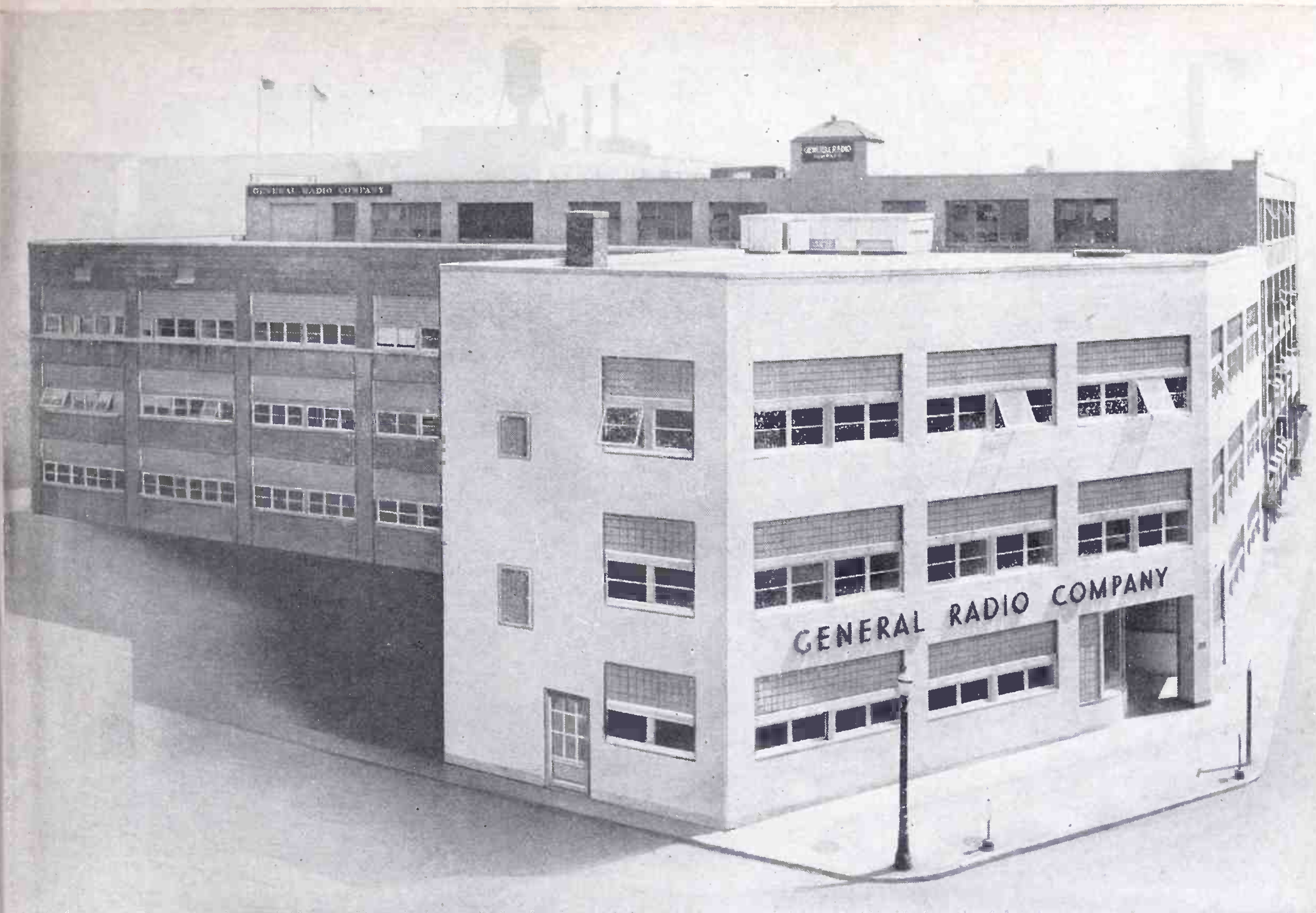
The spectrometer utilizes a Geiger-Muller tube to measure the intensity and position of interference lines which are encountered in x-ray diffraction analysis work.



ADVERTISERS IN THIS ISSUE

COMMUNICATIONS—NOVEMBER, 1944*

*Due to paper restrictions several advertising pages had to be omitted from this issue.



JUST AROUND THE CORNER

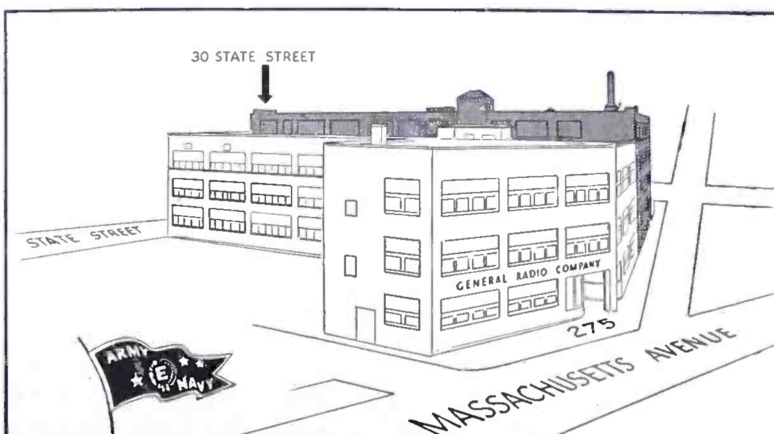
● LATELY, persons corresponding with us have noted a new address . . . 275 Massachusetts Avenue. We've moved our engineering and general business offices into a remodeled building at this location. It's just around the corner from 30 State Street, which is still ours, and which is now devoted exclusively to manufacturing.

For a long time we have felt the need for rearranging our space; for one thing we have been badly cramped in the shop; and our engineering department has been spread over several floors and mixed up with many other activities.

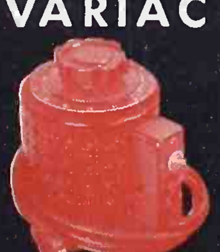
The new building, which is connected by ramps on all floors with the older one, provides about 30 per cent more manufacturing space, and allows all of the engineering department to be on one floor.

Under pressure of the war we have expanded our output in several ways. We have let out the manufacture of several instruments to sub-contractors; we have turned over the designs, drawings and models of several instruments to other manufacturers for their exclusive use; we have rented considerable extra space in two outside buildings, in one of which we have contracted for a large number of war-time workers under our own foremen.

After the war when the armed guards have left us, we hope that you will come to see our new laboratories and offices. In the meantime we continue to devote our energies to filling war orders for electronic laboratory test equipment.



VARIAC



MADE ONLY BY

GENERAL RADIO COMPANY

Cambridge 39, Mass.
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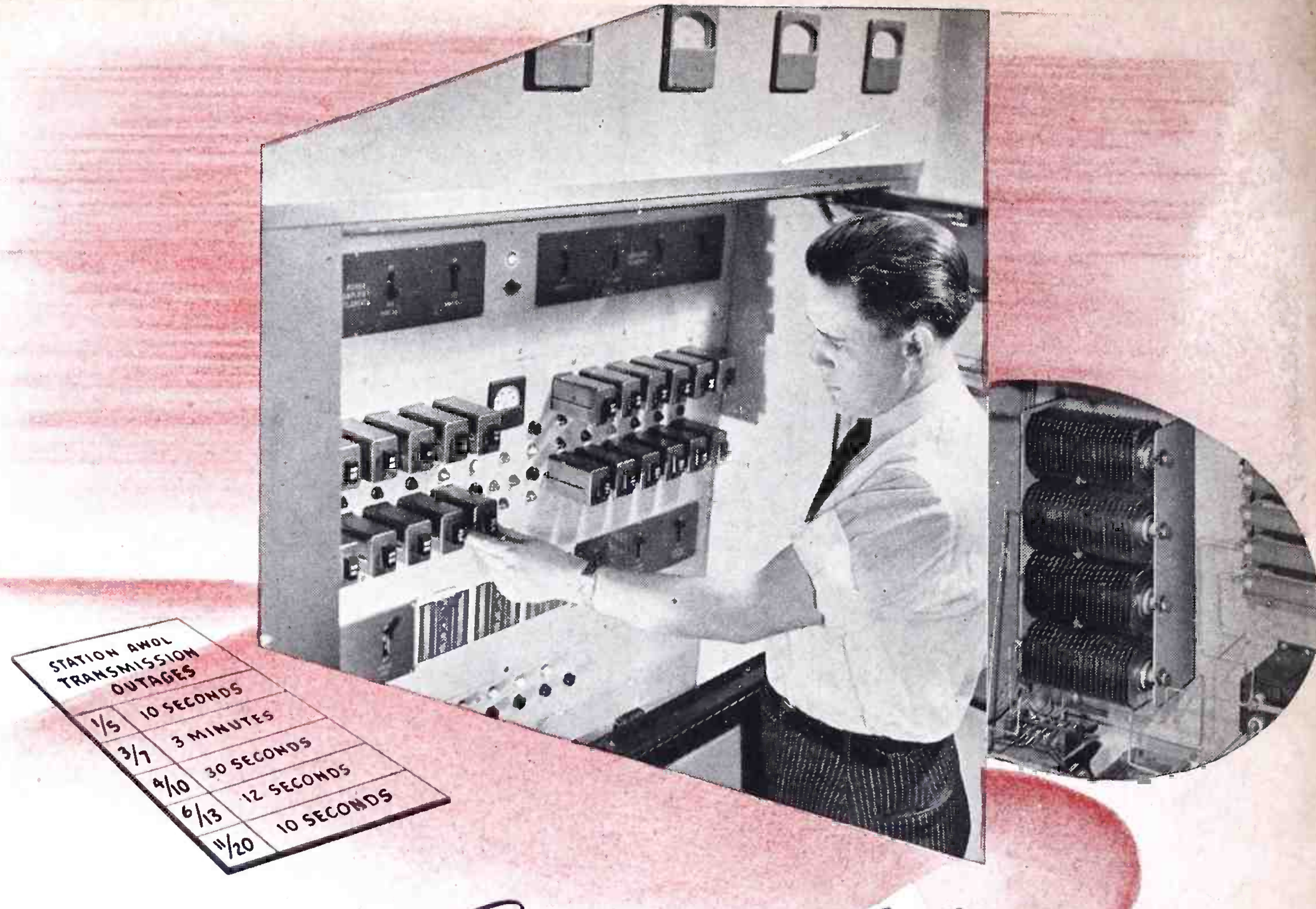

CONSIDER *Continuity of Operation* WHEN YOU SELECT A NEW TRANSMITTER

Off the air, right in the middle of a program—that's the nightmare of operating a radio station. That's when seconds seem like hours, and minutes like eternities. As though you didn't know!

Westinghouse Transmitters have been designed to cut program outage down to an almost unbelievable point. For example:

1. *Indicator Lights* show at a glance which circuit suffered an overload—even though the transmitter has returned to the air . . . making circuit checkup easy.
2. *Conservative Operation of All Tubes*—greatly increases reliability . . . lengthens tube life.
3. *Air-Cooled Tubes*—eliminate complicated and unreliable water cooling equipment.
4. *Surgeproof Metal Rectifiers* eliminate low voltage rectifier failures.
5. *Tube Life Meter* indicates the end of reliable tube life.
6. *Circuit Breakers* supply full overload and undervoltage protection automatically reducing length of outage.

We'll gladly give you complete information on these features, as well as other important advantages of Westinghouse Transmitters, such as: ***Low Operating Cost, Simplicity of Control, High Fidelity Signals, Ease of Maintenance.***

PLACE YOUR ORDER NOW FOR YOUR POSTWAR TRANSMITTER

By placing your order today for a Westinghouse Transmitter, you assure yourself of the fastest possible delivery following the lifting of wartime manufacturing restrictions. We are scheduling deliveries in the sequence in which orders are received. For details, write Westinghouse Electric & Mfg. Company, Dept. 1NB, P. O. Box 868, Pittsburgh 30, Pa.

J-08079

Westinghouse RADIO DIVISION

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

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