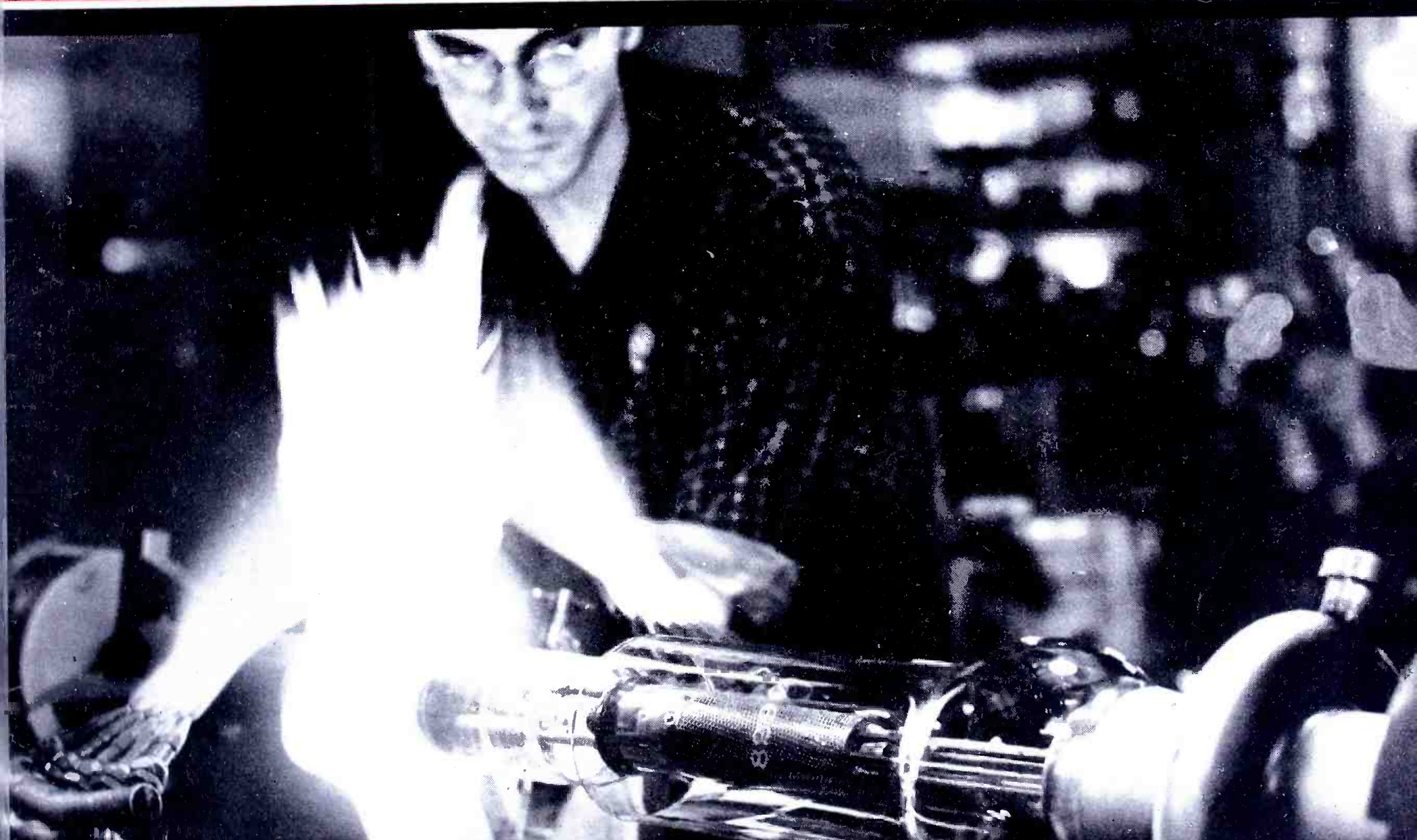
COMMUNICATIONS



DECEMBER

★ RADIO ENGINEERING
★ S-T 330-MC F-M LINKS
★ INTERPOLATION OSCILLATOR
★ TELEVISION COVERAGE SURVEY
★ IMPEDANCE SOLUTIONS ON SLIDE RULE
★ AIRCRAFT COMMUNICATIONS

1943

"We vibrate, 'em, too, Miss Gadfly . . . . ."

Miss "Tiny" Gadfly, impelled and inspired by the vision of a svelte, girlish figure, oscillates in phase with the vibrations of "Little Gem." With like determination, but with a different scientific purpose, Hytron tubes are also vibrated vigorously.

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Tubes which pass this standard Hytron factory test are not likely to fail. When subjected to the ruthless throbbing of machines of war by fighting men too intent on a battle for survival to baby them, these tubes "get the message through."

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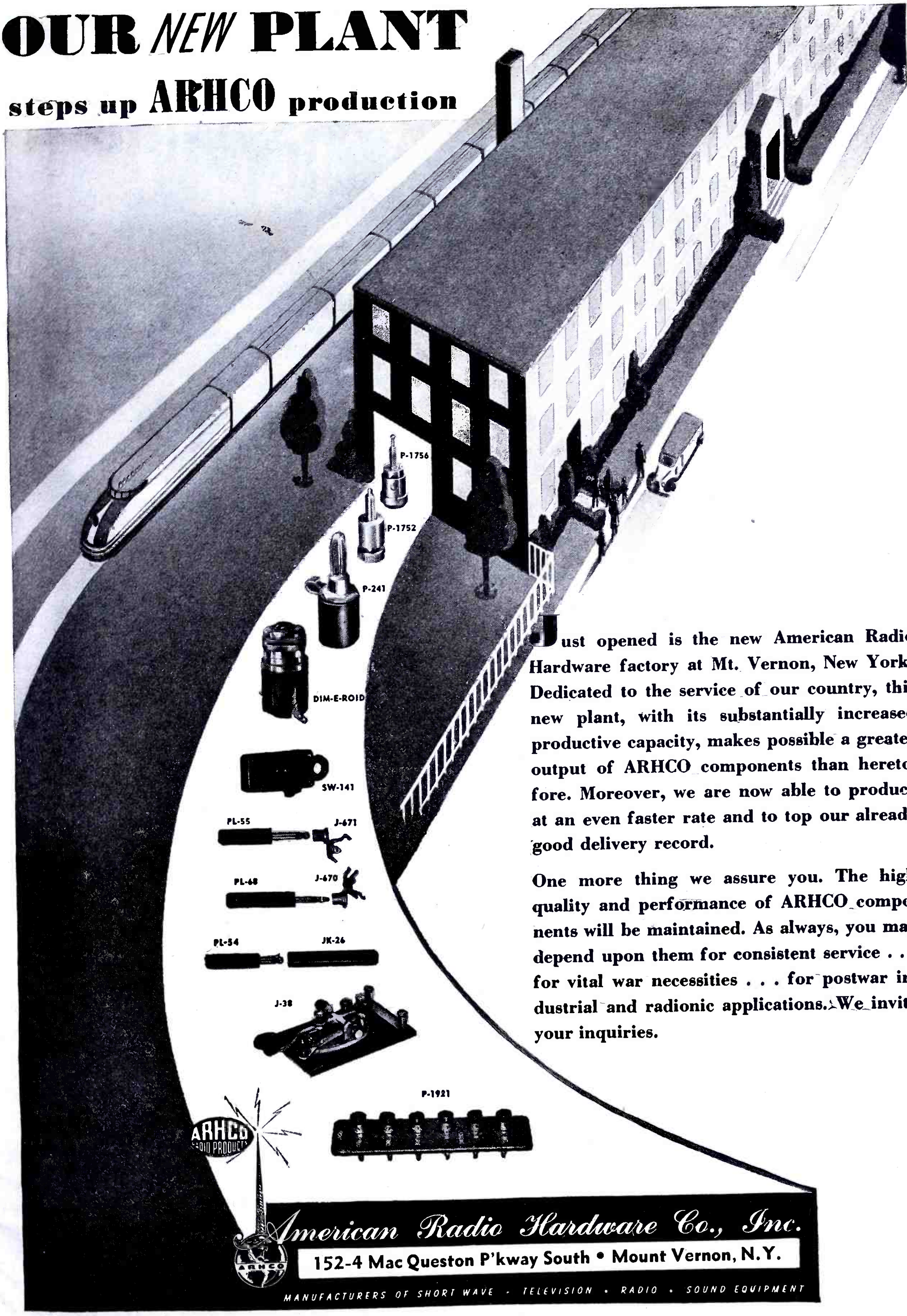

Just opened is the new American Radio Hardware factory at Mt. Vernon, New York. Dedicated to the service of our country, this new plant, with its substantially increased productive capacity, makes possible a greater output of ARHCO components than heretofore. Moreover, we are now able to produce at an even faster rate and to top our already good delivery record.

One more thing we assure you. The high quality and performance of ARHCO components will be maintained. As always, you may depend upon them for consistent service . . . for vital war necessities . . . for postwar industrial and radionic applications. We invite your inquiries.

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LEWIS WINNER, Editor
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We See...

HERE AND ABROAD there's been keen interest in u-h-f application to broadcast services in the postwar era. Speaking before the Wireless Section of the IEE in London, K. I. Jones and D. A. Bell pointed out that experience gained in u-h-f transmission leads the way to the extension of the broadcasting services, which will go far towards satisfying the demand for greater freedom from interference, a wider choice of programs and high fidelity. They also stressed that an urgent need exists for a nation-wide television service. Carrier frequencies only slightly higher than prewar, in the range from 49.5 to 64.5 mc, were suggested for video use.

And on these shores, O. B. Hanson of NBC revealed quite a few pertinent facts on postwar u-h-f before the Senate Interstate Commerce Committee hearings on proposed Communications Act amendments. He said that we will see an extended use of the 30 to 150 mc bands, where practical amounts of power can be generated. He pointed out that at least 1000 television stations can be placed in operation during the next decade, if the present frequency allocations and technical standards are not greatly disturbed in the anticipated frequency shuffling. And under existing rules and technical standards, he showed that it is also technically possible to have 3000 f-m stations.

U-H-F looks ahead!

OUR POSITION IN INTERNATIONAL COMMUNICATIONS, which has never been too sturdy, received a fluent analysis recently by FCC chairman Fly. He said that we must now establish postwar world communications plans and not idle away as we did at the last Peace conference. Congress, he stressed, must act quickly and apply our technological developments to a well linked system of international distribution. We need powerful stations throughout the world, not merely on our shores, he said. America should be on the front line of action in world communications, emphasized Mr. Fly!

PAPER IS A WAR MATERIAL. All kinds must be saved. Cooperate with your local salvage committee. Fight paper waste!—L. W.

COMMUNICATIONS

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DECEMBER, 1943

VOLUME 23 NUMBER 12

COVER ILLUSTRATION

Annealing the seal on the filament end of a 100,000-watt water-cooled tube. (*Courtesy, Western Electric*)

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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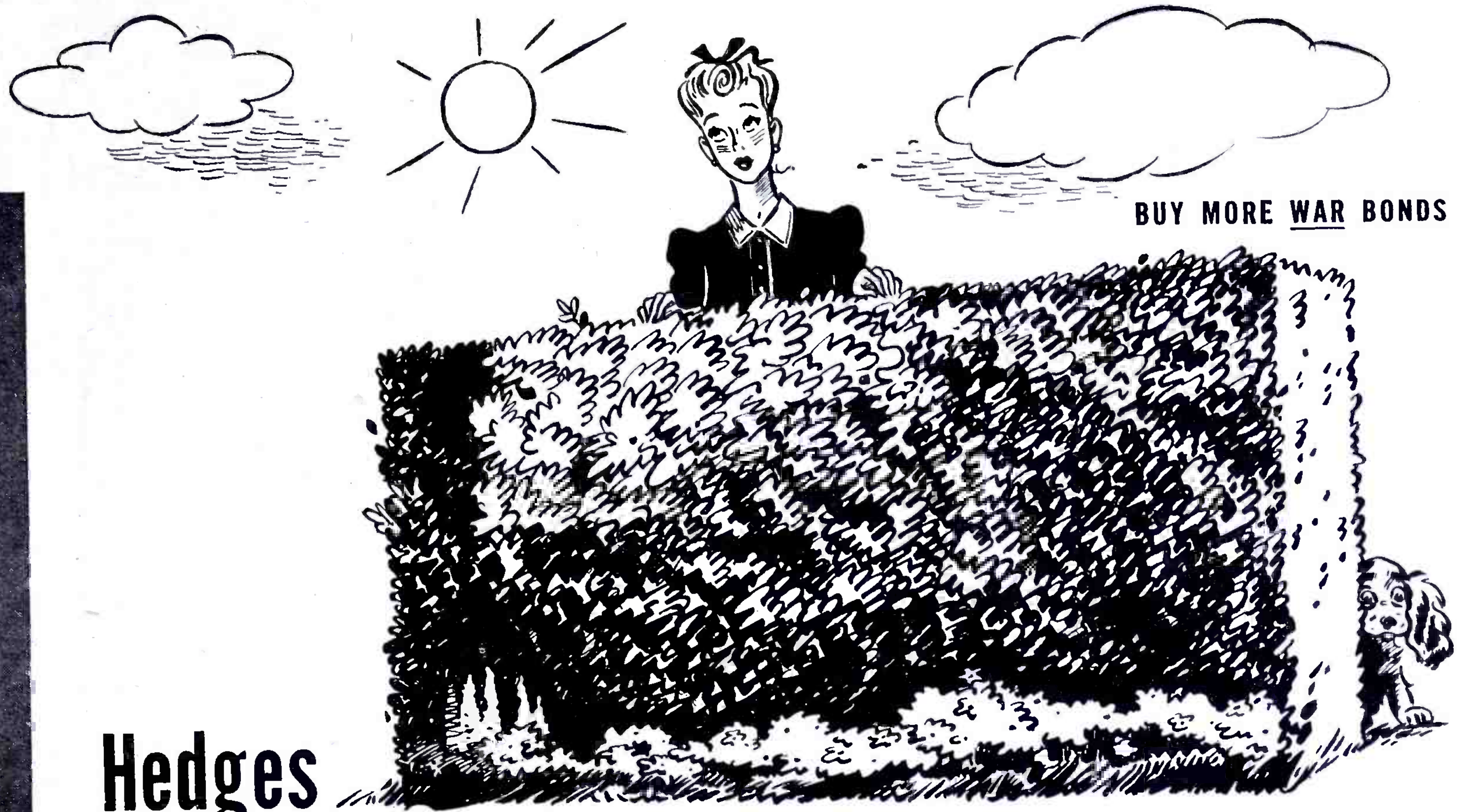
BUY MORE WAR BONDS



Hedges

There are a number of requirements for new transmitter equipment which broadcast station managers, their engineers and consultants must always bear in mind.

1. The equipment must function in a manner consistent with FCC performance requirements.
2. The equipment must meet FCC safety requirements for the protection of operators.
3. The equipment design must include safeguards which effectively protect it from damage due to overload.
4. The equipment design must include maximum assurance against failure during broadcasting.

RCA provides these assurances—"hedges" against trouble.

From microphone to antenna, RCA offers the broadcast station *complete* equipment of coordinated design—assuring superior performance, maximum operating economy and convenience, and *definitely fixed responsibility*.

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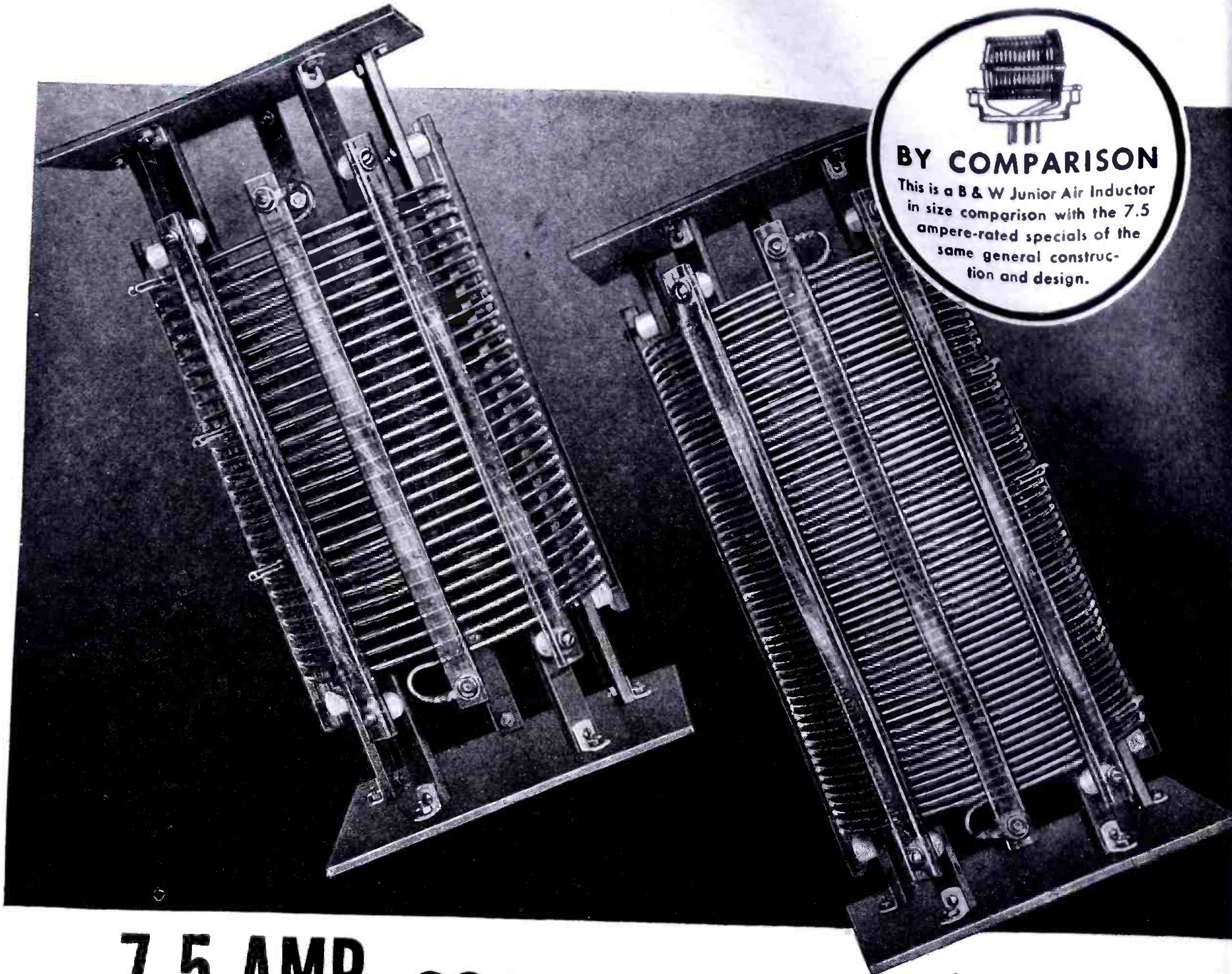
★ *RCA is the only broadcast equipment supplier manufacturing a complete line of measuring and test equipment.*



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Actually, these 20" giant B & W Air Inductors, wound with #8 solid wire, are simply grown-up war versions of the famous B & W Junior "Air Wound" Coils of amateur radio fame. The only special feature is the size plus, of course, the attendant bracing of triple x bakelite strips and plates for absolute mechanical rigidity. They're attractive in appearance, sturdy as you'd ever expect coils to be, and serve as interesting examples of B & W's unexcelled facilities for the production of special units—often with only a minimum of change from standard designs of unquestioned dependability.

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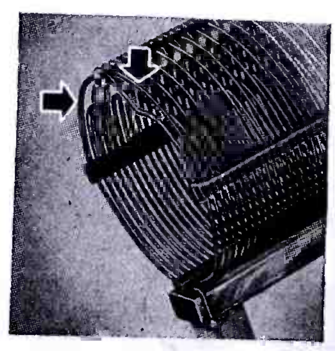

HOW TO TAP SMALL COILS—EASILY

Ever try to tap a tiny coil where the turns were so close together you felt as though you were trying to fasten a rope to a middle tooth of a fine-tooth comb? Then you'll appreciate this special B & W small coil indent feature. The windings on either side of the turn you want to tap are indented out of the way, thus making tapping quick and easy, anywhere on the Inductor.

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Where does the credit go? . . . to the men and women at the Salt Lake City plant now for their recent triumph . . . and to the men and women of both plants always for their collective cooperation and hard work.

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Lug terminals only on styles 25K, 50K, 120K.

Non-inductive windings available.

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STYLES A, B, C, D, E, F: 120, 90, 50, 35, 20, 10 watts.

Hermetically sealed power wire wound resistors. Designed to withstand salt water immersion tests.

Ferrule Terminals for fuse clip mounting.

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250,000 ohms max. per section.

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Type 1—3400 ohms to 100 megohms
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AFTER THE WAR . . . For the Signal Corps, Motorola Electronic Engineers pioneered in the development of the famous Guidon Set, the new Walkie-Talkie and the highly effective Handie Talkie—portable two-way communications systems. When Victory signals resumption of Civilian Radio production Motorola Engineers will add to their impressive list of "Firsts" in the development and production of Special Electronic devices and 2-Way F-M Communications Equipment.

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For the continued development and production of Radio Communications and other special Electronic equipment for our Armed Forces, the Motorola organization has been awarded two stars for their Army-Navy "E" Flag. Motorola is proud of the part it has been privileged to play in the speeding of Victory.

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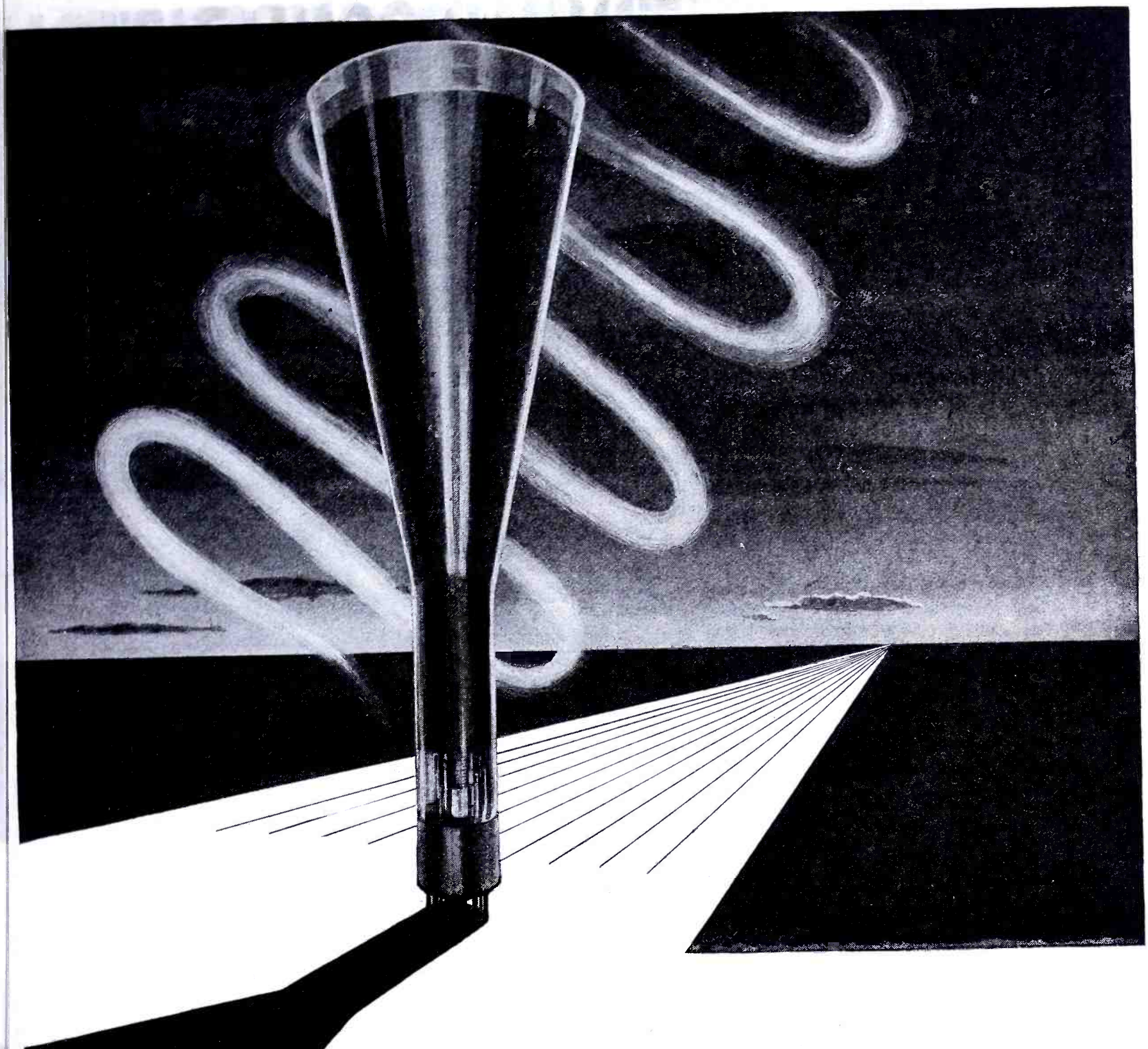

Perhaps your industry was born at the tower of Babel...

The point to the Bible story of the Tower of Babel was that progress on the greatest works of men ceased when by an unfortunate miracle each man was endowed with a different language and could not communicate or receive ideas from his fellows.

By a greater miracle the electrical, and electronic industries undo the confusion of Babel and foster all progress by perfecting not only the communication of ideas but the quick transfer and utilization of electronic power.

Formica's service to these industries includes twenty-five years of research to perfect special grades of laminated plastic designed to meet requirements of their present production and their future creations for closer knit world. These grades stress in varying degree such properties as low dielectric constant, low coefficient of thermal expansion, light weight, great strength, easy machinability and resistance to chemical action and water absorption. Some grades of Formica may be the answer to an old or a future problem of material.

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COMMUNICATIONS

LEWIS WINNER, Editor

* * DECEMBER, 1943 * *

F-M STUDIO-TO-TRANSMITTER LINKS

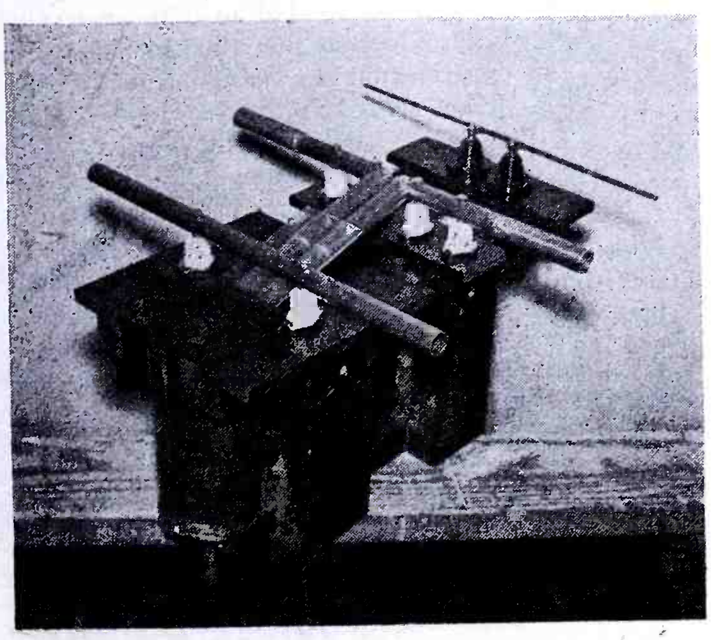
This Paper Discusses S–T Service, Describes The First Commercial F-M Transmitter and Receiver For S-T Service In 330.4 to 343.6 MC Band And Explains The First Application Of Such Equipment For Commercial Use

by W. R. DAVID

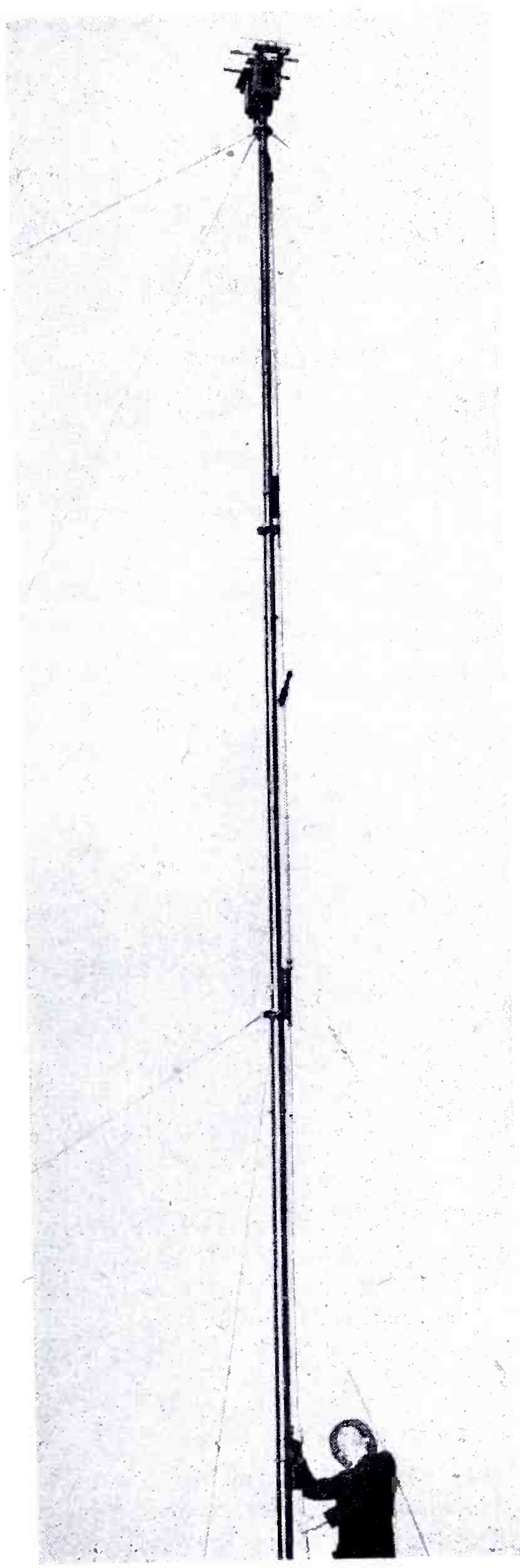
Electronics Department, General Electric

THE designation *S-T* (and the earlier designation *STL*) became identified as a particular service, with the announcement of FCC rules for S-T broadcast stations on March 14, 1941. These rules define the service as follows: "The term 'S-T Broadcast Station' means a station used to transmit programs from the main studio to the transmitter of a high frequency (f-m) broadcast station."

Previous to these rules, s-t service had been authorized at lower frequencies for emergency used by a-m broadcast stations, emergency meaning that the radio circuit could be used only in case of wire line failure between the studio and main transmitter. A few a-m broadcast stations have

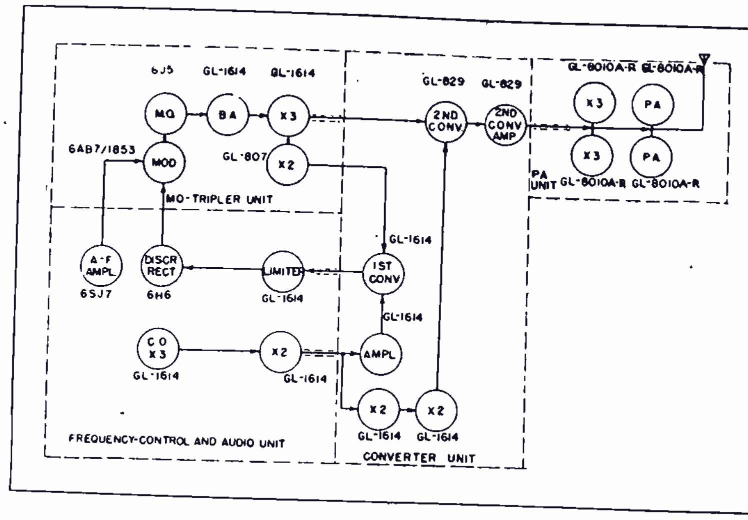


Temporary antenna used by f-m station WBCA for studio-to-transmitter operation. At left, appears a close-up of the antenna, which is shown at right, mounted on top of a 46' mast. The antenna consists of an elevator; a dipole with reflector and director. This antenna is connected to the s-t transmitter with about 100' of 7/8" diameter concentric tube transmission line.



F-M SYSTEM PERFORMANCE REQUIREMENTS

CHARACTERISTICS	F C C OVERALL REQUIREMENTS	TRANSMITTER MEASUREMENTS	STUDIO AUDIO MEASUREMENTS	RELAY CIRCUIT REQUIREMENTS
AUDIO FREQUENCY	±2DB OF 1000 CYCLES 50 TO 15,000 CYCLES	BETTER THAN ±1DB OF 1000 CYCLES 30 TO 16,000 CYCLES	BETTER THAN ±1DB OF 1,000 CYCLES 30 TO 15,000 CYCLES	±1DB OF 1,000 CYCLES 30 TO 15,000 CYCLES. SYSTEM MUST BE COMPENSATED OVERALL
F-M NOISE LEVEL	60DB BELOW 100% MOD. 50 TO 15,000 CYCLES	BETTER THAN 70 DB BELOW 100% MOD 30 TO 16,000 CYCLES	BETTER THAN 65 DB BELOW LEVEL OF 1 MV INPUT TO PRE-AMPLIFIER	SHOULD BE BETTER THAN 65 DB
DISTORTION	LESS THAN 2% (R.M.S.) 50 TO 15,000 CYCLES	LESS THAN 1.5% 30 TO 15,000 CYCLES	LESS THAN 0.5% 30 TO 15,000 CYCLES	LESS THAN 1.5% 50 TO 15,000 CYCLES



Figures 1 (above) and 2 (right)

In Figure 1, we have the FCC requirements for a f-m station. From these data it is obvious that any relay circuit whether it be a wire line or radio link, must have excellent performance characteristics. Figure 2 is a block diagram of a 25-watt f-m transmitter, with 260 to 350 mc coverage. Because of the swing problem the conversion method shown here was adopted. With this method it is possible to obtain an oscillator swing of 8 or 9 kilocycles to keep inherent f-m noise level of the transmitter down 70 decibels.

such emergency equipment. Some employ f-m. It should be noted here that s-t service for f-m broadcasting is authorized for regular commercial operation, in contrast to the a-m emergency authorization.

Wide A-F Range Requisites

The need for s-t radio circuits in regular service for f-m broadcast stations was due principally to the wide audio frequency range possible with f-m and, in fact, required of f-m stations by the FCC. The Commission requires an overall response of plus or minus two decibels of the level at 1,000 cycles for the range of 50 cycles to 15,000 cycles.[1] This range is needed to reproduce faithfully all of the musical instruments and their characteristic overtones.

Noise Level and Distortion

Wide frequency response is not the only requisite for the circuit between the studio and the transmitter of an f-m station. The noise level and distortion must be kept to extremely low values as shown in the tabulation, Figure 1. The FCC requirements for an f-m station are given in the column *FCC Overall Requirements.* The next two columns show *Transmitter Measurements* and *Studio Audio Measurements.* The last column shows *Relay Circuit Requirements.* It is obvious from this tabulation that the relay circuit, whether it is a wire line or s-t radio circuit, must have excellent performance characteristics.

Line Transmission

For conventional a-m broadcasting, it is common practice to use transcontinental wire lines having a frequency response range of 100 cycles to 5,000 cycles. For shorter distances, better wire lines are available and are being used. These better lines have a frequency response of 100 to 8,000 cycles. For very short distances it is possible and economical to obtain wire lines with a frequency response well within the requirements mentioned in the tabulation of Figure 1 for the relay circuit. Several f-m stations are using such lines between their studios and transmitters. Depending upon local conditions, these high quality lines may be uneconomical for even very short distances of twelve miles or less.

F-M Transmission Sites

Sometimes it is necessary to locate the transmitters of f-m stations at high and comparatively inaccessible sites. For example, Gordon Gray's f-m transmitter for station WMIT is located on Clingman's Peak near Mt. Mitchell, North Carolina, and the transmitter for General Electric's f-m station WGFM is located on one of the Helderberg Mountains near Schenectady, New York. These sites were selected because they command line-of-sight views over the principal service area of the stations. WMIT is 110 miles from its studios in Winston-Salem, and WGFM is 12 miles from its studios in Schenectady. These distances are air line and both are line-of-sight propagation paths. The construction and rental of wire lines were found uneconomical for both stations.

Undoubtedly, wire lines would be difficult to maintain if they were constructed. On one occasion, one of the telephone lines on top of the Helderberg Mountains, between our New York relay station and our main f-m station, became partially shorted when snow drifted higher than the sagging wires between two of the poles. At another time the line became very noisy due to unusual local electrical disturbances in the atmosphere.

Another and more extreme example of a site excellent for line-to-sight propagation, but almost inaccessible, is the Yankee Network's f-m station WMTW on Mount Washington in New Hampshire.

Relay Advantages

It should be noted also that s-t radio circuits, in addition to requiring no right-of-way and maintenance between the studio and transmitter, are not subject to fire hazards or possible sabotage along the right-of-way. Some broadcasting stations have been forced off the air for hours when fires damaged or destroyed the wire line connections between their studios and transmitter stations.

Anticipating the trend to higher frequencies, early in 1940 we began the development of a 50-watt f-m transmitter for the 110 to 170-megacycle band, which at that time included the experimental s-t assignments. This design served as a prelude to our 330-megacycle development. This lower frequency transmitter was placed in service as the sound channel s-t at 167.75 megacycles for television station WRGB and has been in regular commercial operation for many months.

The 25-Watt Transmitter

When the FCC ruled that s-t service for f-m stations should be in the 330.4 to 343.6-megacycle band, we proceeded to develop an f-m transmitter of 25 watts rating for the prescribed frequency range. Actually the transmitter covers the range of 260 to

[1]In addition the FCC requires that provision shall be made for preemphasis of the higher frequencies in accordance with impedance-frequency characteristics of a series inductance network having a time constant of 100 microseconds.

350 megacycles which takes in the higher television sound channels. It was decided to employ plus or minus 75 kilocycles swing for two principal reasons; first, to make it possible to relay without demodulation and, second, to obtain better receiver design. If, for instance, you swing the transmitter carrier plus or minus 150 kilocycles, and then take into consideration the stability of the transmitter (± .01% required by the FCC—actually the transmitter stability is ± .002%) and the local oscillator of the receiver, when the variations are in opposite directions, it would be necessary to make the receiver circuits very broad with comparatively low gain.

Swing Problem Solution

This decision regarding swing imposed a problem in the transmitter circuit design; i.e., without employing conversion, the swing of the transmitter oscillator would be approximately 1 kilocycle and our experience has shown that the oscillator swing must be in the order of 8 or 9 kilocycles to keep the inherent f-m noise level of the transmitter down 70 decibels. This led to the adoption of the conversion method shown in the schematic functional diagram, Figure 2. Incidentally, the statements in this paragraph refer to the General Electric method of producing frequency modulation.

Other problems in the development of the transmitter were the electrical and mechanical design of the higher frequency amplifier stages, particularly the final power amplifier. It was necessary to develop a new type of high frequency tube for the last intermediate and the final power amplifier stages. The tube, type GL-8010A-R, is shown mounted in the i-p-a and p-a stages in Figure 3. The complete transmitter is shown in Figure 4. Those inclined to question the size of the transmitter in comparison to its output rating, should remember that in it must be generated f-m with all of the fine characteristics and frequency stability of the basic f-m broadcast transmitter.

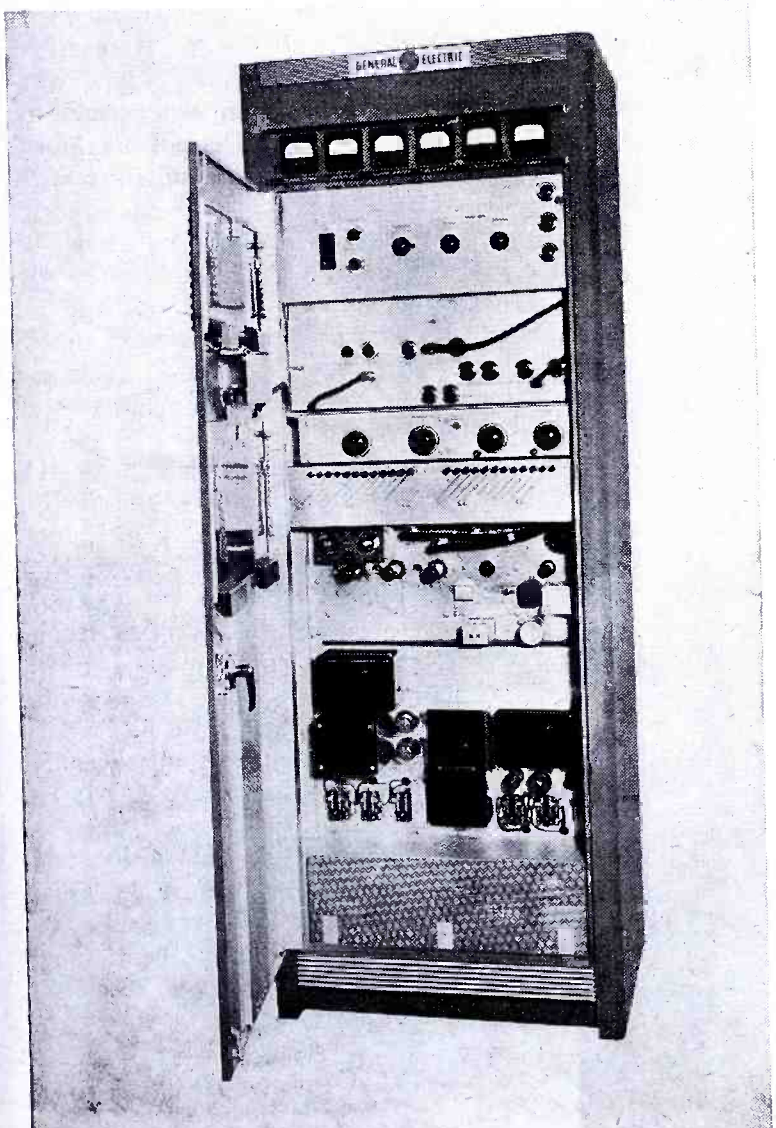
Roof Top Installations

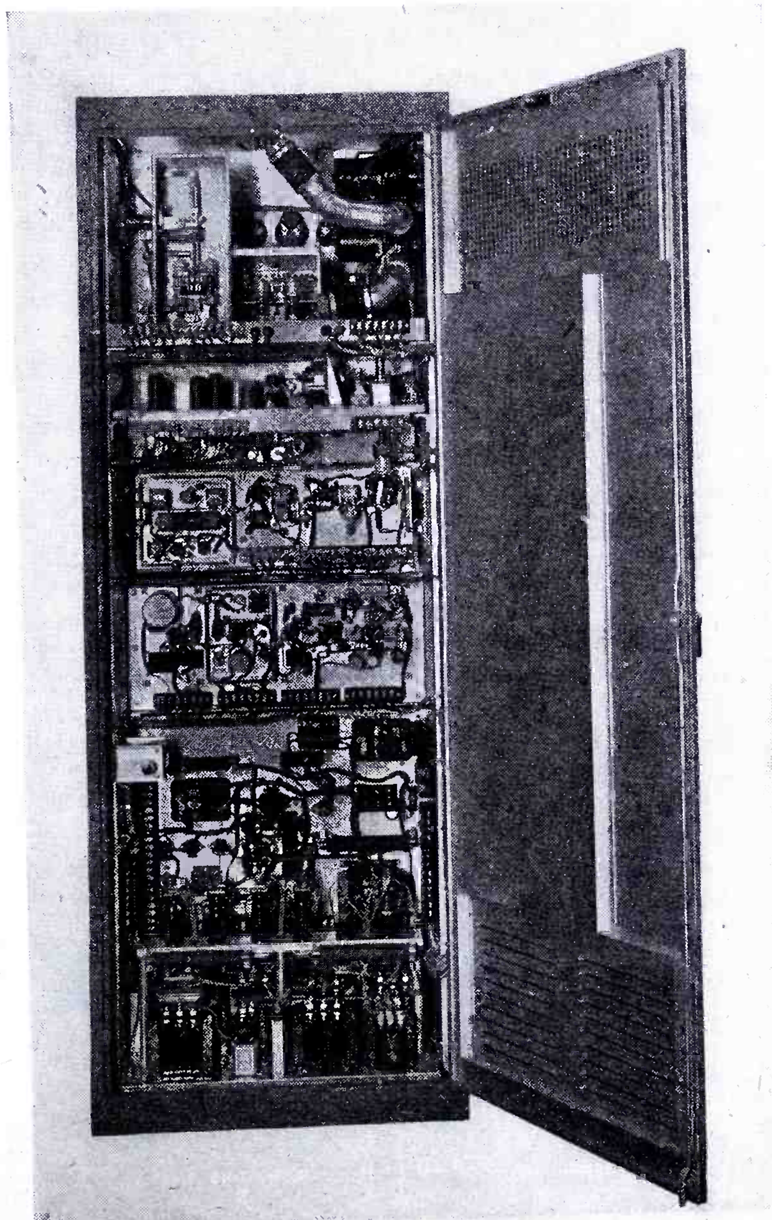
In some cases the s-t transmitter must be installed on the top floor of a studio building to avoid excessive losses in the radio frequency transmission line. It would be uneconomical to maintain a separate operating crew for the s-t transmitter for such an installation, and that problem required the development of remote control equipment. This took the form of an external relay unit at the transmitter, and a small control panel at the control point—usually the main control room of the studio building where the regular control room operators can operate the s-t transmitter. Other accessories for the s-t transmitter include the combination of a high frequency converter and f-m station monitor, high fidelity audio monitoring amplifier, and loudspeaker.

Antenna Problems

The FCC rules for s- t service are very specific in regard to the gain and directivity of the transmitting antenna. The antenna, shown schematically in Figure 5 and mechanically in Figure 6, was developed to meet the requirements. This same antenna may be used at the receiving end if additional gain is needed for the s-t radio circuit. It will be noted that this antenna

Figures 3 (right) and 4 (below).





is enclosed for protection against adverse weather conditions.

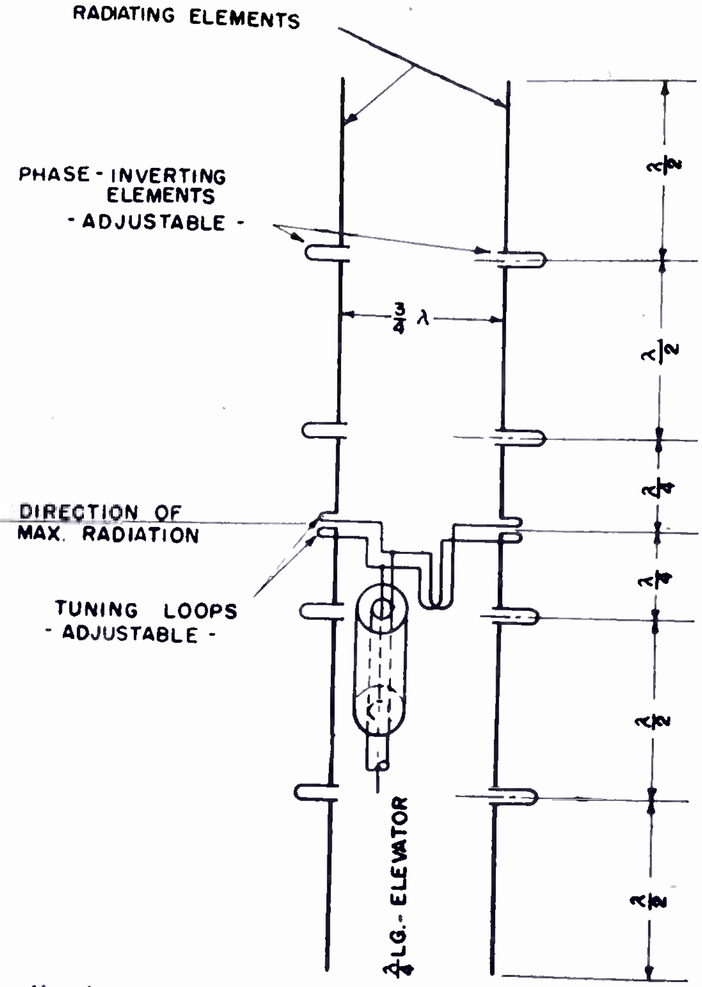


Figure 5

Schematic diagram of the s-t directional antenna. This transmitter antenna, which has been designed to meet the FCC requirements in regard to gain and directivity, may also be used at the receiver end, if additional gain is needed for the s-t circuit.

F-M Receiver Problems

The development of an f-m receiver for s-t service imposed a doubly difficult job on our receiver engineers. First, the operation at this frequency up to that time was chiefly on an experimental basis, and, second, the performance desired was previously unheard of for anything but laboratory work. Following are the required performance specifications:

- Audio harmonic distortion .5 per cent or better at full deviation of plus or minus 75 kilocycles.
- Audio frequency response with de-emphasis within plus or minus .5 decibel of the 100 microsecond curve over the range of 30 to 16,000 cycles.
- Adjacent channel attenuation minus 40 decibels.
- Sensitivity and noise level—
  - Full limiting and —40 db noise level below 0-vu at 20 microvolts input.
  - —60 db noise level below 0-vu at 40 microvolts input.
  - —70 db noise level below 0-vu at 100 microvolts input.
- Rejection ratios—
  - Image 45 db.
  - 40 megacycle i-f 60 db.
  - 4.3 megacycle i-f 75 db.

The production receivers complied with these specifications. Below appears the receiver's tube complement and function of each stage.

No.	Function	Type
1	R-F amplifier	956 acorn pentode
1	First converter	955 acorn triode
2	40 mc i-f amplifiers	6AC7 hi g-m pentode
1	Second converter	6AC7 hi g-m pentode
1	4.3 mc i-f amplifier	6SK7 pentode
2	Amplifier limiters	6SH7 sharp cutoff pentode
1	Discriminator	6H6 double diode rectifier
1	Audio driver and carrier off noise suppression	6SN7G double triode
1	Audio output	6SN7G double triode
1	Oscillator and doubler	6SN7G double triode
1	Doubler	955 Acorn triode
1	Doubler	955 Acorn triode
1	Rectifier	504G

The receiver possesses many features which enhance its application to s-t broadcast service. The local oscillator is crystal controlled. It employs one of the new G-E type G-31 thermocells, which is temperature controlled and hermetically sealed, similar to the crystal used in the transmitter. It has separate program and monitor audio amplifiers, carrier-off noise suppression with threshold adjustable to suit service requirements, simplified circuit tuning using built-in meter and meter selector switch, vernier tuning of discriminator provided on front panel with high sensitivity microammeter, and vertical panel and chassis construction for rack mounting providing complete accessibility of parts. The receiver with front door open is shown in Figure 7.

The construction permit covering the installation of one of the s-t transmitters, with call letters W2XEO, was the first issued by the FCC. It was issued to the Capitol Broadcasting Company, Schenectady, New York, for use in connection with their f-m station WBCA, also located in the Helderberg Mountains. The equipment was placed in operation February 2, 1942, with the s-t transmitter located in the company's studio control room where it can be operated by their control room licensed operators. It is connected to the antenna with about 100 feet of ⅞" diameter concentric tube transmission line. Lack of priority made it necessary to use the temporary antenna shown on page 15, which comprises an *elevator;* a dipole with reflector and director. The antenna was constructed by engineers of WBCA.

The receiver is installed inside the main transmitter building and fed in the original installation by a *V*-type antenna, 5 waves on a side, placed on top of the building. The antenna now used is a corner reflector type having the same gain but physically much smaller. The receiver is in the same room with the 1-kw transmitter and the receiving antenna is not over 50 or 60 feet from the main transmitting antenna. The propagation path between WBCA's s-t transmitter and receiver is shown in Figure 8. Over this path, the 330-megacycle s-t equipment provides an excellent signal at all times, with no trace of noise,

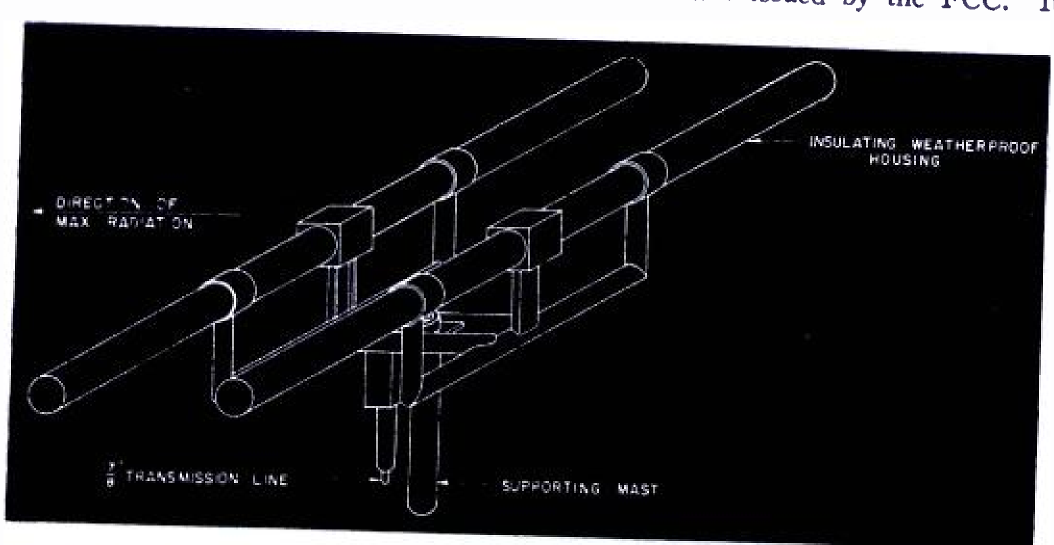


Figure 6
The mechanical structure of the antenna shown in Figure 5.

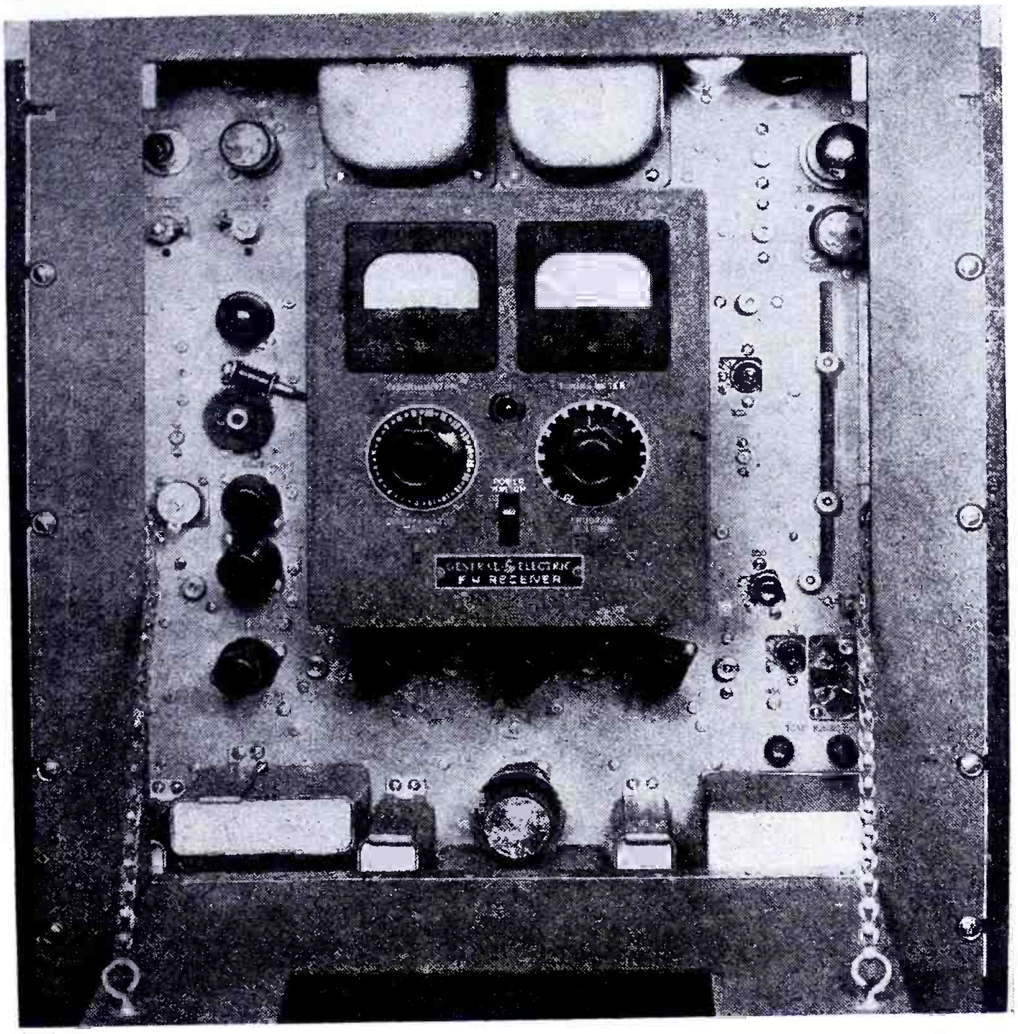


Figure 7
The f-m receiver for s-t service, with a frequency range of from 270 to 350 mc.

even with the temporary transmitting antenna.

Among the stations that now use s-t transmitters and receivers are f-m station WGFM; CBS, New York City, as an emergency circuit for their International short wave station; the f-m station of the Moody Bible Institute, Chicago, Ill.; Gordon Gray's f-m station WMIT; and the Westinghouse stations in Boston, Mass., as an emergency circuit for their International short-wave station.

Appendage

FCC Rules—STL Transmitters

(Copied from Federal Register, March 15, 1941)

Title 47—Telecommunication
Chapter I—Federal Communications Commission

Part 4—Rules Governing Broadcast Services Other Than Standard Broadcast

The Commission on March 12, 1941, effective immediately, took the following action:

Adopted the following new rules to read:

STL Broadcast Stations

Par. 4.31 Defined. The term "STL broadcast station" means a station used to transmit programs from the main studio to the transmitter of a high frequency broadcast station.*

Par. 4.32 Licensing Requirements. An STL broadcast station will be licensed only to the licensee of a high frequency broadcast station. Only one STL broadcast station, which shall be at a fixed location, will be authorized in connection with each high frequency broadcast station.*

Par. 4.33 Service. The license of an STL broadcast station authorizes the transmission of program material, including commercial programs, from the main studio to the transmitter of the high frequency broadcast station in connection with which it is authorized.*

Par. 4.34 Frequency Assignment and Operation. (*a*) The following frequencies are allocated for assignment to STL broadcast stations upon an experimental basis:

KC

330,400	333,400	335,800	338,200	340,600
331,000	334,000	336,400	338,800	341,200
331,600	334,600	337,000	339,400	341,800
332,200	335,200	337,600	340,000	342,400
332,800				343,000
				343,600

(*b*) STL broadcast stations will be authorized to employ frequency modulation only.

(*c*) The maximum frequency swing employed by STL broadcast stations shall not be in excess of 200 kilocycles.

(*d*) The licensee of each STL broadcast station shall install and operate a directional antenna designed so that the gain in power toward the receiver shall be 10 (field gain 3.16) times the free space field from a doublet (137.6 mv/m. for 1 kw at one mile). In all other directions 30° or more off the line to receiver, the power gain shall not exceed ¼ the free space field gain from a doublet. (Sec. 303 (c), 48 Stat. 1082; 47 U. S. C. 303 (c)

Par. 4.35 Power. STL broadcast stations will be licensed with a power out-
(Continued on page 89)

Figure 8
The propagation path between the s-t transmitter of WBCA and receiver. Over this path the 330-mc equipment provides an effective signal, at all times, with no trace of noise.

DIRECT READING

by R. J. MILLER
Technical Assistant to Communications Supervisor
Eastern Air Lines

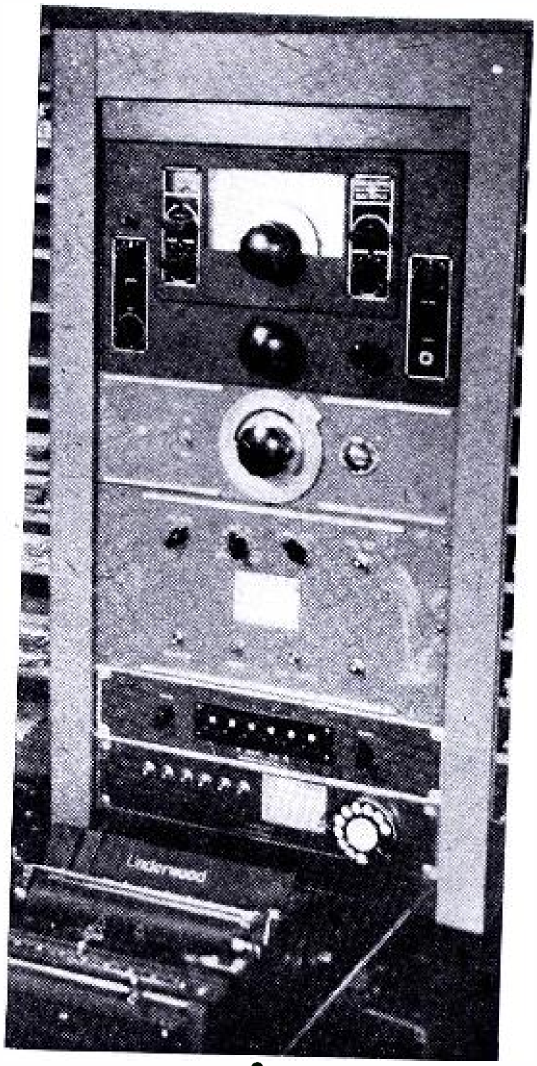


Figure 1
Complete frequency measuring installation, showing from top to bottom . . . receiver, interpolation oscillator and secondary frequency standard. Units below are remote receiver and transmitter controls, not associated with checking equipment.

THE possibility of operator error in arithmetical computations and the danger of harmonic error in many methods of frequency measurement used with secondary standards, has limited the usefulness of such methods among those services operating on several frequencies and with many transmitters. Harmonic error prevails in the audio interpolation method, while in both audio and linear r-f interpolation systems, operator error is the problem.

Audio interpolation, while admittedly the most accurate, does, in those cases where such precise measurements are unnecessary, involve the needless loss of much time, especially in the hands of the relatively inexperienced operator. The possibility of error is largely due to the difficulty of distinguishing harmonic and fundamental beats. Precise mixing of both r-f inputs and audio outputs is necessary to obtain beats of sufficient intensity. To the above, from the standpoint both of time involved and possible error, must be added the final mathematical calculations necessary to determine the frequency of the signal being observed. It is thus desirable to employ a system that eliminates or materially reduces all of the above elements and at the same time affords a high degree of accuracy. A system developed along these lines of thought is shown in Figure 5.

The system involves nothing new or radical insofar as equipment is concerned. But the method of application or procedure has been devised to permit direct reading of deviation in cycles per second. This, of course, eliminates all necessity for computation and the attendant possibility of error. The harmonic error which is the weak point in all audio interpolation systems is disposed of by interpolating at the intermediate frequency of the receiver in use. This obviously represents a compromise between interpolation at the lowest possible frequency, the audio beat, where the highest degree of accuracy will be obtained and interpolation at the highest possible frequency or direct interpolation between harmonics of the standard, where the lowest degree of accuracy will be obtained.

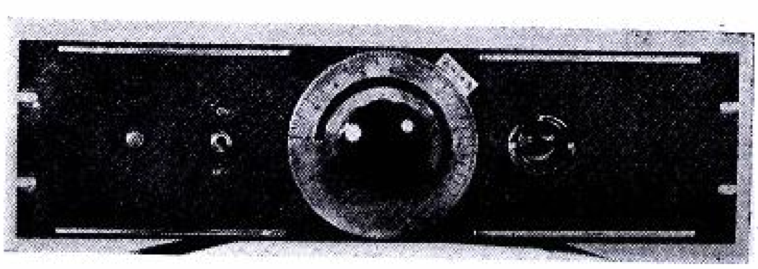
A secondary standard from which can be obtained harmonics every 100, 12.5 and 10 kc is used. A detailed description of the secondary standard will not be attempted here since the subject has been amply covered in numerous texts and periodicals, and the design and construction of a standard with multivibrator orders of 8 and 10 can be readily accomplished. Although the particular receiver in use is a National NC100A with an i-f frequency peaked at 455 kc, and so aligned as to permit 12 kc bandwidth, any good communications type superheterodyne receiver could be used.

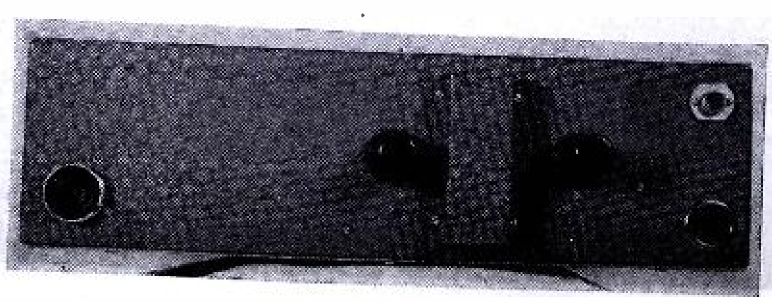
Interpolation at the i-f frequency of the receiver can be accomplished basically by utilization of the bfo of the receiver. For the accurate measurement of frequency, however, this method is impractical for several reasons. Calibration is of course difficult and close zero-beat adjustment due to frequency interlock is also a problem. We must also consider frequency stability. Since the bfo is incorporated in the receiver itself, it is subject to comparatively large thermal changes and is thus dependent upon the receiver's unregulated power supply for operating voltages. These problems can be solved by the use of a specially designed external oscillator.

The interpolation equipment consists of an oscillator functioning at the i-f frequency of the receiver and an r-f amplifier/isolator that prevents interlocking and permits close zero-beat adjustment. To stabilize the oscillator, zero-temperature coefficient components were used, where possible. It was also found necessary to use a voltage regulated power supply. Little drift will be encountered at this frequency in the short space of time involved in completing a measurement.

Figures 2 (left, below) and 3 (right, below)

In Figure 2 we have a front view of the interpolation oscillator showing the main calibrated dial in the center with plate on-off switch at left and 6E5 at right. Figure 3 is a rear view of the oscillator. Receptacle for power and a-f output plug is at extreme left. Left hand tube is 6SJ7 and tube at right is 6SK7. At extreme right upper corner is the output for i-f of receiver. The a-c receptacle appears in the lower right hand corner. Note protective shield covering tuning adjustments, between tubes.





INTERPOLATION OSCILLATOR

The long term drift is small and does not particularly affect the accuracy of measurement. All measurements are predicated upon the difference in frequency between the interpolation oscillator and the h-f oscillator in the receiver as set up when a measurement is begun. This long term drift can, of course, be periodically checked and corrected to insure that the zero point or center scale is substantially at the i-f frequency of the receiver.

Adjustments are provided for bandwidth, and zero-set of the dial, to secure the proper frequency coverage. Also included is an iron-core adjustment of the oscillator coil to permit change of the inductance over a limited range. Visual zero-beat indication is provided by a 6E5 tube which, while mounted in the interpolation unit, is actually connected across the audio output of the receiver. Dial arrangements, other than that shown, are, of course, possible to permit closer reading. However, the dial shown, with calibration points every 100 cps, has been found sufficiently accurate for all normal uses since it can be read to within 25 cps.

For the convenience of the operator making measurements, the dial has been marked on either side of zero in *red* and *green* scales. The low frequency side or 449 to 455 kc is *red* and high side or 455 to 461 kc is *green*. This facilitates the adjustment of the interpolation oscillator when preset and reduces the possibility of errors being made through presetting on the wrong side of zero. The calibration is carried through 6,000 cps on either side of zero for greater ease in measuring unknown frequencies, it having no particular value past 5,000 cps when measurements of known frequencies are made. The output of the interpolation oscillator is injected into the i-f channel and the interpolation oscillator functions as bfo of receiver.

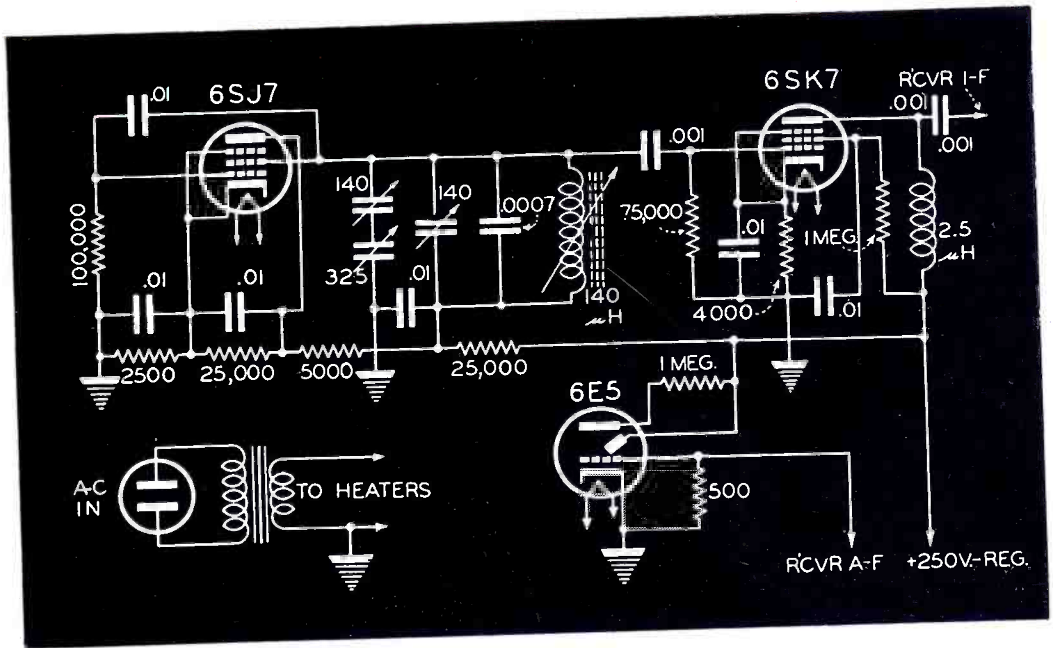


Figure 4

Circuit diagram of the interpolation oscillator covering the 449 and 461 kc range. Note the voltage regulated source, indicated at the plate input to the 6SK7.

Since comparisons are made and deviations measured at the frequency or frequencies which the i-f channel of the receiver will pass after the signal and the standard frequency have been converted to these frequencies by the high frequency end of the receiver, the accuracy of the measurements will be affected by the precision with which zero-beats are obtained and the hfo drift of the receiver, as well as by the deviation of the standard, from an exact 100 kc. Errors due to hfo drift in the receiver can be minimized by reducing the time between the two necessary zero-beat adjustments to as short an interval as possible. Although it has not been found essential, errors could be further reduced by stabilization of the hfo and allowing the receiver a thorough warm-up period before measurements are begun. Some trimmer arrangement across the hfo inductance in the receiver is also desirable to facilitate adjustment of the receiver to zero-beat with the signal.

The procedure outlined below which enables direct reading of deviation in cps, is based upon presetting the dial of the interpolation oscillator to that point (depending upon the frequency being measured) which would, were the frequency exact, force the final reading to be at *0* or midscale of the calibrated dial. Thus, any deviation of the measured signal from its as-

(*Continued on page* 87)

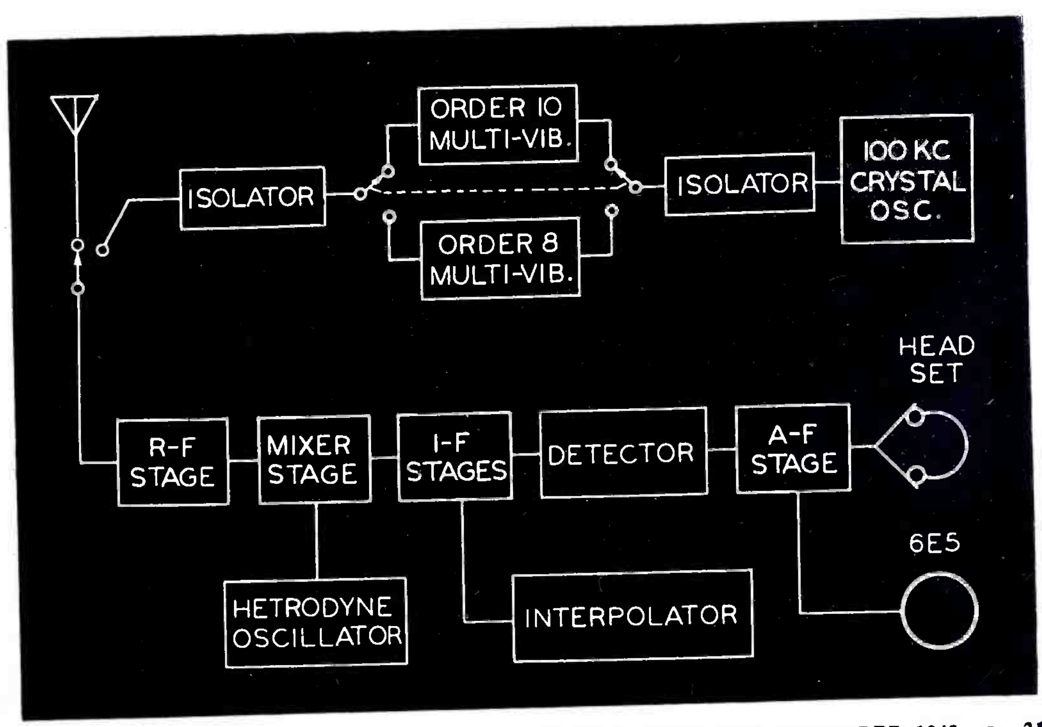


Figure 5

A block diagram of the direct reading frequency measurement system, which operates in the following way. Receiver is first turned on for a short warm-up period and the interpolation oscillator preset to the difference between nearest harmonic of secondary standard and known (or assigned) frequency to be measured. Interpolation oscillator is next turned on and signal tuned in to zero beat. Signal is removed and multivibrator output connected to the receiver input. Interpolator dial is now adjusted for zero beat with multivibrator output. Difference and direction of the actual frequency from the assigned frequency can now be read directly from dial. In the system outlined, the h-f oscillator is on the high side of the signal frequency. However, it will function equally as well with the h-f oscillator on the low side but the plus and minus scales will be reversed. This could, of course, be considered in the construction of any similar system and the dial designed accordingly.

* THE

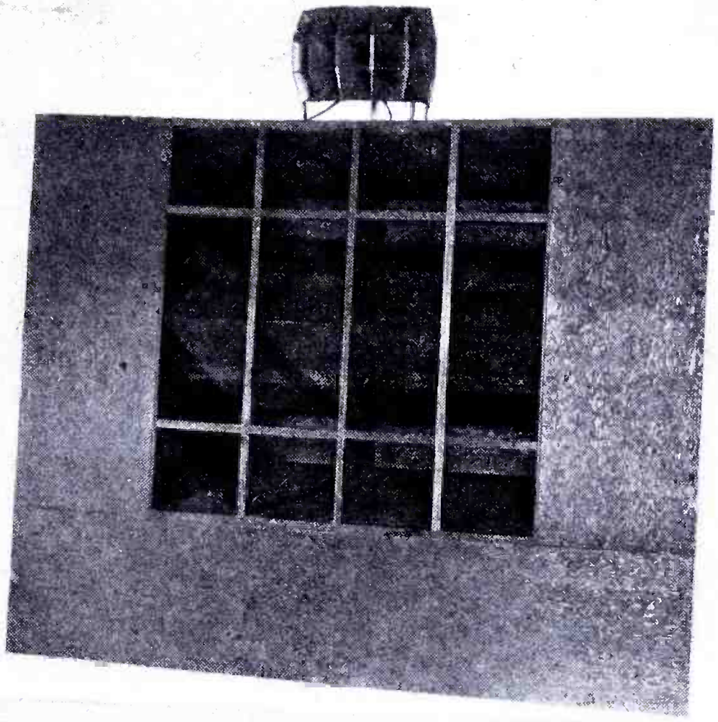


Figure 1
A large size theatre speaker in use around 1935, with a folded type horn.

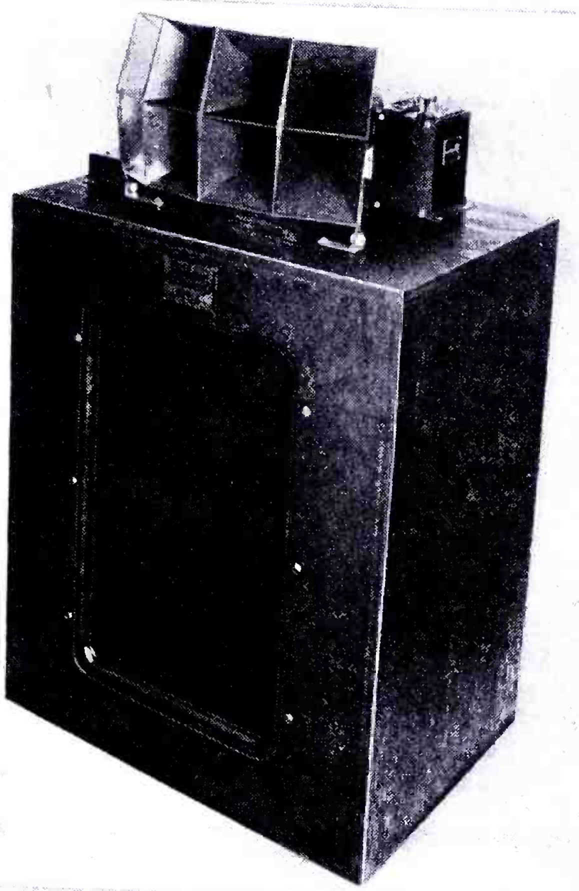


Figure 2
A two-way loud speaker developed in 1937, using a multi-cellular high frequency horn in conjunction with a resonated low frequency baffle. Note the network filter next to the high frequency horn.

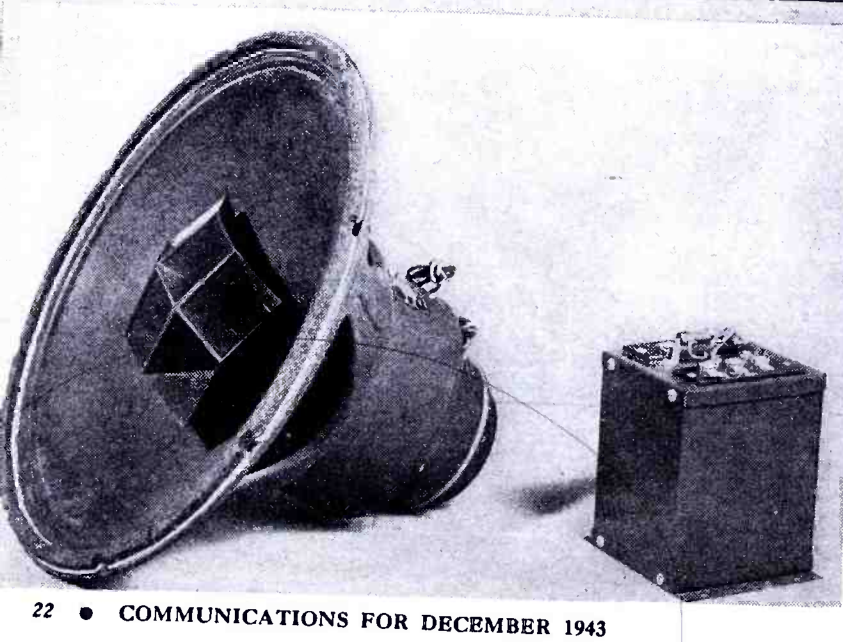


Figure 3
The newest duplex speaker with a six-cell high-frequency horn mounted on the end of a low frequency unit pole piece. Network filter is also shown, at right of speaker.

THE practical application of the *two-way multi-cellular loud speaker system* for theatre use began in 1935. Since that time we have had a gradual improvement in the quality and general performance of the system. The wide acceptance of the high performance standard set by this system indicated that many important benefits would be gained by applying the same principles to speakers for recording, monitoring, and broadcast studio work.

Since the large size of the theatre system (Figure 1) precluded its use in monitoring booths, the immediate requirement was that a substitute be found for the large folded horn used for the low frequency band. Reduction in the size of the low frequency horn called for a corresponding decrease in the size of the high frequency horn in order to make the whole equipment compact.

The first development to meet these requirements for a smaller system made use of a 500-cycle cross-over network and a high frequency horn designed to give proper acoustic loading at cross-over.

The folded type horn, much reduced in size, and using a 15-inch speaker was retained for the low frequency end. While this design had adequate frequency range for most small rooms, it was still too bulky for the *cubby hole* type monitoring room, and the effect of separate sources for the different frequency bands was annoying when used in these close quarters.

In 1937, the first *two-way loud speakers* using the multi-cellular high frequency horn in conjunction with a resonated low frequency baffle were made available (Figure 2). A cross-over frequency of 800 cycles was used with a corresponding decrease in the size of the high frequency horn. These speakers were far more compact than those using horns of various configurations for the low frequency band. Operating efficiency, while not as high as in the larger systems, was still high when consideration was given to the decrease in size.

Recent Design Work

During 1941, intensive work was undertaken to find a method of producing a loud speaker of still more compact form, still retaining the same

*Prepared specially for COMMUNICATIONS from a paper delivered before the Society of Motion Picture Engineers' 54th semi-annual technical conference in Hollywood.

DUPLEX LOUD SPEAKER

by JAMES B. LANSING

Altec Lansing Corportion

performance characteristics of the larger systems, and at the same time totally eliminating the tendency to radiate from split sources when used in close quarters.

The inter-modulation distortion effects produced by a single diaphragm, when operating at a multiplicity of frequencies simultaneously, precluded the use of a single diaphragm for all frequencies. These effects were confirmed by G. L. Beers and H. Belar in their SMPE paper on *Frequency Modulation in Loud Speakers* (Vol. XL, page 207).

The metal diaphragm was chosen for the high frequency reproducing system. It was designed to operate as a piston up to frequencies above the limits of audibility. Aluminum alloy was used because of its high mass stiffness and high velocity of transmission. The resulting light weight diaphragm is stiff enough to prevent its breaking up as a piston, which would introduce the intermodulation effects so common to the familiar paper and other fibrous types of diaphragms.

Careful consideration was given to the type of high frequency radiation system to be used. If the diaphragm was to radiate directly, and was made small enough to avoid sharp beam effects at the high frequency, it became too small to handle enough power near the cross-over region for practical purposes. Accordingly, the multicellular type of high frequency horn was chosen as the radiating medium.

In the final design of the high frequency horn we chose a 2 x 3 configuration of six cells, with a 900-cycle cut-off, which could be enclosed by the low frequency cone. The maximum angle of distribution was held to approximately 60° in order to prevent interference from the mounting baffle at the higher frequencies.

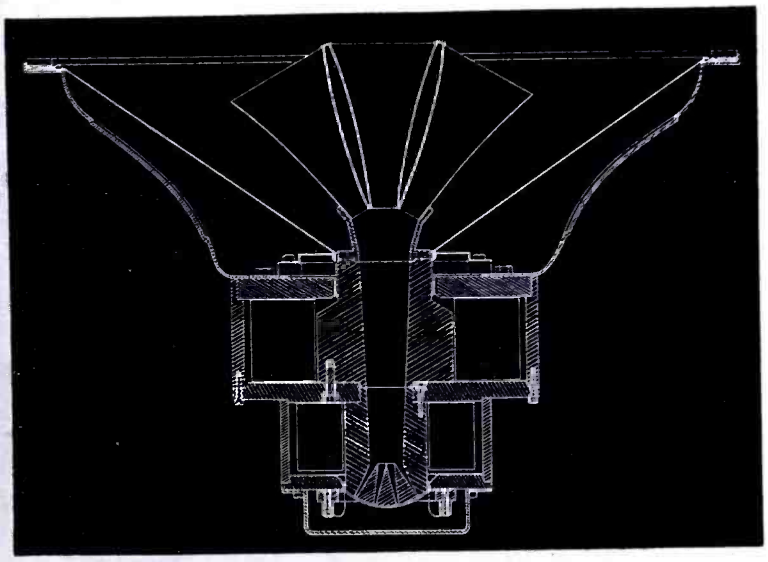
Figure 4 illustrates a cross-sectional view of the completed speaker, showing the arrangement of the functional parts. The heavy field coils and their magnetic circuits provide ample excitation for the magnetic gaps in which the voice coils operate. The high frequency horn is shown mounted on the end of the low frequency unit pole piece, which is bored out to permit the passage of sound from the high frequency unit. A fine mesh bronze screen at the junction of the pole pieces prevents the entrance of foreign particles into the high frequency sound chamber. Positive alignment of the bores of the two pole pieces and of the horn mounting flange, avoids discontinuities which would cause destructive interference along the high frequency sound transmission path. The high frequency horn is covered with a sound deadening material, but is not finished with a smooth surface which would set up a regular reflection pattern for sounds being generated by the surrounding low frequency cone. The dome-shaped high frequency diaphragm is shown in place over its transducer. This effectively prevents destructive interference from being set up in the sound chamber. The high frequency voice coil is wound with aluminum wire to hold the mass of the moving system to a minimum. The low frequency system consists of a 15-inch paper cone with its actuating diaphragm and voice coil assembly and surrounding mechanical structure.

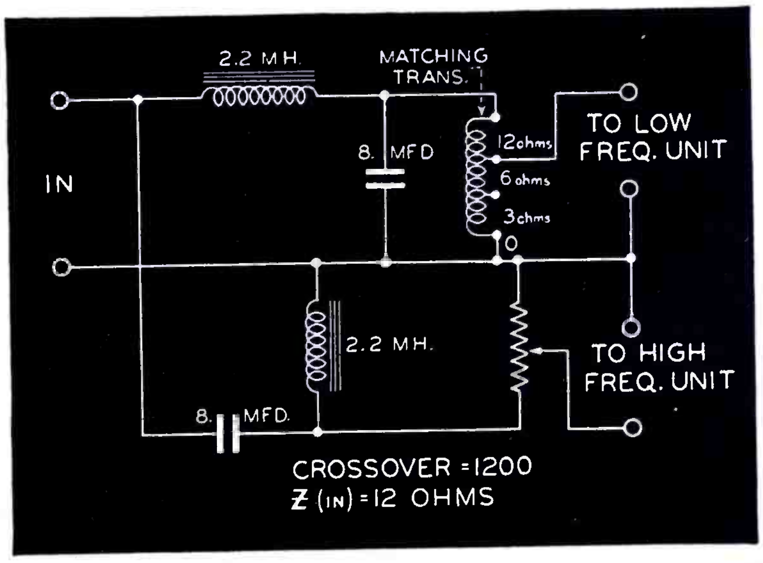
A frequency dividing network of the constant impedance type is used with a cross-over frequency of 1,200 cycles (Figure 5). The selection of the 1,200-cycle cross-over point permits the 900-cycle cut-off horn to adequately load the high frequency unit down to a frequency where little power is being transmitted by it. This eliminates any tendency to produce the distortion effects which would be caused if the acoustic loading were to cut off sharply at cross-over. It also prevents any damage to the high fre-

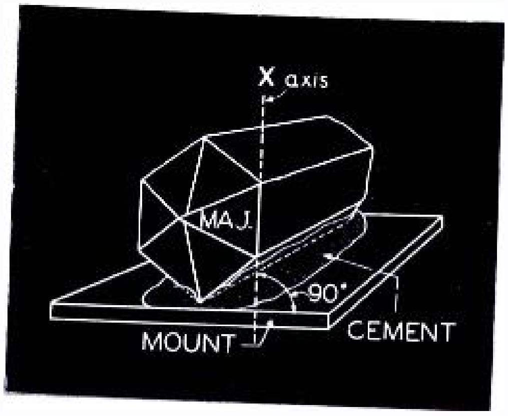
(*Continued on page* 90)

Figures 4 (left, below) and 5 (right, below)

In Figure 4 appears a cross-sectional view of the duplex speaker. In Figure 5 we have the frequency dividing network of constant impedance used with this new speaker. Note that the cross-over frequency is 1200 cycles.



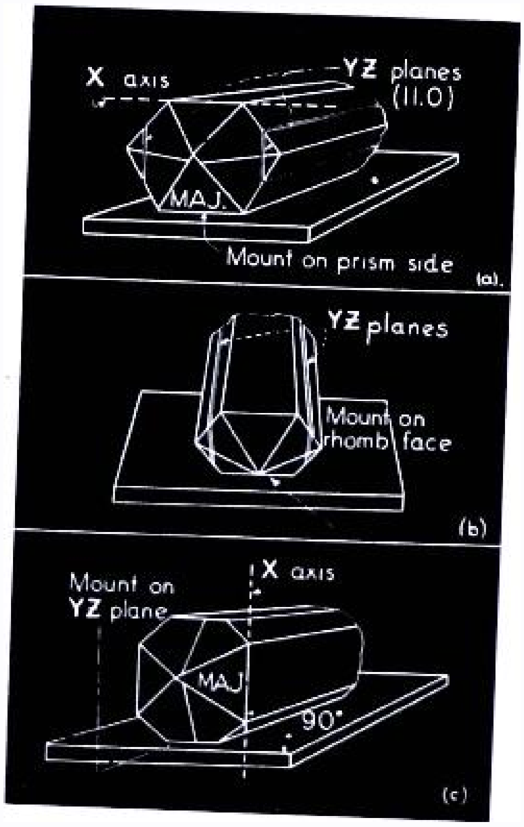




THE USE OF

by SIDNEY X. SHORE

Project Engineer, Crystal Division, North American Philips Company, Inc.



Figures 1 (top, left) and 2 (left)
Fundamental orientation position of mother quartz for cutting BT oscillator plate. The cement is built up around the two lower prism sides to physically support the quartz as well as to serve as an adhesive to the mount. In Figure 2 (a), raw quartz mounted on prism side showing X-axis direction parallel to mount and two XZ-planes cut from the two sides of the rock. At (b) appears the YZ-planes which may also be cut with a quartz mounted on any rhomb face. At (c) we see raw quartz remounted on one of the YZ-planes with the X-axis perpendicular to the mount as in the fundamental orientation position.

ORIENTATION means for mounting quartz for sawing have been developed for great accuracy. The actual procedure to be followed in the factory should be as foolproof and universal as it can be made.

Perhaps the simplest procedure would be to utilize a once-and-for all orientation and mounting technique to handle all quartz cutting in the same way, if such a development were feasible. If natural quartz crystals were homogeneous, alike in shape, unflawed and untwinned, such an ideal might be practical. But, with regular and irregular, twinned and untwinned, flawed and unflawed raw quartz of widely varying weights, the procedure to be used to gain maximum yield of finished oscillator plates per pound of raw quartz must be adapted to the individual case at hand.

Broadly speaking, raw quartz falls into regular or faced and irregular or unfaced categories. Broadly speaking, there are also two orientation procedures; first, orientation for direct wafering from the raw quartz in the proper direction; and second, orientation for sawing prior to the wafering operation. The second requires, at least, two orientation and sawing steps, whereas the first requires but one step of orientation and sawing.

In order to ultimately slice the quartz crystal into wafers or blanks with the proper orientation, the entire series of preparatory measures lead to mounting the crystal so that an X-axis is parallel to the plane of the quartz saw blade, and so that the crystal may be rotated about this X-axis. The plane of the quartz saw blade is usually

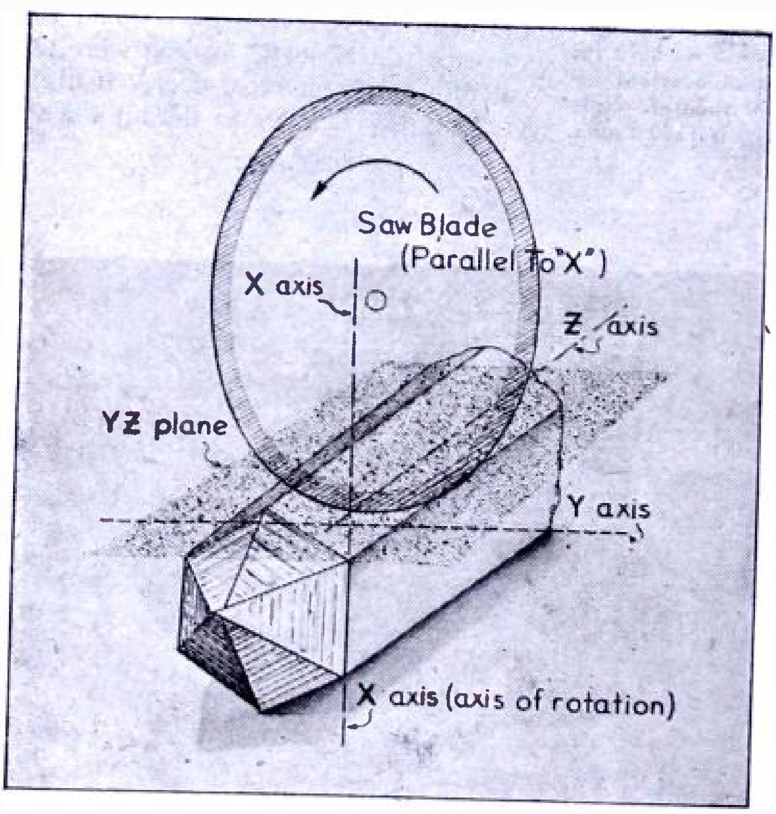
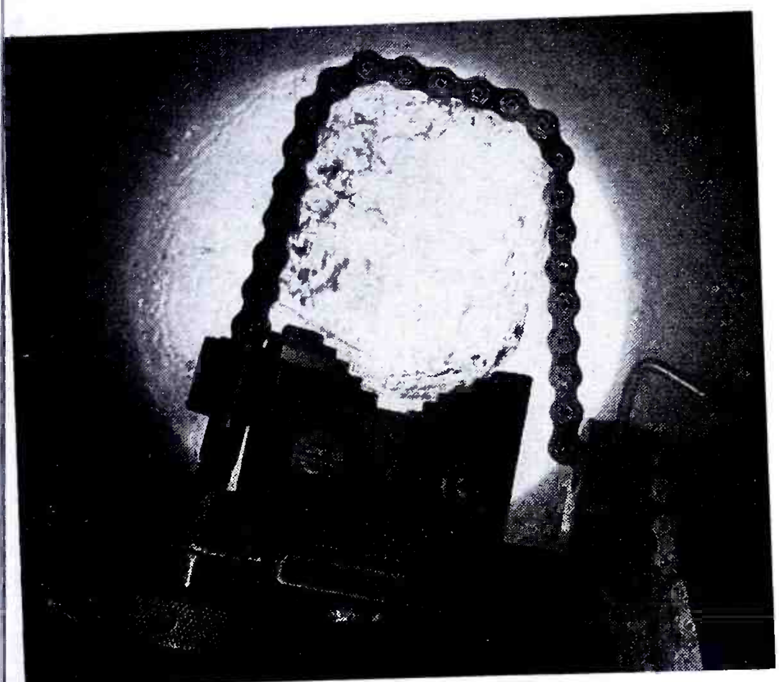


Figure 3
View of quartz crystal showing the orthogonal X-, Y- and Z-axes, the YZ-plane and the saw blade in position to cut the quartz in a direction perpendicular to the YZ-plane. Depending upon the angle which the Z-axis makes with the saw blade, by rotating the quartz about the vertical X-axis, we may saw Y, AT, BT, CT, DT, ET, FT and GT cuts.

This is the third of a series of articles covering a detailed analysis of crystal manufacture. In subsequent papers, Mr. Shore will discuss lapping, and finishing and testing.

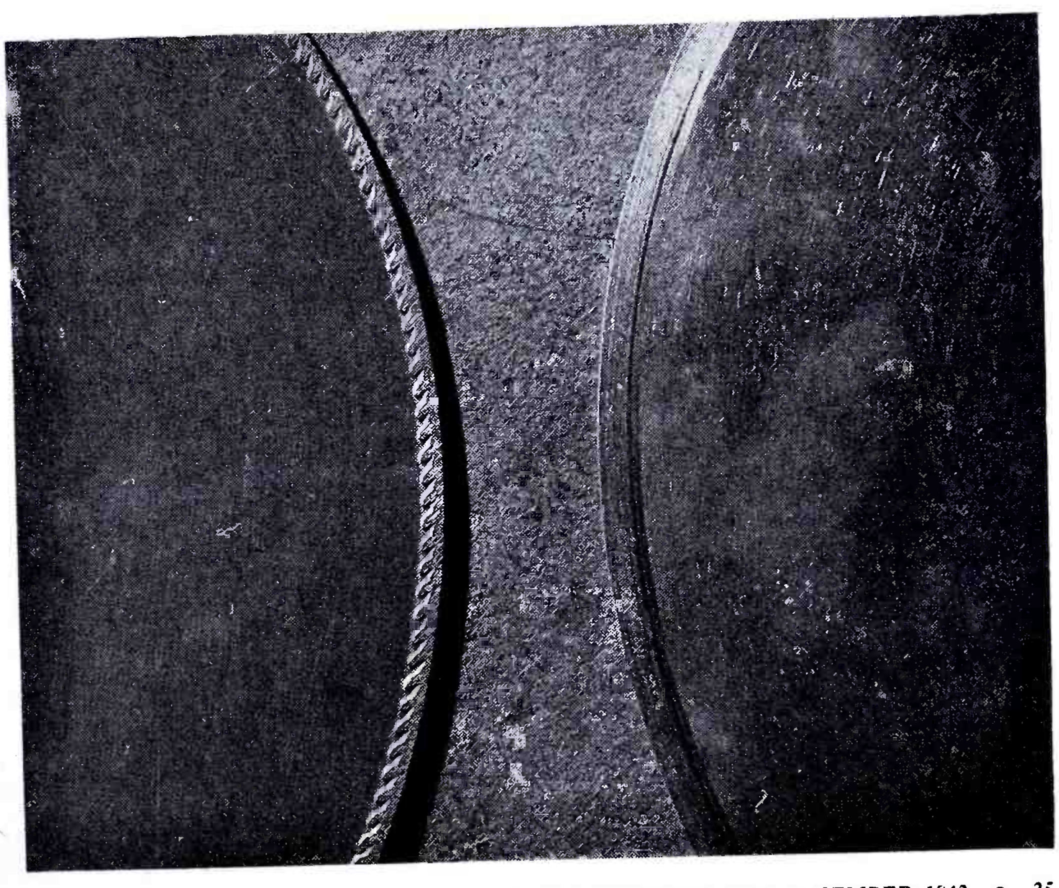
QUARTZ ORIENTATION DEVICES AND SAWING EQUIPMENT

Necessary To Maintain Accuracy of Orientation of Sawed Wafers



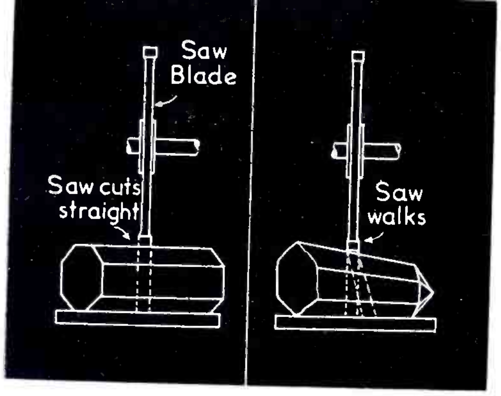
Figures 4 (left) and 5 (below)

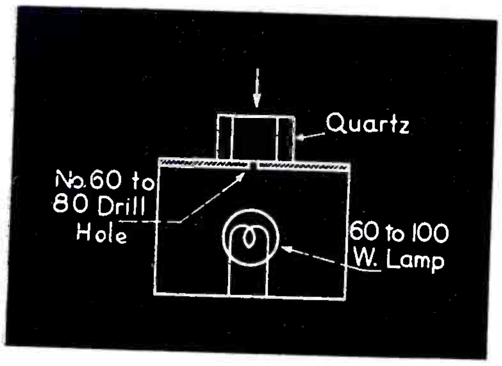
In Figure 4 we see a chain vise set in position in a polarized light oil bath, showing an unfaced crystal mounted with the Z-axis approximately vertical or parallel to the direction of propagation of polarized light. The upper polarizer (analyzer) has been moved out of position to show more clearly the actual mounting of the quartz in the chain vise and the support of the chain vise in the oil bath. Figure 5 shows two types of quartz cutting diamond saw blades. The blade at the left is the nicked-rim type having diamond dust rolled into the nicks. Blade at right is the sintered-alloy type, having the diamonds embedded in the rim during sintering.



vertical. The rotary table on which the quartz is finally mounted may rotate about a vertical or a horizontal axis. In either case, this axis of rotation is parallel to an X-axis of the crystal and, therefore, parallel to the plane of the saw blade.

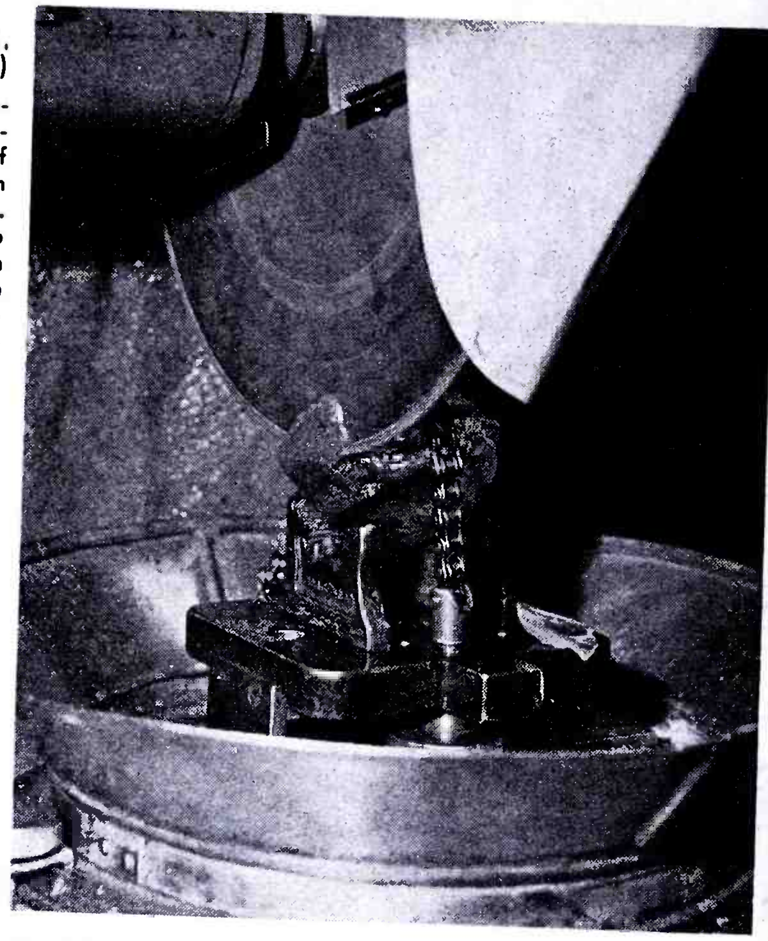
The type of quartz saw most commonly used has a mounting table which rotates about a vertical axis and, therefore, our orientation for this saw must set *X* vertical. Since *X*, *Y*, and *Z* are orthogonal axes, *Z* will be set horizontal as will the *Y* axis. Therefore, we may say that the YZ-plane, meaning the plane formed by the *Y* and *Z* axis, will be perpendicular to the saw blade and parallel to the saw table. If we can now cut quartz perpendicular to the YZ-plane, the quartz may be rotated so that the slabs cut will make any desired angle with *Z*. Any one of the common low temperature coefficient crystals which have their sur-





Figures 6 (upper left), 7 (right) and 8 (left)

At left in Figure 6, appears the preferred position of upper surface of the quartz crystal with respect to the saw blade. At right, note that the saw blade will have a tendency to walk in the direction of slope of the upper surface, if the surface is not perpendicular to the saw blade. Figure 7, the chain vise and irregular quartz in place on a quartz saw, showing a sintered saw blade cutting through the end of the quartz approximately perpendicular to Z. The other end of the quartz has already been cut off and may be seen lying on the right side of the chain vise. Figure 8 illustrates a simple pin-hole light box showing an etched Z-section in place over the pin hole.



faces parallel to an X-axis, may be cut in this fashion. For the high frequency thickness—shear *BT* oscillator plate, the saw table is set so that the saw makes the angle of 49°30′ with *Z* and 11°17′ with the vertical major rhomb, or other values determined by the turning point temperature required.

The accuracy of sawing is dependent mainly upon mechanical considerations of the quartz saw and mounts. Tolerances of ±15′ or ±30′ in *ZZ′* or *XX′* angles, respectively, are simple to measure in an x-ray machine and to hold in cutting. And, if the conoscope and x-ray machine are used in orientation, the greatest source of error in cutting becomes the physical and mechanical deficiencies inherent in the procedure. The best precautions are to align the quartz saw so that it rotates in a vertical plane with a minimum of wobble, to attempt to make the entering notch in the quartz slowly, and to have the upper surface of the quartz as nearly flat, smooth and horizontal as possible. If the mechanical or physical setup will allow the saw blade or the mounting table to shift in any fashion during sawing, each wafer should be x-rayed before the next cut is made to determine whether an angular correction is necessary. In a properly designed saw and using a properly planned procedure, the saw cuts will be true relative to one another within 5 to 10 minutes, but it is advisable to x-ray check every fourth or fifth wafer cut to save

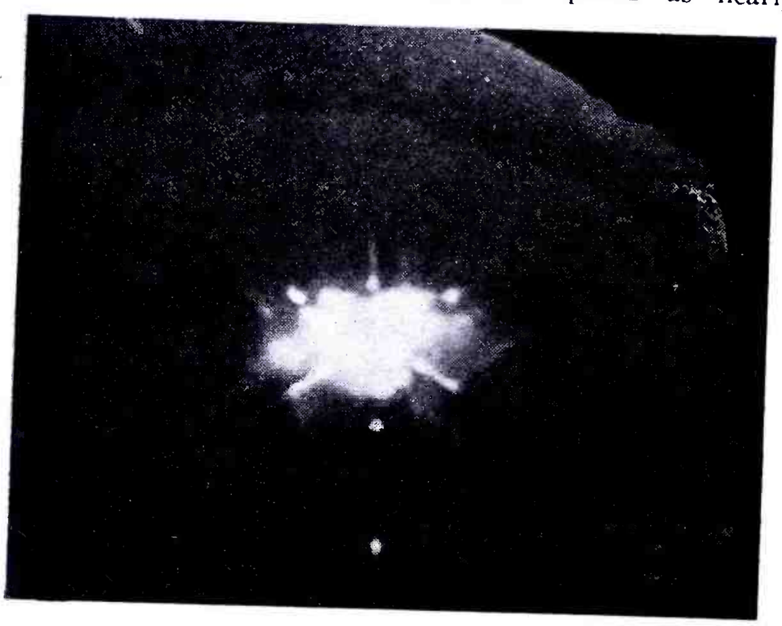
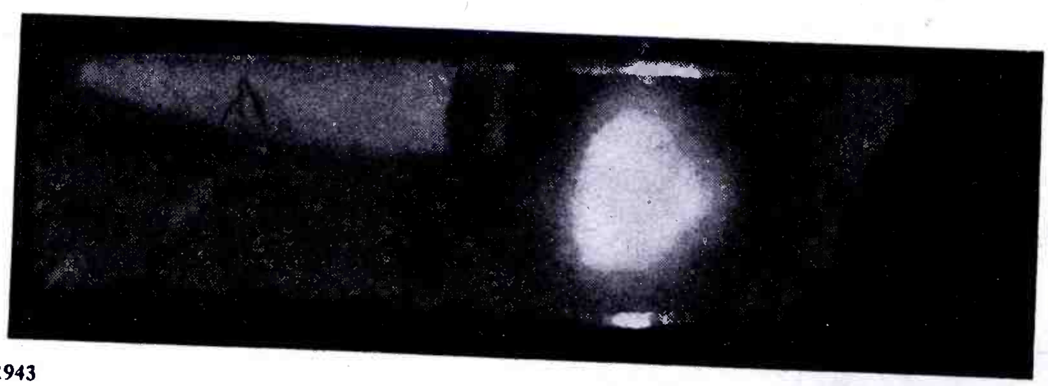


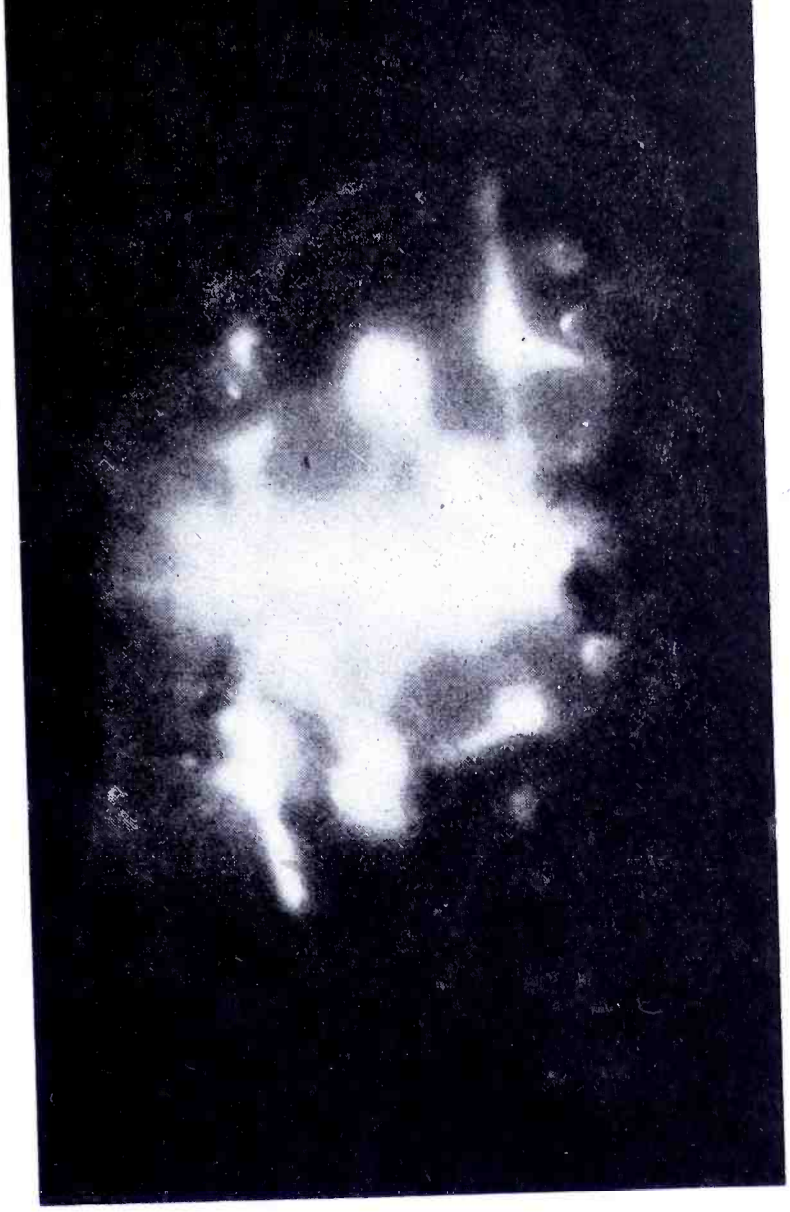
Figure 10

Etch pattern of etched Z-section viewed over pin-hole light box. This specimen was etched for twelve hours in luke warm ammonium bifluoride. The three dots in the pattern when joined by straight lines show fairly accurately the X-axis directions. The small triangle whose apices are slightly rotated with respect to the dots indicates the handedness of the quartz. The three short lines midway between the dots show the Y-axis directions.

Figure 9

Etch pattern of Z-section viewed over a pin-hole light box. This specimen of quartz was etched for 48 hours in luke warm ammonium bifluoride.





Figures 11 (left) and 12 (right)

Figure 11, a right-handed quartz etched and viewed over a pin-hole light source with the positive end of the X-axis (on compression) down. The surface viewed to see this typical Z pattern is the YZ-plane. Figure 12 shows a specimen of left-handed quartz viewed under the same conditions. Note that in this specimen the major rhomb direction is approximated by the irregular cleavage of the upper left-hand surface of the quartz. The minor rhomb appears at the upper right-hand surface, approximately parallel to the inclined portion of the Z-pattern. Halation makes these photographs slightly fuzzy.

additional processing later. The orientation means available are: mechanical and physical; optical, including the use of plane polarized light or characteristic etch patterns; and the x-ray machine and its accessories.

As stated before, mechanical orientation by the use of growth lines and machinist's squares is primitive and subject to much human error.

If the best surface examination for twinning is to be made, the raw quartz should first be sandblasted and then etched. This would largely erase the landmarks used in mechanical orientation. Thus the technique should utilize the conoscope, pin-hole etch pattern light box, and the x-ray machine in any efficient combination.

Faced quartz may be sawed without the use of swivel or universal joint mounting fixtures entirely. Knowing that a prism side of a rhomb face is parallel to an X-axis, a *mother* may be mounted on a glass plate on either a prism side or a rhomb face. The YZ-plane may be set approximately parallel to an edge of the glass with a stauroscope. YZ is perpendicular to X and therefore, also perpendicular to the surface of the glass. If the glass plate

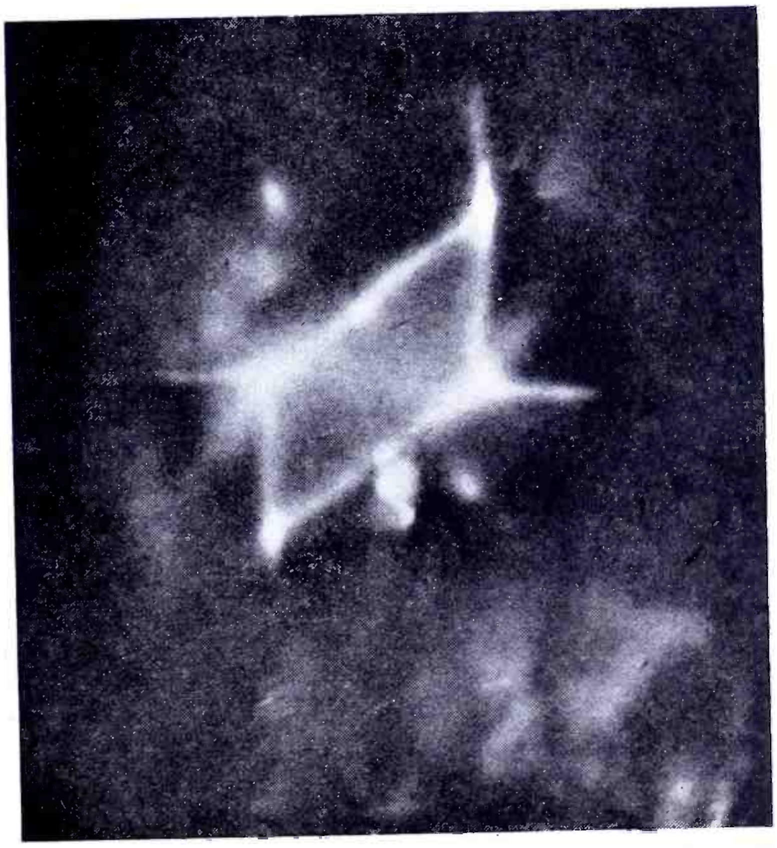


Figure 13

Right-handed quartz showing etch pattern of parallelogram figure.

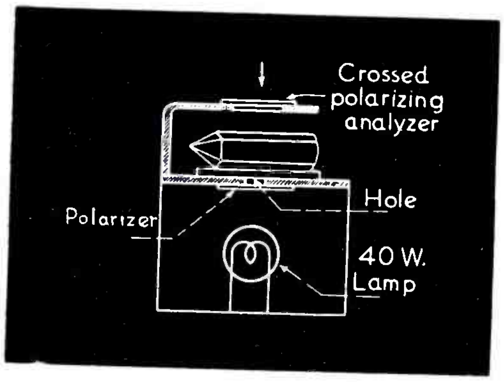
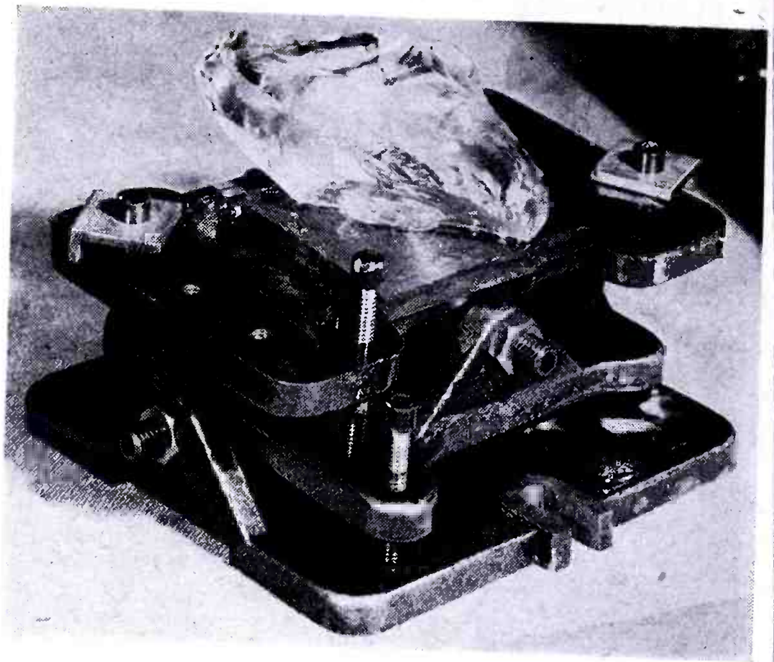


Figure 14

Simple stauroscope, used in orienting the Z-axis of a quartz crystal parallel to an edge of the glass mounting surface.

Figure 15

A two-way swivel fixture for the mounting and orientation of raw quartz, showing an unfaced crystal cemented to a glass plate and mounted on the upper plate of the fixture. The upper plate is tilted first in the conoscope to adjust Z parallel to the base of the fixture. Then the lower plate is tilted in the x-ray apparatus to adjust X perpendicular to the base.



is fastened to the horizontal saw table with *YZ* parallel to the blade, a 11.0 plane may be cut immediately. The quartz need only be etched, have the major rhomb identified over a pin hole light source, remounted on glass on its 11.0 plane, and then wafered. This technique resembles the Y-bar method which will be described later.

In a search for a universal sawing method, a procedure useful for wafering faced or unfaced quartz was developed. In this technique, after the sandblast and etch operation on the raw quartz, if the quartz appears to be fairly free of twinning, and if the twinning boundaries are not apparently planar but are skew curves, the raw quartz is immersed in a vertical conoscope with a chain vise attachment. The vise is fixed so that its base is parallel to the direction of propagation of light. When the quartz is positioned so that the concentric ring pattern appears centered it is locked in the chain vise. The vise is then set on the saw table and two sections of quartz are cut approximately perpendicular to *Z* within 5° to 10°. Extreme accuracy is not necessary. The approximate Z-section is etched. After etching, one of the cut surfaces is placed over the pinhole light source and an etch pattern is formed at the upper surface. This pattern shows us the direction of the X-axes very closely. A marking jig may be used to rule three lines to indicate the X-axes. If the cut surfaces are now set vertical and the quartz is rotated about *Z* while over the pinhole light source, the parallelogram and Z-shaped etch figures illustrated previously will be visible as the negative end of *X* and the positive end of X-axes come into vertical positions over the light source. A marking may be made on the quartz to indicate the major rhomb which will be used. After this marking the Z-section is clamped in a simple lever vise on the saw table and a surface is cut perpendicular to the X-axis which was used to locate the major rhomb. This surface will be the final mounting surface and may be within 5° to 10° away in any direction from a true YZ-plane. This approximate YZ-plane is now glued to a glass plate in such fashion that the Z-axis is set parallel to a trued

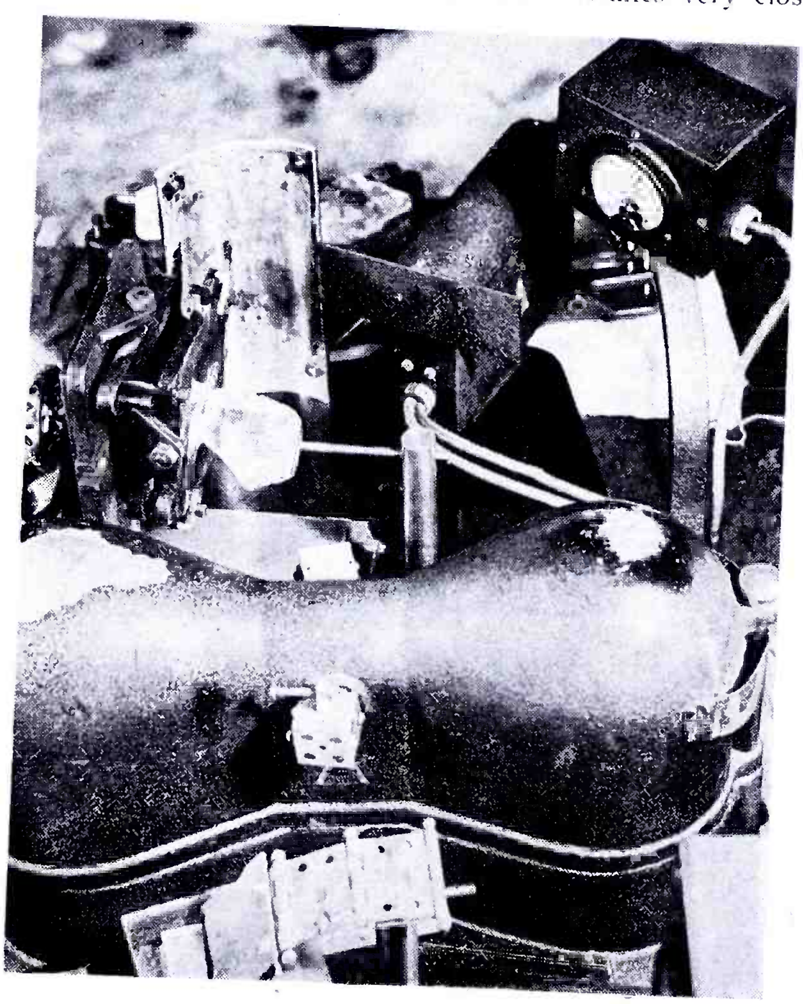
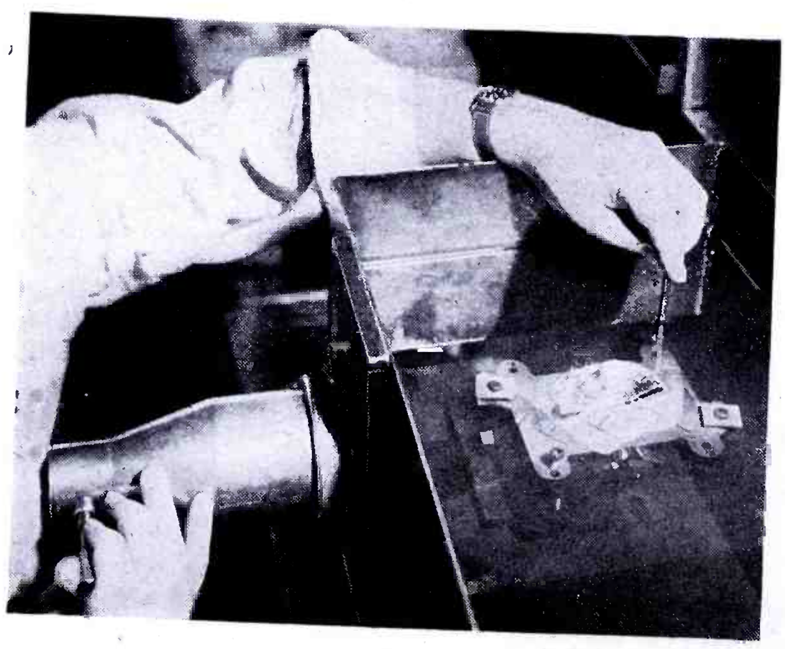
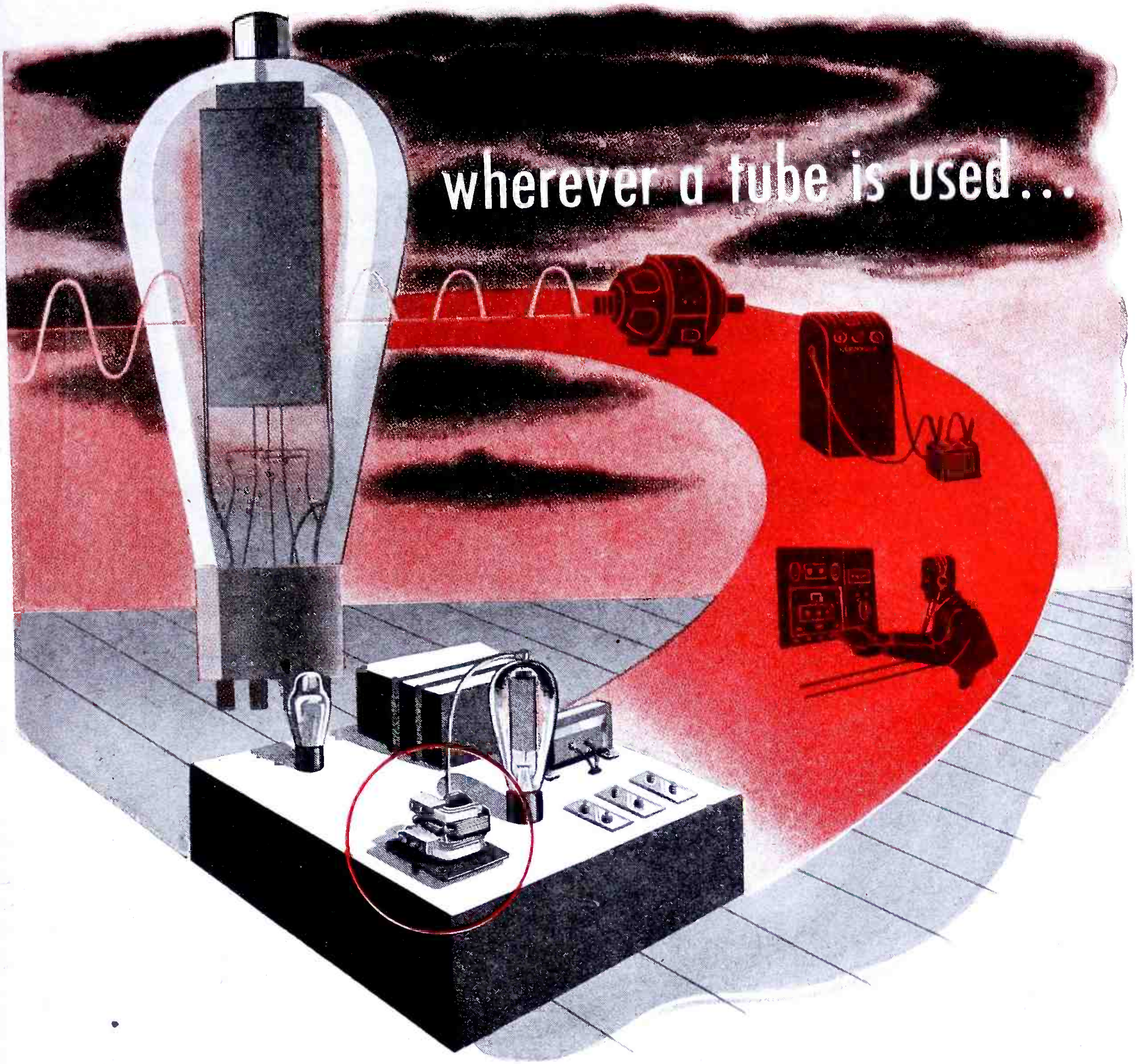


Figure 16 (below) and 17 (left)

Figure 16 shows a two-way swivel fixture in place in the conoscope, with the Z-axis being aligned. Figure 17 shows a two-way swivel fixture mounted on an x-ray machine properly oriented for the X-axis alignment.





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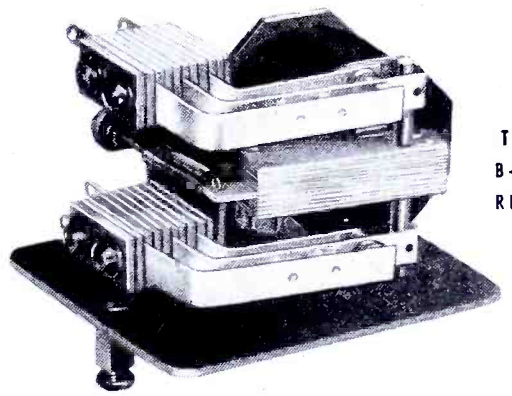

TYPE B-100 RELAY

Electronic rectification, long used to convert A.C. to D.C. power, is now coming into use to operate variable speed D.C. motors . . . battery chargers, etc. In such applications, the type B-100 relay shown above is often used.

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Figure 18

X-ray operator measuring the angle of a cut surface of quartz crystal with respect to one of the atomic reference planes. A goniometer, which consists of a rotating table with a vertical reference surface against which the quartz wafer rests and a radius attached to the rotating table which terminates at an arc calibrated in degrees and minutes, is used as the angle measuring means.

edge of the glass plate serving as a reference edge. This parallelism alignment is made with a simple stauroscope and can easily be held within 4 degrees.

The glass plate is mounted on the upper platform of the two way swivel fixture immersed in the conoscope oil bath. The plate is rotated slightly on the platform until the concentric Z-axis ring pattern is centered within the vertical cross hairs. Then the upper plate is tilted to account for the Z error in sawing the YZ-plane, until the rings are centered on the horizontal cross hair. When it is locked in place at this point the Z-axis is parallel to the plane of the base of the mounting fixture and to its reference edge.

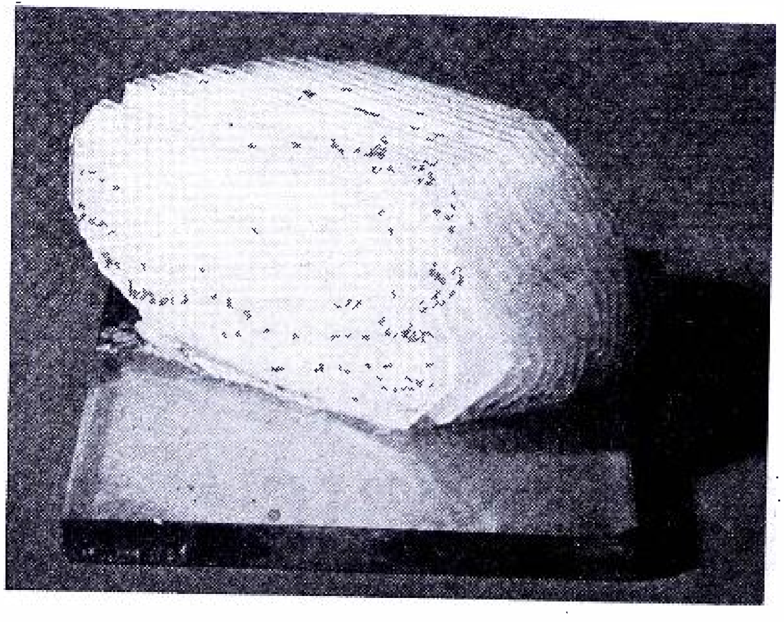
The fixture is removed from the conoscope and set on the x-ray machine specially built for the purpose of aligning the X-axis perpendicular to the plane of the base of the mounting fixture. The YZ-plane is set parallel to the base of the fixture by rocking the lower swivel plate until a maximum deflection occurs on the 0-1 ma meter in the Geiger-Muller tube amplifier plate circuit. In this position the lower swivel plate is locked and the quartz is ready for wafering at the BT-angle.

The wafers are usually cut .040″ to .050″ thick depending upon the final frequency desired and the rigidity or flexibility of the saw blade.

Quartz saw blades are made in several ways. The simplest involves the rolling of some diamond dust into the edge of a copper disk, thereby imbedding the dust in its rim. When used to cut quartz the copper is abraded by the hard quartz, leaving the diamonds exposed, which in turn abrade the quartz. The sawing rim of the blade must be thicker than the body of the disk to provide clearance for the blade to pass into the saw cut. If the disk is not relieved, any vibration of the blade will tend to crack off the .040″ thick slice being cut. Much heat is generated at the line of abrasion of the quartz by the saw blade. A coolant and lubricant of deodorized kerosene or light oil or a mixture of both is in common use. This may be sprayed directly onto the blade, into the cut, or fed into a cup shaped flange on the blade, having radial holes to eject the lubricant onto the blade and into the cut by centrifugal force.

Better saw blades are made of copper or steel disks having short radial slots at the edge into which diamond dust is forced. The slots are peened to trap the dust later exposed after the retaining metal is abraded by the quartz. An excellent blade is made by a sintering process, where large pressures and high temperatures are applied to a powdered alloy to form the disc. These saws are used for speeds up to 8000 surface feet per minute and are manufactured in sizes from 3″ to 18″ in diameter. Diamond saw blades have replaced the old type *mud* saws for obvious reasons. The *mud* saw was a disk of copper or steel which *ploughed through* a mixture of rough abrasive and water or kerosene. The abrasive, usually carborundum, was picked up by the saw in its circular travel and ripped into the quartz. Unfortunately, the silicon carbide wasn't hard enough to slice the quartz before the quartz wore away a large part of the saw blade. Cut surfaces were thus stepped and uneven.

The orientation method described may be used for faced and unfaced



Figures 19 (left) and 20 (below)

Figure 19 shows a wafered quartz crystal with the wafers still in place, cemented to the glass mounting base. Note that the top surface of the quartz is parallel to the mounting base and therefore was perpendicular to the quartz saw blade during cutting. Figure 20 shows a wafered Y-bar with painted out twin-section at the right-hand end of the bar. This section was not wafered because of the twinning.

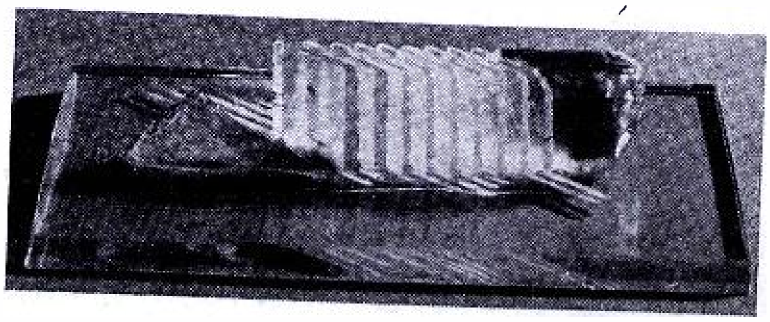


Figure 21

Crystal oscillator plate testing and calibrating position. This equipment is correlated to the standard audio and radio frequency signals transmitted by WWV.

quartz alike and yields excellent results with fairly good raw quartz that is not too large. Wafering large quartz directly may be undesirable because the blade often *walks* during a large area of cut, giving a stepped surface or an off-angle surface.

With large crystals of raw quartz, the Z-section Y-bar method is often used. In this method, the quartz is first cut into sections from ⅜" to several inches thick with faces perpendicular to *Z*. To cut a Z-section, it is only necessary to orient the Z-axis parallel to the base of a simple swivel fixture in the conoscope and then saw perpendicular to *Z*. The saw cut is a 00.3 plane or an XY-plane. If the section is mounted on a glass plate on its 00.3 plane, the *YZ* or 11.0 plane may be located in the x-ray machine and set parallel to an edge of the glass plate. Then the Z-section may be sawed parallel to *Y* and *Z* along the 11.0 plane. Sections whose width approximates the width of the final oscillator plate may be sawed in this fashion. These sections are called Y-bars. If the Z-section were etched, the twinning would be visible and the most productive *YZ* direction could be chosen for sawing.

The Y-bars should be etched and the major rhomb located over the pin hole light box. Then the bars are ready to be mounted on the YZ-plane for wafering.

Three mountings on glass and three sawings are necessary for this technique. And each sawing requires a test cut and then an x-ray check of the angle of cut.

With the two-way swivel fixture shown, it is possible to cut Y-bars from unfaced raw quartz more easily. *Z* is oriented, as described in the first method, and the same approximate Z-section is cut in the chain vise. The etching is done as usual, but now the X-axes are marked on the cut ends. An approximate XZ-plane, 10.0, is cut for mounting on glass. The glass mounted quartz is set on the two-way swivel fixture, then into the conoscope and finally to the x-ray machine to align *Z* and X respectively parallel to the base of the fixture. Now the 11.0 planes may be cut in the saw and from here the process follows the one just described. To save mounting time the chain vise is used to great advantage.

Faced quartz may be mounted on a prism side on glass and then in the two-way swivel fixture and then Y-barred without further ado since the prism side is almost a 10.0 plane.

For direct wafering faced quartz, an approximate YZ-plane may be either sawed or ground on an abrasive wheel. Then the quartz is mounted and oriented for *Z*, and *Y* parallel to the fixture base, and wafered as in the first method.

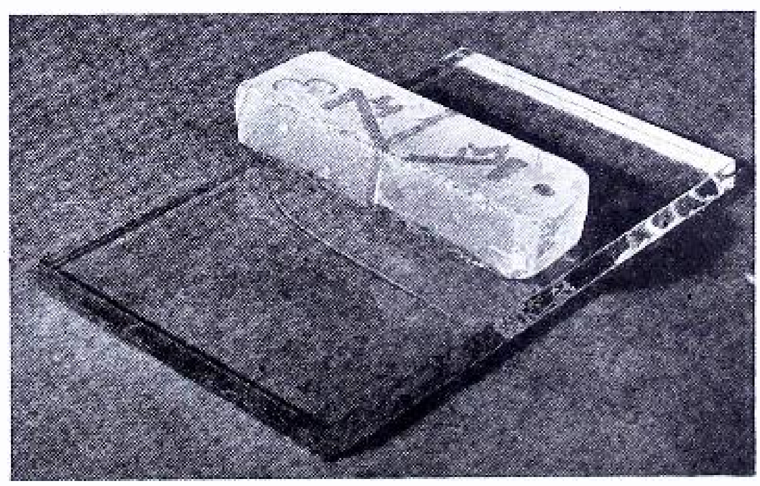
An advantage of bar cutting before wafering is an economy of quartz when twinning boundaries are approximately parallel to *Z*. Then each portion of the bar may be sawed in the proper direction for a minimum waste and a maximum yield from twinned volumes.

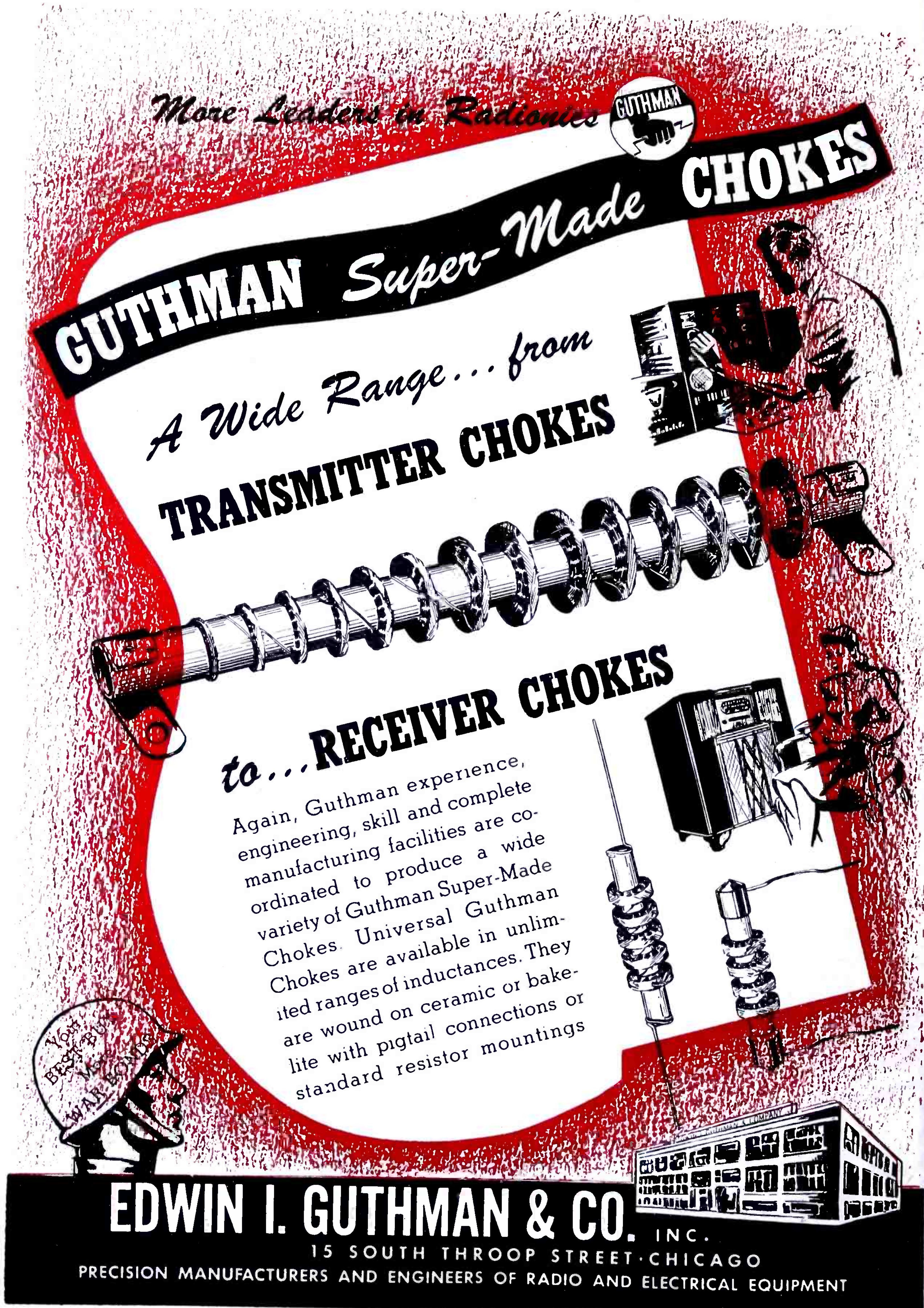
If an accurate Z-section has been cut, a rodometer (spot centering jig) may be used to locate the X-axes instead of the x-ray machine although the x-ray machine is the more reliable and convenient tool. The XY-plane of the Z-section must be lapped in the

(*Continued on page* 91)

Figure 22

Mounted Y-bar showing two twin sections which can be cut in different directions, each to yield good BT-cut wafers. The inverted check marks and the letters *M* painted on the upper surface of the bar show two adjacent sides of the parallelogram etch figure, the small side indicating the approximate Z-direction and the long side marked *M* indicating the approximate major rhomb direction for each portion of the twinning.

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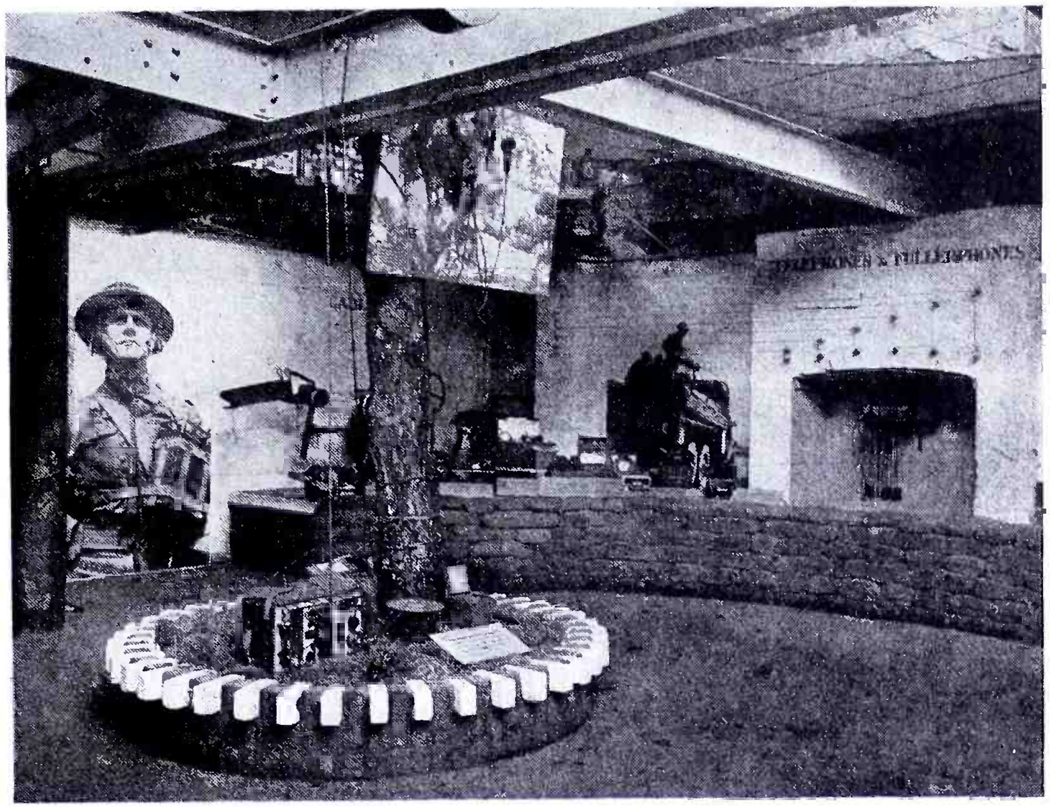
BRITISH COMMUNICATIONS EXHIBIT

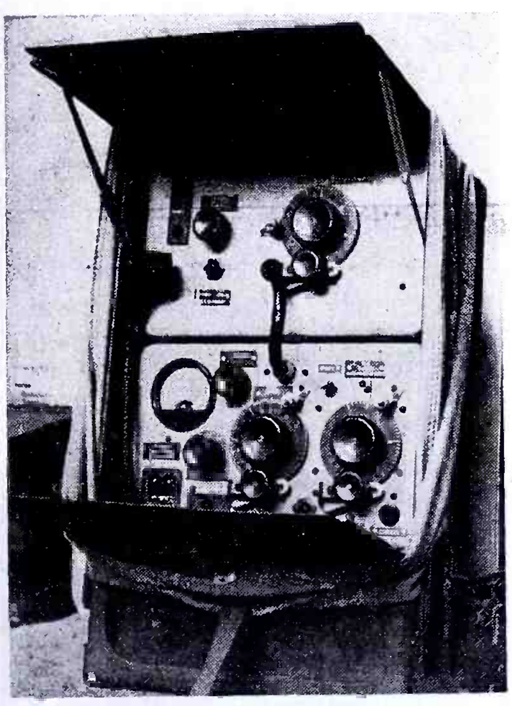
(Courtesy Electronic Engineering, London, England)

Transceiver exhibited at Army show. It is equipped with headphones and a laryngaphone that is used by paratroops and infantry platoons. Operated from a dry battery. The complete unit weighs 13½ pounds. Note the laryngaphone, which is of a carbon type construction, on the girl's throat.



(British Official Photo)

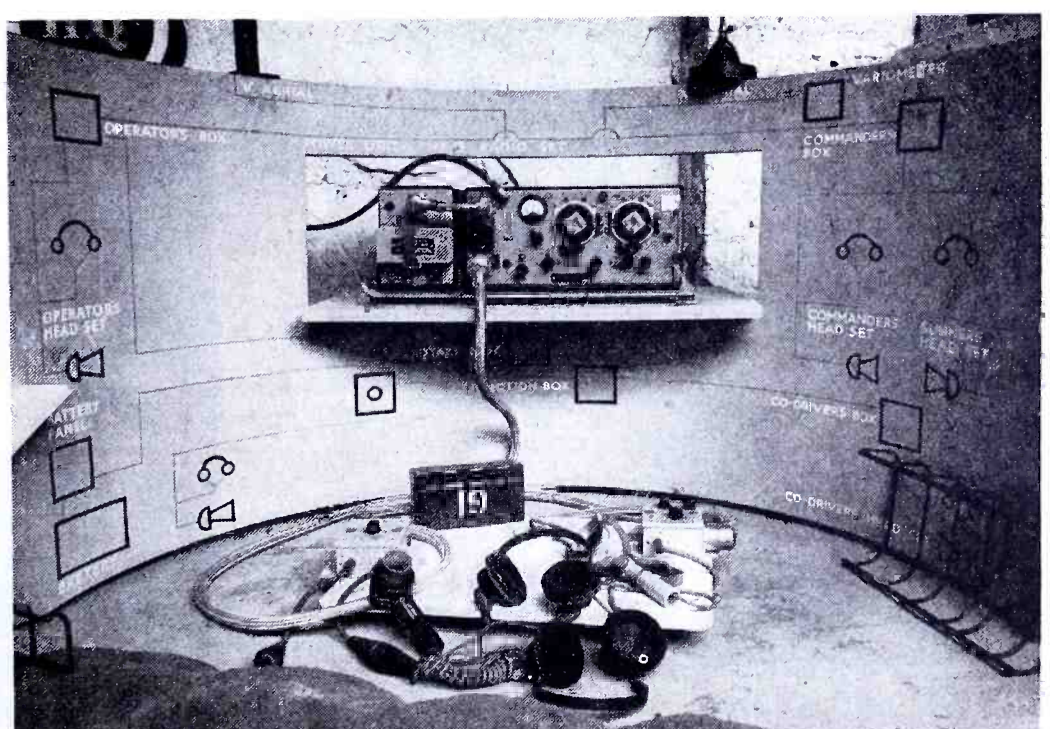
Above appears an over-all view of the communications section of the British Army equipment exhibition recently held in London. American receivers were also included in this exhibition. The portable unit being worn by the infantryman in the photograph is a type 38 pack unit. Below appears a close-up of a type 19 tank arrangement that was on exhibit. This unit is a 15-tube affair for three-way communications—tank to commander, tank to tank, and intercommunication in the tanks. The phones are fitted with ***snatch plugs*** to provide a quick getaway by the crew.



(Courtesy Electronic Engineering, London, England)

British pack set, No. 18, shown in London exhibit. This is a 7-tube set for use by infantry battalions, for either code or 'phone. The transmitter, receiver and batteries are mounted in a single case weighing 35 pounds. It is carried on the back, with a second man operating it.

(Courtesy Electronic Engineering, London, England)



TELEVISION COVERAGE

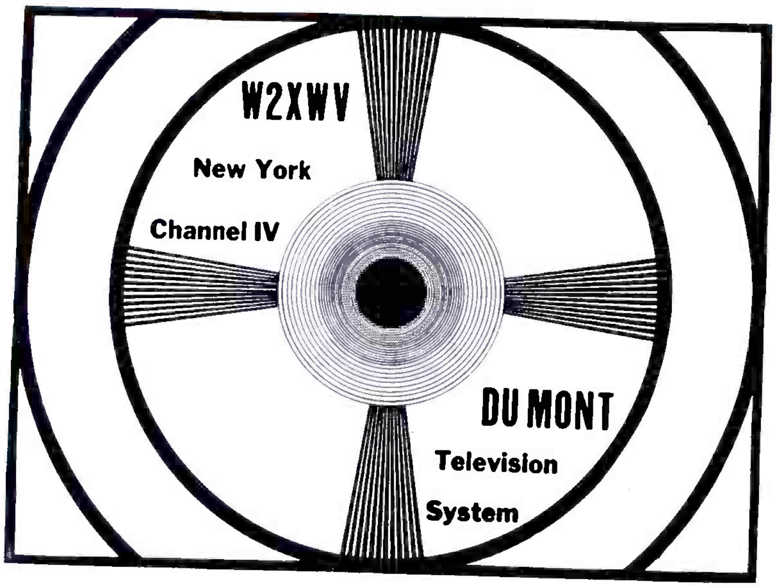
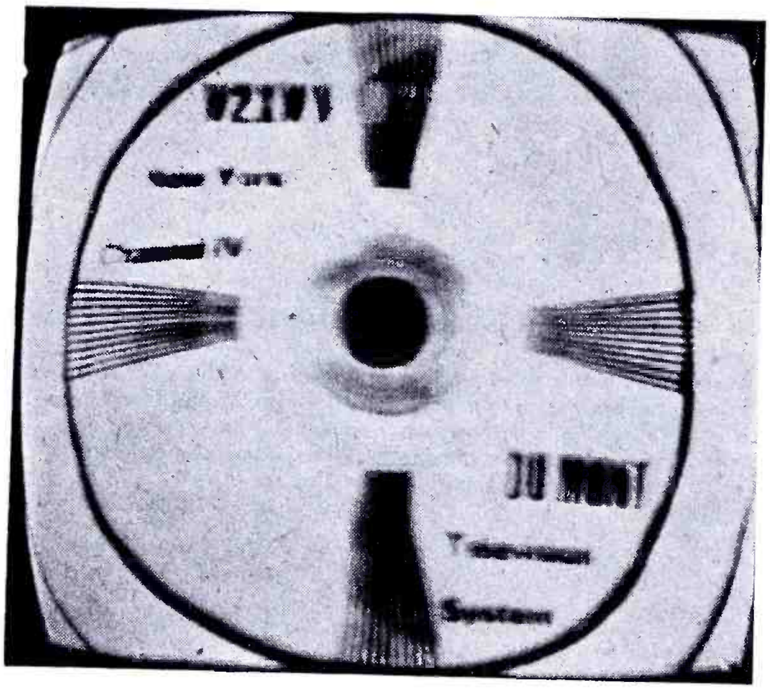


Figure 1
DuMont station W2XWV pattern as it appears in the original.

Highlights of Paper on "Television Broadcast Coverage", Presented By Allen DuMont And Dr. T. Goldsmith, Jr., Before IRE And Radio Club of America

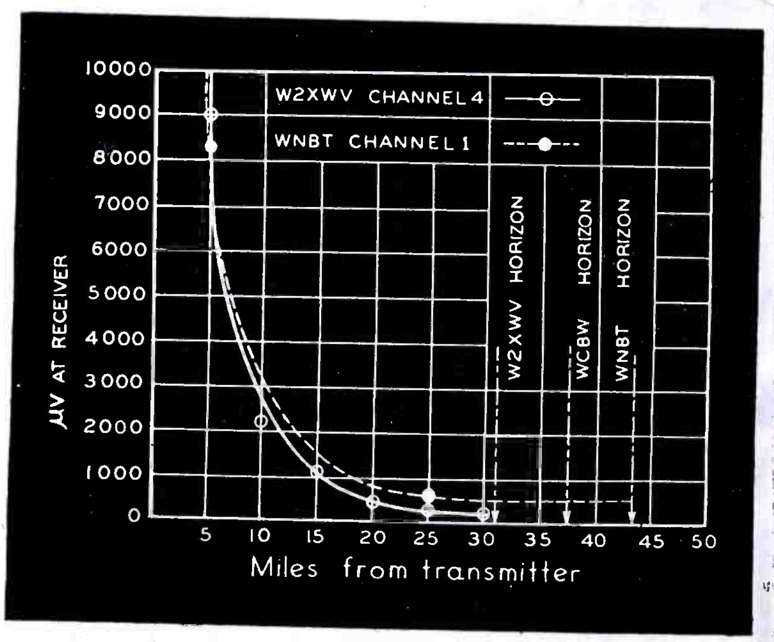


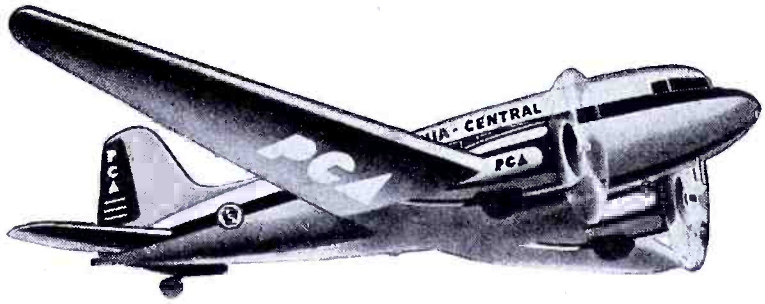
Figures 2 (left), 3 (left, below), and 4 (right, below)
Figure 2 shows a smear ghost with vertical wedged lines lacking definition, and pattern generally distorted. In Figure 3 we have a typical ghost or fixed ghost, with a weaker duplicate pattern displaced to the right of the main pattern. Figure 4 illustrates response data, recorded during tests.

SEVERAL months ago, Allen B. DuMont and Dr. Thomas T. Goldsmith, Jr., of the Allen B. DuMont Laboratories, began an exhaustive field survey of television signals being transmitted by stations WNBT, WCBW and W2XWV, all of the New York City area. Receivers permanently installed in the metropolitan area and special receiving equipment aboard the cruiser Hurricane II which cruised around the New York waters, were used. And to permit a thorough analysis of the tests, continuous recordings of field signal strength, and still photographs and motion pictures of patterns were prepared. The results of these observation were then recorded in an extensive report.

This interesting report, entitled *Television Broadcast Coverage* was presented before a joint session of the

(*Continued on page* 92)





WILCOX IS IN SERVICE

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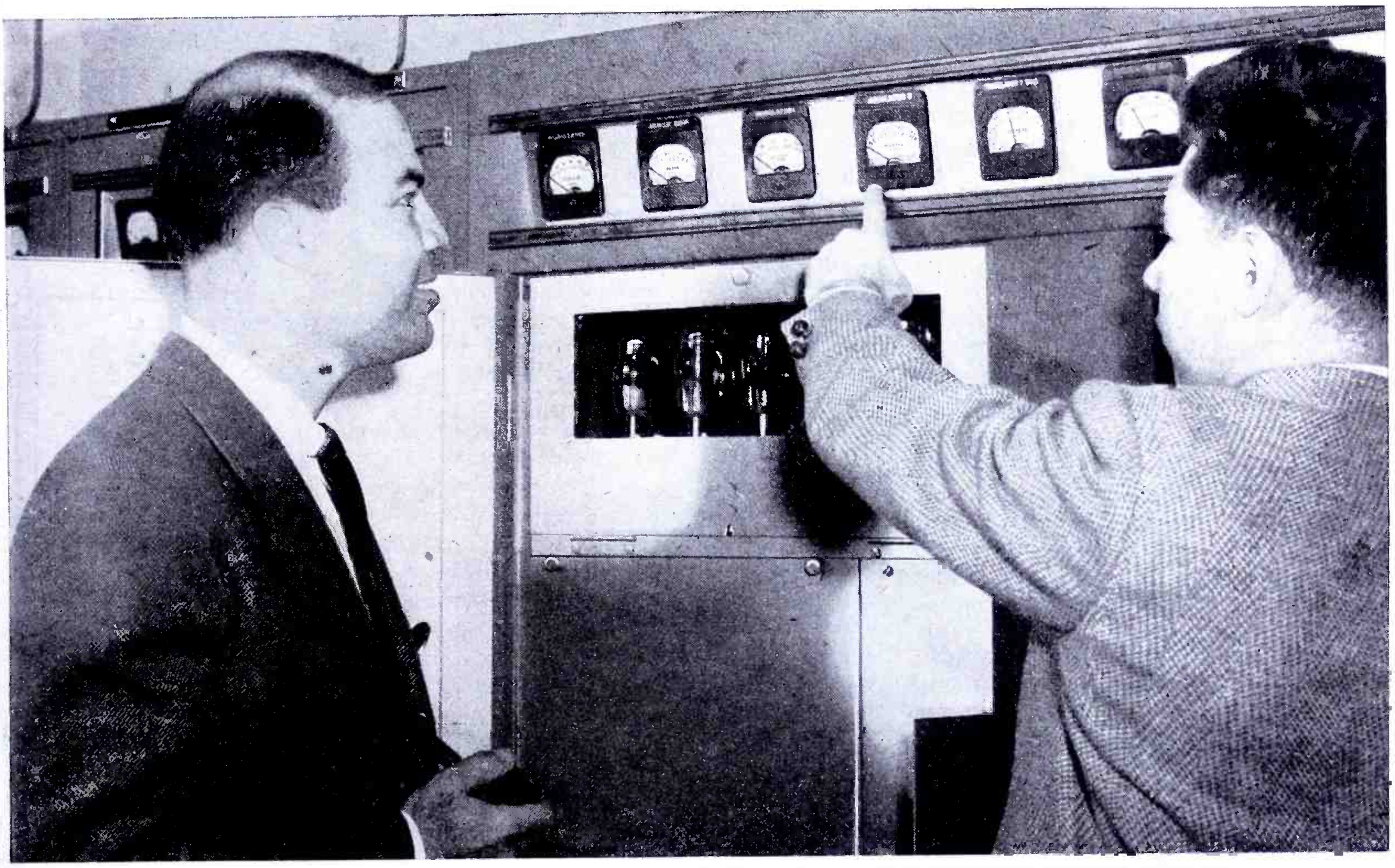

Photograph, courtesy PENNSYLVANIA-CENTRAL AIRLINES,
(left) B. J. Vierling, Supt., Maintenance, (right) Earl Raymond, Chief, Ground Station Maintenance.

"Installation of Wilcox transmitters, at many of our points, has given our communications the high degree of dependability so necessary for airline operations," states Mr. Earl Raymond of Pennsylvania-Central Airlines. In addition to installations on major airlines throughout the United States, Wilcox radio equipment is being used now in connection with world-wide military aircraft operations.

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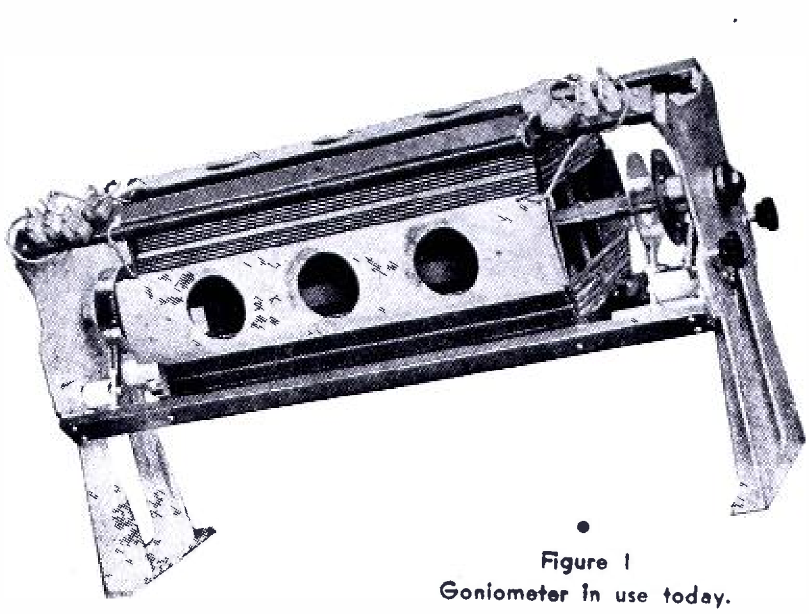

Figure 1
Goniometer in use today.

THE RADIO

by **WILLIAM W. MACALPINE**

Communications Engineer
Federal Telephone & Radio Corporation

ONE of the most interesting of the aviation fostered developments of the radio industry, and one now accepted as an indispensable circuit element in all radio range equipment, is the variable coupling inductor known as the *goniometer*. Though simple in function, and apparently simple in mechanical construction, today's version of this device incorporates subtleties of design and engineering refinements comparable with the most delicate components of the radio circuit itself.

Prior to the development of a suitable goniometer, the earlier radio range systems transferred energy from the transmitter through a keying relay directly to two crossed loop antennas with the disadvantage that a change in direction of the courses could be effected only by physical rotation of the loop antennas. The high degree of accuracy attained with the modern goniometer not only avoids this disadvantage but also keeps pace with the many other important improvements incorporated in the present highly stable and reliable radio range facility.

The use of the goniometer in radio range equipment dates back somewhat more than a decade. It was not a new invention at the time, but rather the adaptation of an early type of radio device known as the *radiogoniometer* used in the receiver of the well known Bellini-Tosi direction finder. Greatly refined versions of the radiogoniometer are still used in many modern direction finders for general and certain specialized applications.*

The goniometer is essentially a radio frequency transformer employed for the purpose of coupling r-f energy from a radio transmitter to the antenna array of a radio range system, in such a manner as to make possible the geographical *rotation* of the *courses* or *beams* being broadcast, thereby avoiding the necessity of aligning the antenna array for the desired courses. On account of the power it must handle, it is necessarily a large component, roughly 20 inches long by 12 inches diameter, and usually occupies the major portion of an accessory piece of station equipment called the coupling unit, in which are also housed the necessary tuning capacitors, together with a resistor bank and phase shifting networks used for other deviations of the range courses known as *course squeezing* and *course bending*.

In construction the goniometer consists of a cylindrical stator, usually of bakelite or similar phenolic base material, within which a smaller, but similar cylindrical rotor may be turned concentrically on the common axis. Two separate primaries are wound longitudinally, with winding directions perpendicular to each other on the stator, and two separate secondaries, similarly, on the rotor, in such a manner that either of the secondaries may be coupled wholly to one or the other of the primary windings, or partially to both. Contacts to the secondary windings on the rotor are made through two pairs of collector rings and brushes.

In Figure 1 appears a modern type of radio range goniometer. On the stator tube are seen the two equal halves of one of the primary windings with their horizontal end conductors. The other primary winding has vertical end conductors, the plane o its turns being perpendicular to tha of the first primary. The rotor shaft slip rings and brushes are discernible as well as part of the rotor form an windings, seen through the large ac cess holes in the stator tube. On one o the horizontal tie rods are seen some of the primary terminals, and the capacitors feeding a pair of compen sating shield windings assembled with in the stator tube. The front suppor bracket carries a drive knob, a lock ing knob, and the hub to which wil be pinned a large dial calibrated in 36 equal divisions around its circumfer ence, all these being located on th front panel of the completed coupling unit. A precise reduction gear drive is assembled on the rear surface of the front support bracket.

From the construction it is apparent since the two primary windings are mutually perpendicular, and the two secondary windings likewise, tha when the windings on rotor and stator are exactly aligned, one secondary wil have maximum coupling to one pri mary, and nominally zero coupling t the other primary. Similarly the othe secondary will have maximum coupling to the other primary and nominally zero coupling to the first primary. Fo this position the index will be at 0° on the dial attached to the rotor. Also if the rotor be turned 90°, the wind ings will again be aligned, but the first secondary will now be coupled by a maximum amount to the second pri mary, and the second secondary by a maximum amount to the first primary At any position of the rotor other than 0°, or a multiple of 90°, both sec ondaries will be coupled in part to each of the primaries. The windings are so designed that each secondary will be coupled to each primary by an amount substantially proportional to the sine or the cosine, as the case

* COMMUNICATIONS, Page 33, January, 1943. The application of the goniometer in radio direction finding systems is treated at length in a standard work on that subject, *Wireless Direction Finding* by R. Keen, published by Iliffe, London. Treatments of the radio range beacon system are found in the various electrical and radio engineering handbooks and in *Aeronautical Radio Engineering* by P. C. Sandretto, McGraw-Hill, 1942.

RANGE GONIOMETER

An Exposition of Its Principles, Design and Modern Applications

may be, of the angular position of the otor.

For an understanding of the manner in which the goniometer is used o adjust the orientation of the radio beams, it is advisable first to review the manner in which the radio range signals are broadcast, and the respective courses established.

Principles of Radio Range Transmission

The course along which the aircraft pilot is guided by a radio range signal source is actually an equi-signal zone lying between the two directional radiation fields set up by two vertical crossed-loop antennas, or by two pairs of vertical radiators. The horizontal pattern of each of these directional fields is in the form of a figure-of-eight, the axis of which lies in the plane of the loop or vertical radiators emitting it.

The combined pattern of the fields of the two antenna systems is then a sort of cloverleaf with four overlapping lobes at right angles to each other. The two figure-of-eight fields are distinguished by broadcasting a dash-dot or *N* combination of signals in one field, and a dot-dash or *A* combination in the other. For simplicity and accuracy in the detection of the equi-signal zones, the keying of the two sets of signals is interlocked in such a manner that the dashes and dots of one occur during the intervals between the dots and dashes of the other. When two such sets of signals are heard with equal intensity, the resultant sound is a continuous and uniform note of the 1020 cycle-per-second frequency at which the radio range transmission is modulated. At any point outside the zone of equal intensity either the *A* set of signals or the *N* set will predominate.

The keying of the interlocking *N* and *A* signals is controlled by a motor driven mechanical keying device, by means of which also the station identification letters are sent out, once in the *N* field, then once in the *A* field following every twelfth *N-A* cycle. This occurs at intervals of about 40 seconds.

In common practice the radio range station is located a short distance from the airport to be served, and in line with the most used runway so that one course may be aligned with this runway.

When first developed, radio range equipment was operated from fixed loop antennas, but had the disadvantage that a change in the direction of courses could be effected only by physical displacement of the antennas or mechanical rotation of the crossed loops. To overcome this difficulty, a goniometer was introduced into the system. In recent years the simultaneous radio range system has taken precedence over the loop type at all larger installations. This system employs a carrier channel which is radiated from the center tower, and also a side band channel tuned 1020 cycles per second above the carrier channel and radiated by the four corner towers. Simultaneous operation is accomplished by voice modulation of the carrier channel, up to 70%, and by adjustment of the output of the side band channel to about 30% of the carrier channel field strength.

The simultaneous stations employ four corner towers comprising an Adcock antenna system, and one center tower. The four corner towers are the virtual equivalent of the vertical components of two crossed loops. Since the vertical components are the only components effective in establishing the horizontal figure-of-eight field patterns, this system has all the advantages of the loop system, and at the same time, eliminates the vertical radiation from the horizontal portions of the antennas and the consequent sky wave night effects often encountered at distances within the effective range of the facility. Time phase opposition of 180° in opposite towers to correspond with that existing in opposite sides of a loop, is effected by means of coupling transformers associated

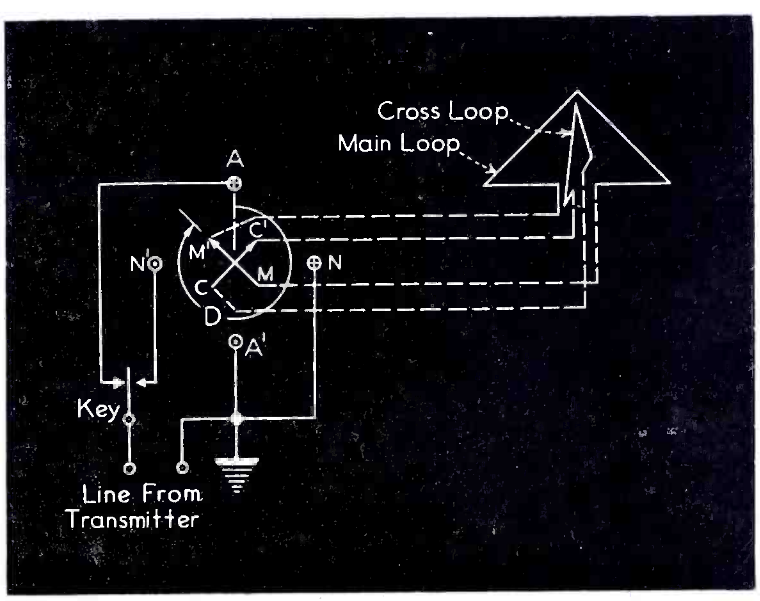

Figure 2
A simplified schematic of a goniometer, key, and loops.

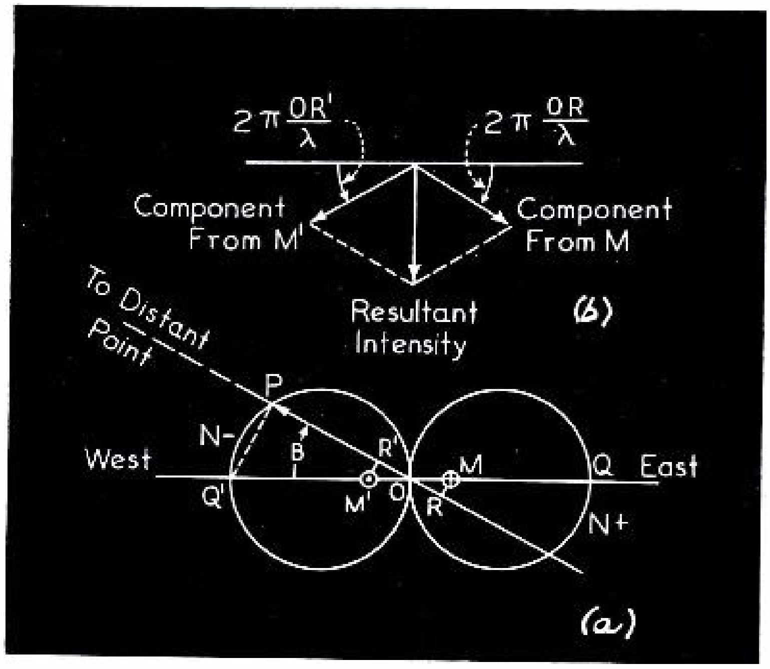

Figure 3

In (a), figure-of-eight diagram of radiation intensity distribution in the horizontal plane around a pair of equal vertical radiators carrying currents 180° apart in time phase. In (b) appears an a-c vector diagram of radiation components received at a distant point.

with the tuning equipment located at the base of each tower.

Goniometer Principles and Radiation Patterns

A schematic representation of the goniometer and associated loop antennas is shown in Figure 2. The primary windings are indicated by a section perpendicular to the axis, *NN'* representing the conductors of one primary winding, and *AA'* those of the other. The output line from the transmitter is keyed alternately to the *N* and the *A* primaries. The dots and crosses in the small circles represent the directions of current flow, the terminals of one primary being at the front of the goniometer and those of the other at the rear. Two arrows *MM'* and *CC'* represent the two rotor or secondary windings, the arrows in this case indicating schematically the direction of each winding. The dashed lines show the connections of the rotor windings to the two mutually perpendicular loop antennas. The angle *D* represents the setting of the goniometer dial.

Due to the sinusoidal characteristic of the couplings in the goniometer, it will be seen that, with the dial set at an angle *D*:

$$\text{for the } N \text{ signal } \begin{cases} I_M = I \sin D \\ I_C = I \cos D \end{cases} \quad (1)$$

and for the *A* signal

$$\begin{cases} I_M = I \sin (D + 90°) \\ I_C = I \cos (D + 90°) \end{cases} \quad (2)$$

where I_M and I_C are the amplitudes of the currents flowing in the main and cross loops, respectively, and *I* is the maximum amplitude (when the goniometer is at 0°, 90°, etc.). It can be seen from these equations, and by reference to the diagram of Figure 2, that for any goniometer rotor dial setting *D*, the signal current will flow in the main and cross loops in a certain ratio I_M/I_C. If the dial be now turned 90° the ratio will be inverted, the main loop now carrying the same current amplitude as originally carried by the cross loop, and vice versa. Furthermore, the current in one loop will remain in the same direction or time phase, while that in the other loop will be reversed. The effect is exactly the same as if the goniometer dial had remained unchanged but the loops had been turned bodily through 90° in space. The radiation field pattern due to the currents in the loops will thus be rotated through 90° by the rotation of the goniometer dial. Note also that reversal of one of the secondary connections to the loops will cause the field pattern to move in the reverse direction with respect to the setting of the goniometer dial. Reversal of the *N* or the *A* primary winding will invert the phase of the *N* or *A* field, but will not affect the patterns, as only one primary is active at a time.

Inspection of the Figure and the equations will also show that the *A* signal will give a field pattern similar to the *N* pattern but displaced 90° in space. In this connection it is interesting to note that for a dial setting of exactly 45°, ammeters in the two loop circuits will show steady and equal readings as the input is keyed from the *A* to the *N* primary. However it is easily seen that while the current in one loop remains in the same direction or time phase as the key passes from the *A* to the *N* primary or vice versa, the current in the other loop is reversed for each passage of the key. The *A* and *N* field patterns are thus seen to be displaced 90° in space, as truly at the 45° position as at any other dial setting.

We will now consider the figure-of-eight pattern as radiated from a pair of vertical radiators, *M* and *M'*, Figure 3(a). These represent either the sum of the vertical components of the current elements of a loop, or the equivalent Adcock antenna masts. (For each horizontal current element of the loop there is an equal and oppositely directed horizontal current element vertically above or below it. The two elements cancel the radiation of each other in all horizontal directions.) The currents in *M* and *M'* are of equal amplitude but are 180° out of time phase. Also one-half of the spacing of the radiators is assumed to be a small fraction of a wave length. (Actually, tower spacings are used which amount to electrical angles up to 45° for half the spacing distance.)

In Figure 3(a) geographical map layout procedure has been applied, with the radiators *M* and *M'* arbitrarily assumed to be located on an east-west axis. The point *O* is at the center of the radiating system and the line through *OP*, making an azimuth angle *B* with the axis through the radiators *M* and *M'*, represents the direction toward some distant point on the map. For all practical purposes, the distant point in question is assumed to be so far away compared to the physical separation of *M* and *M'*, that lines drawn from that point to *M* and *M'* would be substantially parallel to the line through *OP*. For the same reason the amplitude of the radiation intensity as received at the distant point from *M* will be equal to the amplitude received from *M'*, but their phases will be different.

An a-c vector diagram, Figure 3(b), depicts the relative phase and amplitude relationships of the components of radiation received at the distant point from *M* and *M'*. If a hypothetical radiator is pictured as being located at *O*, the center point of the radiators of Figure 3(a), the radiator *M'* is closer to the distant point than the radiator at *O* by distance *OR'*, the projection of *OM'* on the direction line *OP*. The phase of the radiation from *M'* then leads that from the hypothetical radiator at *O* by the electrical angle corresponding to the distance *OR'*, which is

$$2\pi \frac{\text{distance}}{\text{wavelength}} = 2\pi \frac{OR'}{\lambda} \quad (3)$$

This is shown in Figure 3(b) by the fact that the vector component *M'* is drawn at a leading angle with respect to the horizontal line. In the same manner, it is easily seen that the phase of the component from *M* will lag that of the hypothetical radiator, and by the same angle. Furthermore, since the currents in *M* and *M'* are 180° out

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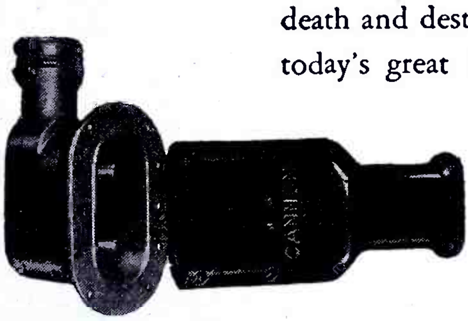

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of phase, the general direction of the component from M' is opposite to that of the component from M. The resultant intensity is easily seen to be a vector perpendicular to the horizontal line, with its length proportional to the sine of the angle given in expression (3).

Since the separation between the radiators M and M' is assumed to be small, the sine of the angle is practically equal to the angle, which in turn is proportional to the projection of the distance MM' on the direction line OP. The maximum radiation intensity is thus found to be along the line through the radiators, and may be represented by lines of equal length OQ and OQ'. The intensity along any direction line OP, being proportional to the projection of MM' on OP, is also proportional to the projection of OQ' or OQ on OP. This may be expressed by the equation

$$OP = OQ' \cos B \qquad (4)$$

By geometry the locus of the point P is two circles, which is therefore the field pattern, one circle being 180° out of time phase with the other. Note that the vector OP is not a rotating a-c vector, but a vector in space whose direction represents the physical direction of the distant point in question with respect to the radiating system, and whose length represents the intensity of radiation received at the distant point relative to that received at any other point on the horizontal plane, at the same distance from O as the point in question.

Figure 4 shows the field patterns from the two loops, MM' the main loop carrying the N signal and CC' the cross loop carrying the A signal, the goniometer dial being set at 90°. Since the N and A signals appear alternately, being keyed in interlocked fashion, the courses of equal signal intensity will be as shown, four mutually perpendicular courses at 45° to the axes of the loops.

Consider now what takes place when the goniometer dial is set at any angle D. Figure 5 shows the field pattern for the N signal only, and Figure 6 for the A signal only. For the N signal the maximum intensity of the fields from the main and cross loops for goniometer dial setting D are

$$I_M = I \sin D$$
$$I_C = I \cos D \qquad (5)$$

(The symbols I_M and I_C are used here for maximum field intensity, while previously they had been used for loop current. As the two are proportional to each other there should be no ambiguity.) The main and cross loops produce circular field patterns, indicated in Figure 5 by the small and large solid circles, respectively. Since the currents in the two loops are in the same time phase, the resultant radiation intensity I_N along any direction OP at an azimuth angle B is proportional to the algebraic sum of the intensities from the two loops. Thus

$$I_N = I_C \cos B + I_M \sin B$$
$$= I (\cos B \cos D + \sin B \sin D)$$
$$= \cos (B - D) \qquad (6)$$

The field pattern for the N signal is thus a pair of circles, or figure-of-eight, with axis displaced through an angle equal to the setting of the goniometer dial. Similarly, the field pattern (Figure 6) for the A signal is displaced by the same angle D, from the position it occupied for dial setting $D = O$.

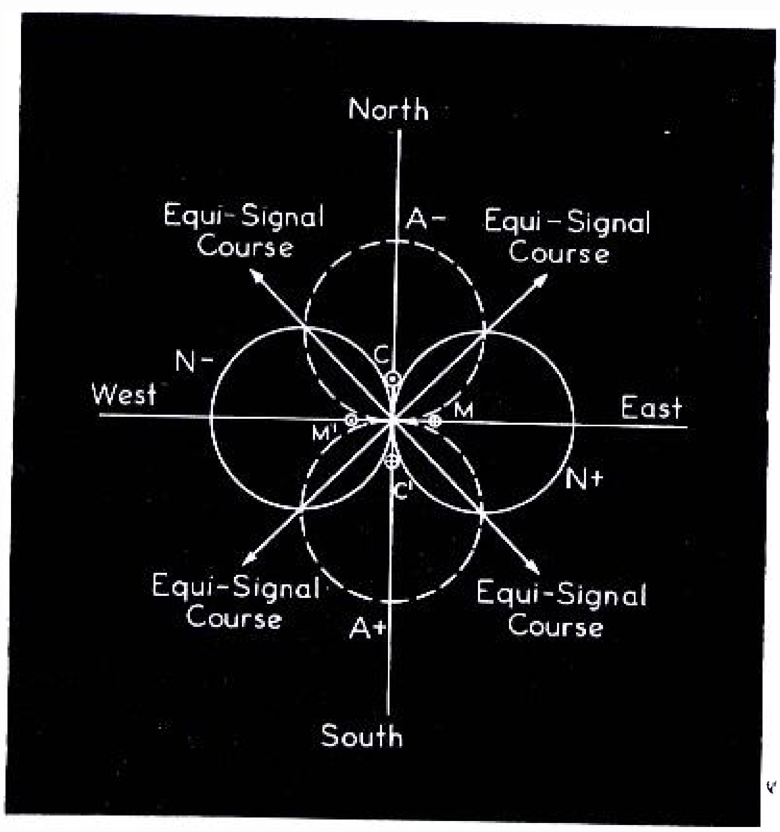
Note that the ability of the goniometer to rotate the field patterns, unchanged in shape and with the angular position of the axis of the patterns following exactly the angular setting of the rotor, is contingent upon the field pattern from each loop being truly circular. When the semi-distance between the vertical legs of the loop, or between diagonally opposite towers, is as much as one-eighth wavelength, the figure-of-eight patterns are slightly flattened circles. The resultant courses theoretically will then be correct at 0°, and at every 45° thereafter on the goniometer dial, but will display a small error at intermediate points. This error similarly is present in direction finders employing large Adcock antenna systems, and is recognized as *octantal error*. If the electrical spacing is increased further, due to greater physical distance between towers, or due to use of a higher frequency, the octantal error will become greater.

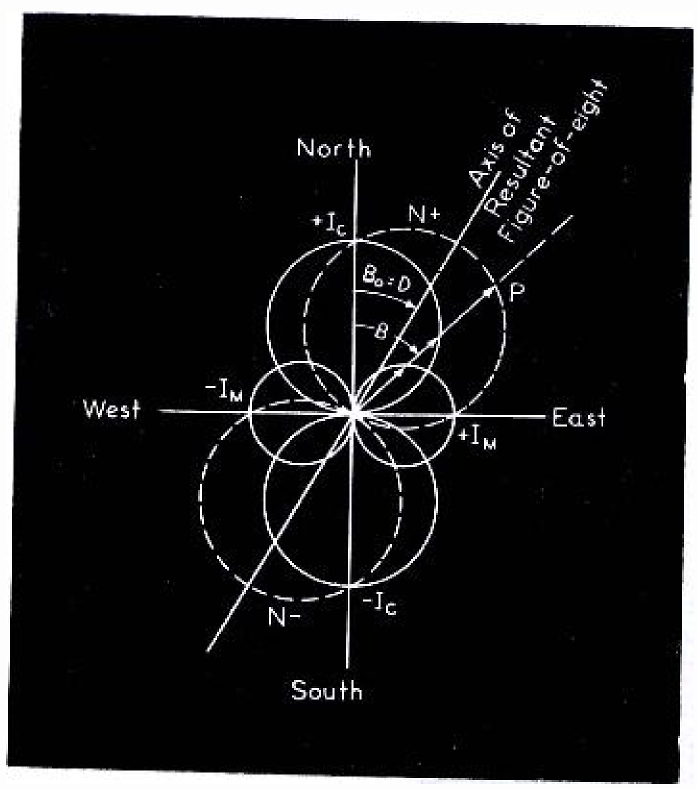
Radio Direction Finder

We will now analyze the corre-

Figures 4 (left, below) and 5 (right, below)

Figure 4 illustrates the development of the four equi-signal courses. Directions of compass, which are purely arbitrary, are indicated to give added clarity to the diagram. Figure 5 illustrates the figure-of-eight for the *N*-signal only, with the goniometer rotor dial set at angle *D*.





sponding goniometer principles as applied to radio direction finders.

In receiving applications the operation of the goniometer is reversed with respect to its use with a radio range transmission system. Each of two mutually perpendicular loop antennas is connected to one of two mutually perpendicular primary windings on the goniometer stator. The direction of the loops is fixed and the goniometer may be at some distance from the antenna array. The voltages induced in the two loop antennas by a passing wave are in the ratio of the sine and cosine of the angle of incidence of that wave, being a maximum in either loop when the plane of that loop is in the direction of propagation of the wave being received, and minimum when the plane of the loop is perpendicular to it. The resulting two antenna currents, in turn, flow through the respective goniometer primaries to which they are connected, and in so doing set up magnetic fields in these two coils which are proportional to the currents and hence proportional to the sine and cosine of the angle of the incident wave.

The resultant of two such mutually perpendicular fields is an effective field in a direction corresponding to the angle of incidence of the approaching wave, and of uniform value, whatever the direction. Inside the primaries and coaxially and centrally located, is a rotor or search coil. This coil is rotated to a null, or point of minimum signal, which condition is attained when the magnetic axis of the rotor winding is perpendicular to the resultant effective field established by the two primaries. The angular position of the rotor thus corresponds to the direction of the original incident wave.

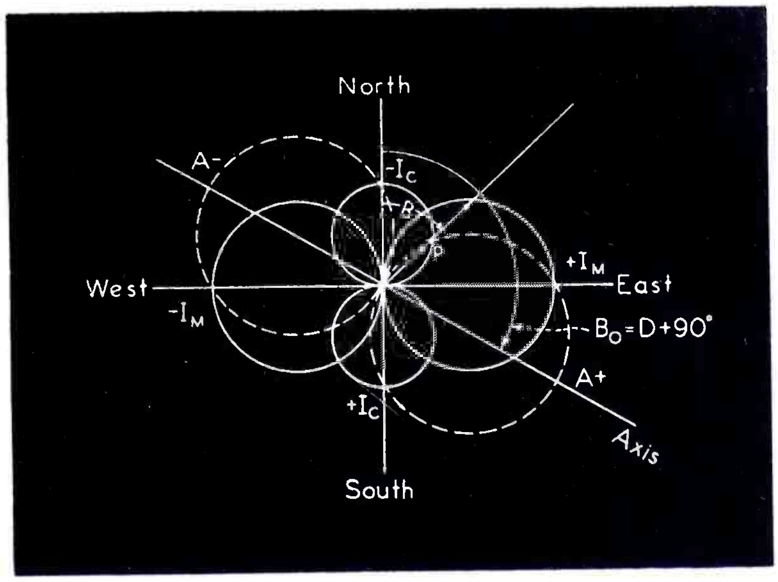


Figure 6

A figure-of-eight for an *A*-signal only with the goniometer rotor dial set at angle *D*.

Refinements of Design

In order to attain the highest degree of ease of commissioning and operating a radio range station it is necessary that the input impedance of the goniometer remain constant within close limits as the rotor is turned, and that the variation in coupling between each rotor secondary winding and each stator primary winding should approach as closely as possible to the ideal sine or cosine relationship. In order to accomplish these results it is required that the instrument be carefully designed, that the parts such as winding forms be accurately machined, and that skill and constant vigilance be employed in the winding and assembly operations.

In large goniometers capable of handling up to 2 kilowatts of radio frequency energy, the voltage and current handling capacity of the windings is of importance and exerts considerable influence on the means which may be used to approach perfect characteristics. These goniometers are used on frequencies from 200 kc up to 550 kc and many of the problems become increasingly difficult toward the high frequency end, whereas small receiving type goniometers can be made which retain excellent characteristics up to much higher frequencies.

Fundamentally, to produce constant input impedance for all rotor positions it is necessary to have all four combinations of maximum mutual inductance between one primary and one secondary of equal value. (The rotor windings must be accurately the same diameter and length, and similarly for the stator windings, and the winding forms must be machined precisely so the mean planes of the two windings on each form are accurately at 90°. The longitudinal displacement of one rotor winding with respect to the other, and that of the stator windings as shown in the photograph of the goniometer, have very little effect on the mutuals, showing that the field is relatively uniform at the rotor windings.) Also the variation of each mutual inductance must be sinusoidal, and the two secondaries must be equally loaded — this latter condition being external to the goniometer itself. From this point on, numerous *second order* effects appear.

Some of the *second order* effects are:

(*1*)—The distribution and orientation of windings may be such that the coupling is not truly sinusoidal. For instance in addition to the principal sine coupling, which may be more or less accurately attained by proper distribution of windings, there may be present a very small amount of coupling independent of rotor position, and of coupling proportional to the cosine of the position, as well as couplings proportional to multiples of the angular position. All these frequently produce more noticeable effects in the reflected resistance characteristic than they do in the simple sinusoidal characteristic, producing peaks and dips of input impedance at certain angular positions of the rotor.

(*2*)—Capacitive couplings between the two primary windings and their associated circuits, and between the primary and secondary circuits are most apparent in shifting the angular position of the rotor where the secondary current passes through a minimum value, and in making this minimum current something other than zero. These effects depend, respectively, on the amount of currents produced by the capacitive couplings which are in phase with the normal secondary currents, and on the amount which is in quadrature phase.

(*3*)—Capacitive and inductive couplings exist to some extent between the two secondary windings and their associated circuits. These affect both the minimum currents in the secondary circuits and the impedance reflected into the primary circuits.

In designing a goniometer and its associated circuits all these undesired second order effects are reduced as much as possible at their source. Further improvement is then possible by employing special design features and by actually introducing small amounts of such second order couplings in order to compensate for inherent ef-

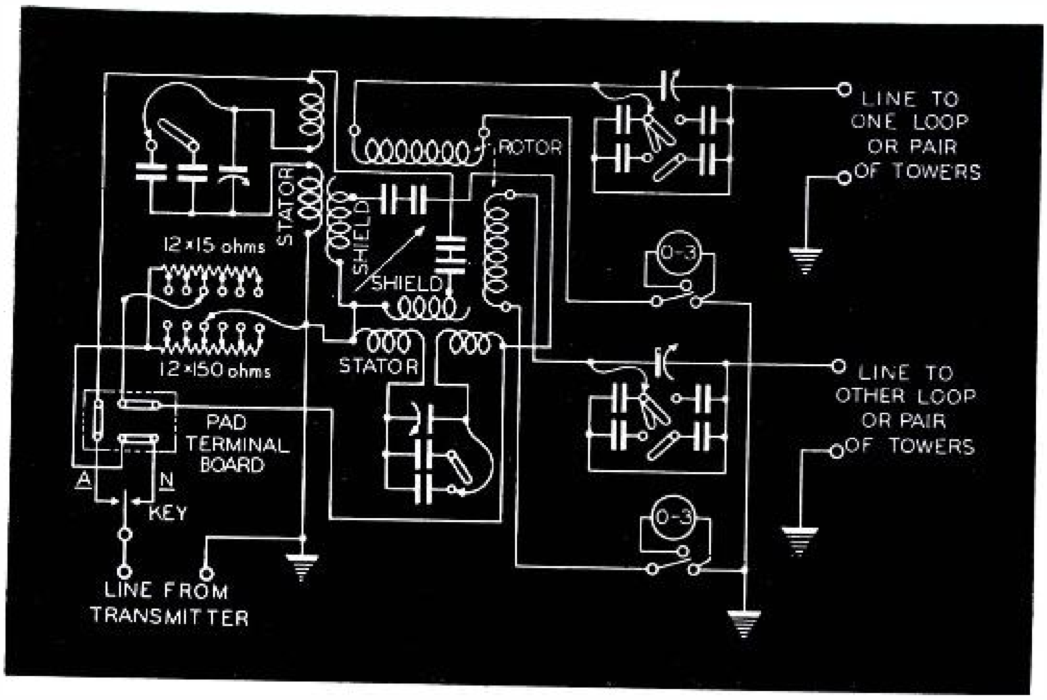


Figure 7

Schematic diagram of goniometer and associated primary and secondary circuits.

fects which become impractical to reduce further by direct methods.

The effect of small amounts of undesired coupling may be seen by substitution in the equation for the input impedance of the goniometer. With all primary and secondary circuits tuned to resonance, the input impedance will be

$$R = \frac{\omega^2 M_1^2}{R_1} + \frac{\omega^2 M_2^2}{R_2} \qquad (7)$$

where M_1 and R_1 are the mutual inductance and load resistance respectively for one secondary and M_2, R_2 for the other. Assume

$$M_1 = M_0 + M \sin D + M' \cos D$$
$$M_2 = M_0 + M \cos D + M' \sin D$$

Here *D* is the goniometer dial setting or angular position of the rotor and *M* is the principal coupling, assumed to be the same for both secondaries. M_0 is the small undesired fixed coupling, and M' the small undesired quadrature coupling. If $R_1 = R_2$ and M_0 and M' are zero, *R* will be constant, independent of *D*. However, if M_0 and M' are say each 1% of *M*, substitution in the equation and evaluation of *R* versus *D* will reveal peaks and dips in *R* instead of a constant value.

An old trick in radio equipment, including the goniometer, is to design the circuits and windings so they are electrically balanced to ground in order to reduce stray capacitive coupling effects. In the goniometer the reactive component of the primary circuit is balanced to ground by winding each primary coil in two equal symmetrical sections and connecting the tuning capacitor in series between the two sections. This not only reduces the maximum voltage to ground to half the value it would have if the capacitor were on one end, but results in a condition where the voltage at each part of one section of the winding is balanced by an equal voltage of opposite phase on the corresponding part of the other section. Since the transmitter energy is keyed to the two primaries on one side only, with the other side of the primaries common, it is not possible to balance the resistive component which is reflected into the primary, so certain capacitive couplings remain due to this unbalance.

Capacitive couplings are further reduced and partly compensated by a shield of special design introduced inside the stator form. This shield consists of heavy copper wires stretched longitudinally nearly the whole length of the stator form, resembling a squirrel cage. Instead of being connected in parallel to form a Faraday screen, these wires are connected in series to form two compensating windings. These windings are so arranged that they carry capacitive currents whose fields oppose the fields of similar currents carried by the primary windings as the transmitter output power is keyed alternately to the two primaries. In some types of equipment the simple capacitance between the primary and the shield is not sufficient to provide the full degree of compensation required, so small series capacitors are used to increase the currents in the shield.

Among other effects which are sometimes used, may be mentioned the introduction of a small amount of inductive coupling between the two secondary circuits, and the introduction of a minute quadrature, or cosine coupling to the main sinusoidal coupling of each secondary to the primaries. The latter is accomplished by suitable orientation of the leads along the shaft between the rotor windings and the slip rings.

The diagram of Figure 7 shows a portion of the schematic diagram of a radio range coupling unit, including the goniometer. It shows the two split primary windings with tuning capacitors connected between the two winding sections, the compensating shield windings and auxiliary small capacitors to increase their currents, and the secondary tuning capacitors and meters. The resistive "pad" in the primary circuit is for the purpose of reducing the currents in one primary or the other in order to produce course squeezing.

Tests of the Goniometer

The goniometer and its associated components in the assembled coupling unit must be subjected to careful tests to assure the maintenance in production of the high degree of performance required of the unit. Three tests may be cited:

(*1*)—The determination of the points of minimum coupling and pinning of the dial to the rotor shaft.

(*2*)—The measurement of the sinusoidal characteristic of the goniometer.

(*3*)—The measurement of the input impedance of the coupling unit.

Test *1* is readily made with a radio frequency bridge with the goniometer primary circuit connected to the unknown terminals. With one secondary open circuited and the other short circuited and tuned to resonance, little or no impedance will be reflected into the primary at the point of minimum coupling. A rapid rise of reflected resistance will occur as the goniometer dial is moved from that point, giving a ready means for locating the point accurately. If the bridge is set for a fraction of an ohm above the impedance of the primary circuit alone, two sharp bridge balances will be noted as the goniometer rotor dial is turned through each point of minimum coupling. The average dial setting for these two points is the actual point of minimum coupling. The minimum coupling points may be determined also in the process of measuring the sinusoidal characteristic of test *2*. The eight points of minimum coupling, two for each combination of one primary with one secondary, are determined and the dial pinned to its hub so the

(*Continued on page 95*)

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CIRCUIT DESIGN OF MIXERS AND FADER CONTROLS

(PART TWO OF A TWO-PART PAPER)

by PAUL B. WRIGHT

Communications Research Engineer

Part I of this paper considered the general aspects of the fader and mixer system. The conditions that must be met for these systems to function in the most satisfactory manner were outlined. Analytical methods were applied to determine exact relationships between the various parameters of the system. Tabulations were then made for the cases of the series, parallel and series-parallel types of mixers. These data were offered so that a designer could obtain the resistance values required to place the complete system on an image impedance basis.

Part II of this paper continues the analysis as applied to series-parallel, parallel-series, multiple bridge, and lattice types of mixer systems. Tables of the functions derived in the analysis are presented in similar form and manner to those of Part I. In tables 8 and 9, we find (for this special case) that, when the number of mixers in series equals the number of such series mixers in parallel, or when the number in parallel equals the number of such parallel mixers in series, the ratio of the input and output impedances equals unity. Therefore, the mixers and faders may all have the same input and output impedances. Further, the insertion loss for either type of mixer is the same as we can see by comparing Table 5 of Part I with Table 10 of Part II. In addition all relationships between the series-parallel and parallel-series mixers are completely reciprocal in *n*, *k* and functions of the real variable *θ*, except for the factor Z, the input impedance, or z, the output impedance of the mixer system.

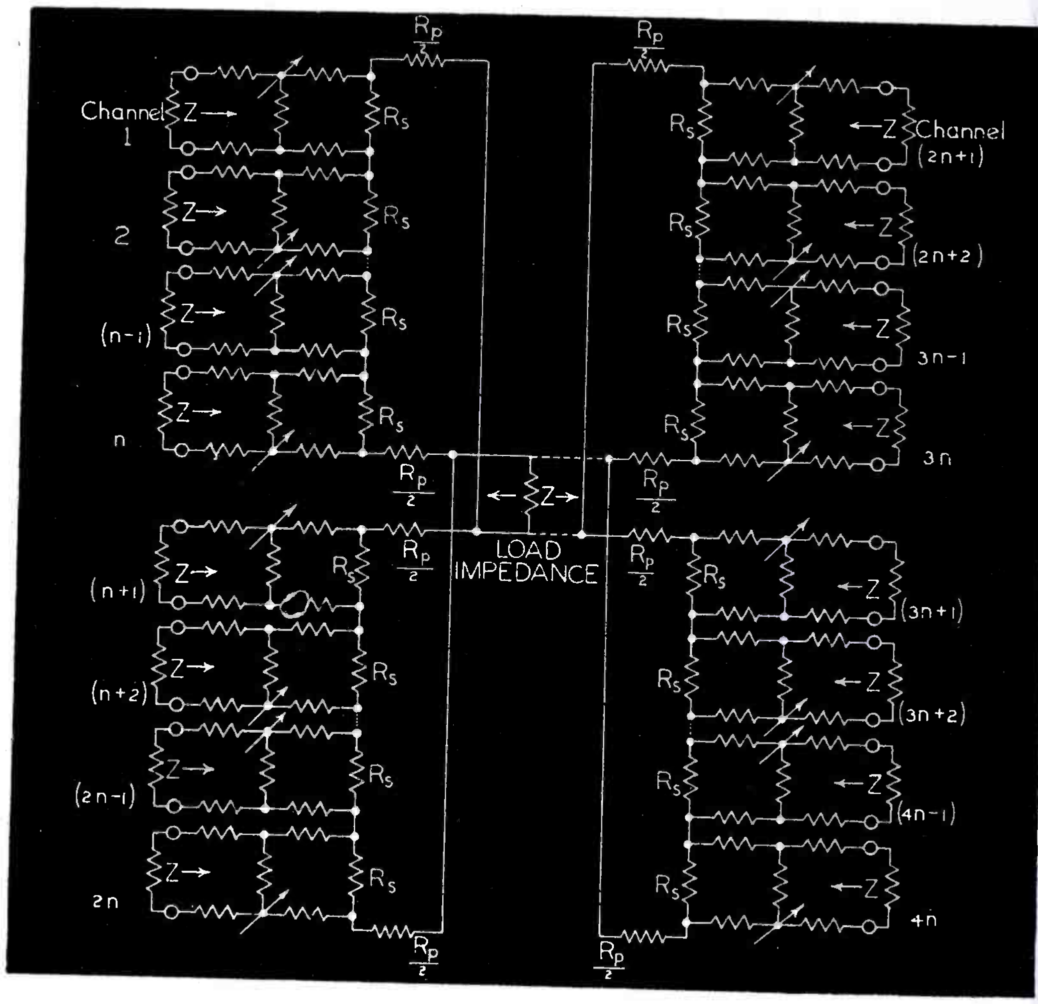


Figure 7
Series parallel mixers of *n* channels in series, in parallel with *m* groups of series-arranged circuits.

A SIMILAR method of analysis, as used in the series and parallel mixers might be followed here with the aid of the equivalent circuit shown in Figure 9 of the general form shown in Figure 7. This is quite straightforward, but laborious.

There is a simpler method of handling this case. In this instance we consider N_s sources connected in series, and N_p such groups then connected in parallel. The normal series output becomes the new source for the parallel group, or $z_{2s} = Z_{1p}$. The input impedance of each source is as before equal to Z, and the impedance of the output of the parallel groups combined is equal to the load impedance, z. We may rewrite the equations for the series and parallel cases, only this time, using proper subscripts. It is convenient to use the subscripts s for series, and p for parallel; also 2s for each series group and 1p for the input of the parallel group. N_s = the number of mixers in series; N_p = the number of series groups in parallel.

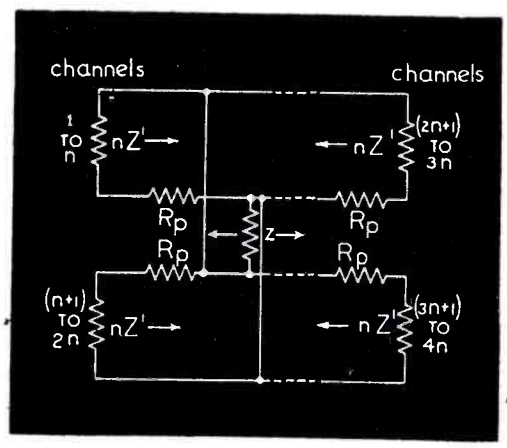


Figure 8
Equivalent of Figure 7, where $Z' = ZR_s/(Z + R_s)$.

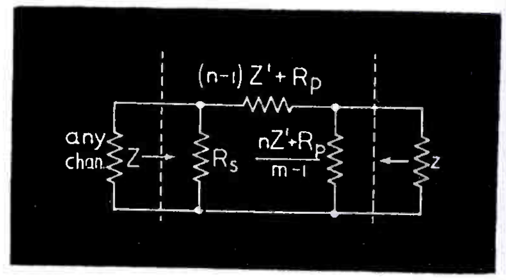
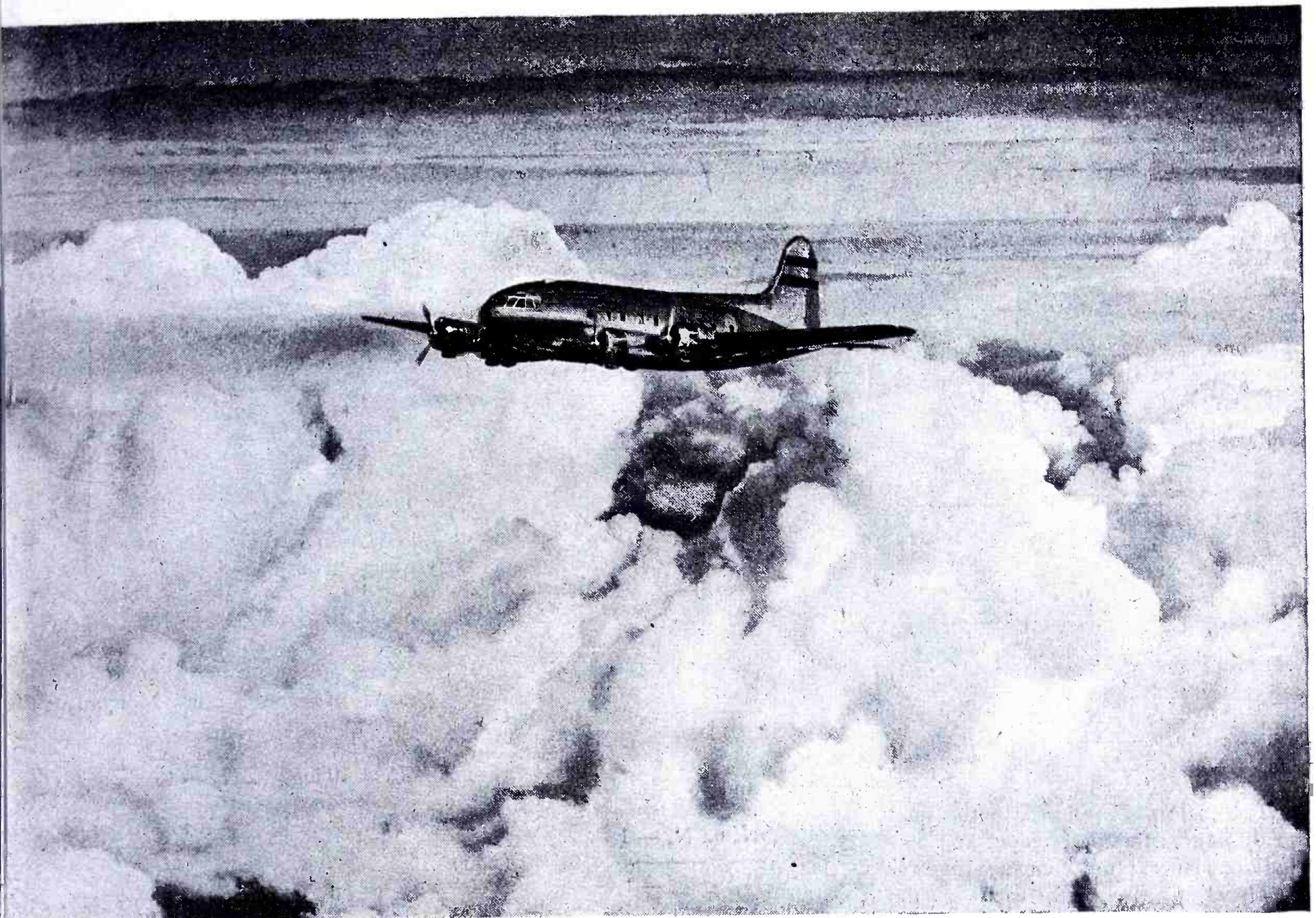


Figure 9
Equivalent circuit of Figure 7 for any single channel representation.

From equations *3*, *6* and *5*, we may write for the series mixers, the equations



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> ***A postwar airport development program to cost approximately $800,000,000 is recommended by William A. M. Burden, special aviation assistant to the Secretary of Commerce. The airport survey, made by the CAA in 1939 and which recommended some 4000 airports, will now be increased to approximately 6000, most of the increase being in small fields. "One thing is certain," Burden said, "And that is, if the program is to be developed on a sound basis, there must be a far higher proportion of local financial participation than there has been in the past."***

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$$R_s = Z \cdot \frac{N_s}{N_s - 1} \qquad (55)$$

$$Z = z_{2s} \cdot \frac{2N_s - 1}{N_s^2} = Z_{1p} \cdot \frac{2N_s - 1}{N_s^2} \qquad (56)$$

$$z_{2s} = Z_{1p} = Z \frac{N_s^2}{2N_s - 1} \qquad (57)$$

For the paralleled groups of series mixers, we may utilize equations *33*, *34* and *36* and write with the proper subscripts

$$R_p = z_{2s} \cdot \frac{N_p - 1}{N_p} = Z_{1p} \cdot \frac{N_p - 1}{N_p} \qquad (58)$$

$$z = z_{2s} \cdot \frac{2N_p - 1}{N_p^2} = Z_{1p} \cdot \frac{2N_p - 1}{N_p^2} \qquad (59)$$

$$z_{2s} = Z_{1p} = z \cdot \frac{N_p^2}{2N_p - 1} \qquad (60)$$

The factors of interest in the final analysis are: the mixer input and output inpedances; the compensating resistances to use with each of the series mixers, and the parallel groups; and finally, the number of mixers needed in series, and the number of such groups in parallel. We do not want the intermediate factors to appear, namely those designated z_{2s} and Z_{1p} as they are only incidental factors to obtaining the final result. The elimination of these two factors from the equations *55* to *60* inclusive, give four sets of three equations each. These are obtained in the following manner, and give the equations for the various parameters as indicated.

From equations *55* to *59* inclusive, we obtain the value of the impedance compensating or correction resistance, R_s to use in shunt with each of the series mixers. These are:

From *55*

$$R_s = Z \cdot \frac{N_s}{N_s - 1} \qquad (61a)$$

From *55*, *57* and *58*

$$R_s = R_p \cdot \frac{N_p}{N_s} \cdot \frac{2N_s - 1}{(N_s - 1)(N_p - 1)} \qquad (61b)$$

From *55*, *56* and *59*

$$R_s = z \cdot \frac{N_p^2}{N_s} \cdot \frac{2N_s - 1}{(N_s - 1)(2N_p - 1)} \qquad (61c)$$

The value of the impedance correction resistance, R_p to use in series with each series group of mixers is found as follows:

From *56* and *58*

$$R_p = Z \cdot \frac{N_s^2}{N_p} \cdot \frac{N_p - 1}{2N_s - 1} \qquad (62a)$$

From *61b*

$$R_p = R_s \cdot \frac{N_s (N_s - 1)(N_p - 1)}{N_p (2N_s - 1)} \qquad (62b)$$

From *58* and *59*

$$R_p = z \cdot \frac{N_p (N_p - 1)}{2N_p - 1} \qquad (62c)$$

The input image impedances of the individual mixers are:

From *55*

$$Z = R_s \cdot \frac{N_s - 1}{N_s} \qquad (63a)$$

From *56* and *58*

$$Z = R_p \cdot \frac{N_p}{N_s^2} \cdot \frac{2N_s - 1}{N_p - 1} \qquad (63b)$$

From *56* and *59*

$$Z = z \cdot \frac{N_p^2}{N_s^2} \cdot \frac{2N_s - 1}{2N_p - 1} \qquad (63c)$$

The output image impedance of the complete series-parallel mixer system is:

From *61c*

$$z = R_s \cdot \frac{N_s}{N_p^2} \cdot \frac{(N_s - 1)(2N_p - 1)}{2N_s - 1} \qquad (64a)$$

From *62c*

$$z = R_p \cdot \frac{2N_p - 1}{N_p (N_p - 1)} \qquad (64b)$$

From *63c*

$$z = Z \cdot \frac{N_s^2}{N_p^2} \cdot \frac{2N_p - 1}{2N_s - 1} \qquad (64c)$$

For the special case of $N_s = N_p = N$, equations *61*, *62*, *63* and *64* give for the parameters,

$$R_s = Z \cdot \frac{N}{N - 1} = R_p \cdot \frac{2N - 1}{(N - 1)^2}$$

$$z = \frac{N}{N - 1} \qquad (61d)$$

$$Z = R_s \cdot \frac{N - 1}{N} = R_p \frac{(2N - 1)}{N(N - 1)} = Z \qquad (63d)$$

$$R_p = Z \cdot \frac{N(N - 1)}{2N - 1} = R_s \cdot \frac{(N - 1)^2}{2N - 1}$$

$$= z \frac{N(N - 1)}{2N - 1} \qquad (62d)$$

$$z = R_s \cdot \frac{N - 1}{N} = R_p \cdot \frac{2N - 1}{N(N - 1)} = Z \qquad (64d)$$

Insertion Loss

The insertion loss of the series group, from equation 19 is

$$db_s = 10 \log_{10} (2N_s - 1) \qquad (65)$$

The insertion loss of the parallel group of series mixers is, from equation *45*

$$db_p = 10 \log_{10} (2N_p - 1) \qquad (66)$$

The total insertion loss from *65* and *66* is

$$db_{ps} = 10 \log_{10} [(2N_s - 1)(2N_p - 1)] \qquad (67)$$

For the special case of $N_s = N_p = N$, the insertion loss is

$$db = 20 \log_{10} (2N - 1) \qquad (68)$$

Where N = No of, either the mixers in each series group, or the number of such groups in parallel, but not their sum.

Power Ratio

The power ratio is P_z/P_s. The insertion loss of the network when $N_s = N_p = N$ may be written from *68* as

$$db = 10 \log_{10} \frac{P_z}{P_s} = 10 \log_{10} (2N - 1)^2 \qquad (69)$$

if we define the power ratio

$$\frac{P_z}{P_s} = k^2 = (2N - 1)^2 \qquad (70)$$

we can solve *70* for N in terms of k, or

$$N = \frac{k + 1}{2} \qquad (71)$$

Substituting *71* in *61d*, *62d*, *63d* and *64d*, the equations are obtained in


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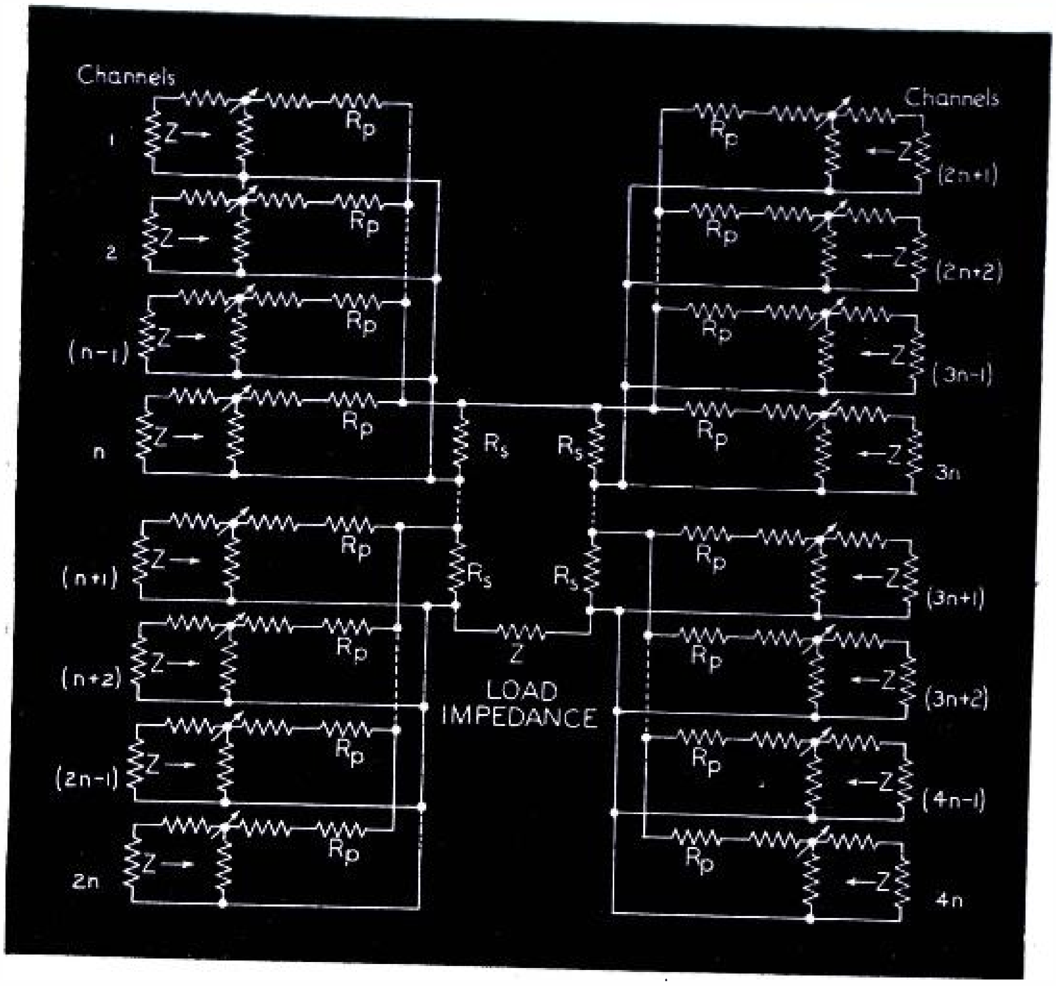


Figure 10
Parallel series mixers of n channels in parallel, in series with m groups of parallel-arranged circuits.

terms of k and the various parameters as

$$R_s = Z\frac{k+1}{k-1} = R_p\frac{4k}{(k-1)^2}$$

$$= z\frac{k+1}{k-1} \qquad (61e)$$

$$R_p = Z\frac{k^2-1}{4k} = R_s\frac{(k-1)^2}{4k}$$

$$= z\frac{k^2-1}{4k} \qquad (62e)$$

$$Z = R_s\frac{k-1}{k+1} = R_p\frac{4k}{k^2-1} = z \qquad (63e)$$

$$z = R_s\frac{k-1}{k+1} = R_p\frac{4k}{k^2-1} = Z \qquad (64e)$$

In terms of the hyperbolic functions of a real variable these last four equations may be transformed by means of the substitution,

$$k^2 = e^{2\theta} \qquad (72)$$

where

$$\theta = 0.11529 \times \text{No. of db loss.}$$

Using equation *72* in *61e*, *62e*, *63e* and *64e* the hyperbolic forms are obtained as,

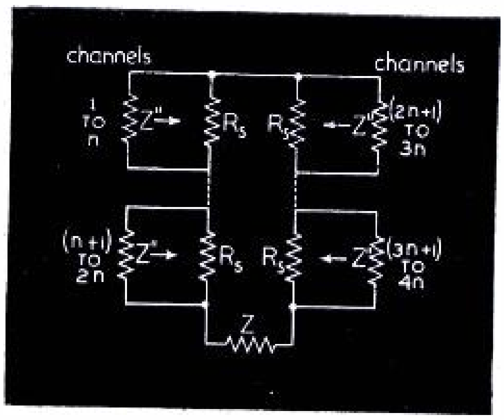


Figure 11
Equivalent of Figure 10, where $Z'' = (Z + R_p)/n$.

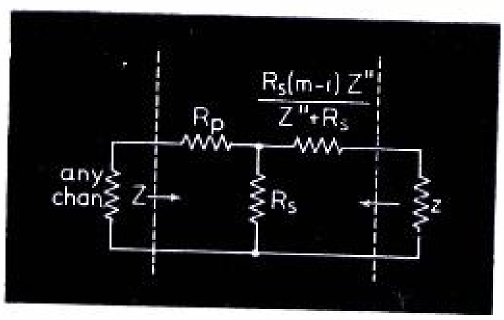


Figure 12
Equivalent circuit of Figure 10 for any single channel representation.

$$R_s = Z\coth\frac{\theta}{2} = R_p\cdot\frac{2}{\sinh^2\frac{\theta}{2}}$$

$$= z\coth\frac{\theta}{2} \qquad (61f)$$

$$R_p = Z\frac{\sinh\theta}{2} = R_s\cdot\frac{\sinh\frac{\theta}{2}}{2}$$

$$= z\frac{\sinh\theta}{2} \qquad (62f)$$

$$Z = R_s\cdot\tanh\frac{\theta}{2} = R_p\cdot\frac{2}{\sinh\theta}\; z = \qquad (63f)$$

$$z = R_s\tanh\frac{\theta}{2} = R_p\cdot\frac{2}{\sinh\theta} = Z \qquad (64f)$$

The hyperbolic forms for the general case lead to expressions which are unwieldy and cumbersome to handle. And since there are no tables available to make computations easily, they are not presented here.

Tabulations for the various formulae *61, 62, 63* and *64* have been prepared and are shown as Tables 3, 4, 5, 6, and 7. These Tables make the practical work of computation one involving only the product of two numbers. By their usage, any relationship of given data to that desired may be found.

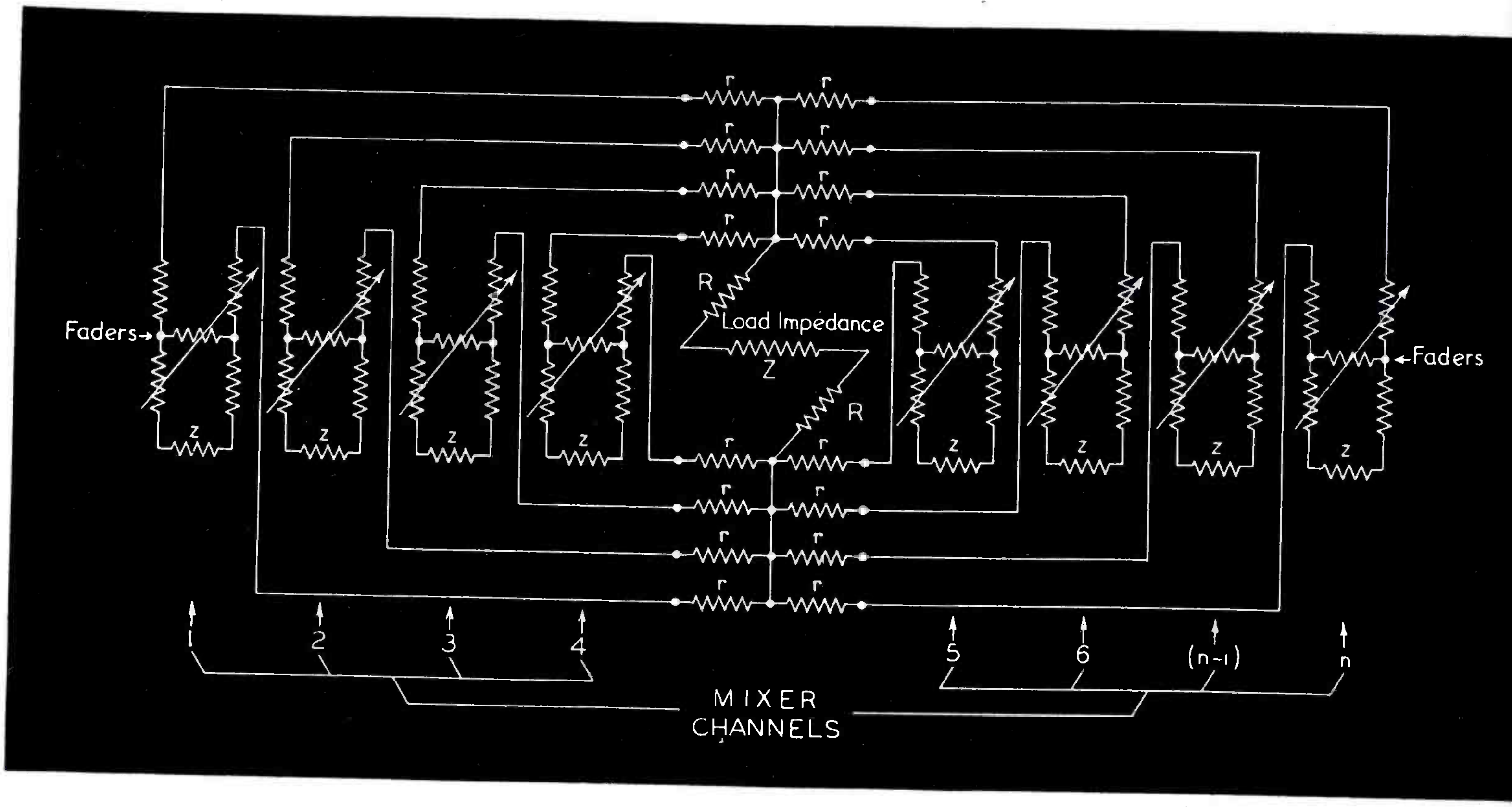
Parallel-Series Mixers

Straightforward circuit analysis applied to Fig. 10, or its equivalent shown in Figure 12 might be applied to obtain all of the necessary information about the relationship of the parameters of the network, but the simpler method to use is that followed for the series-parallel mixers.

For this purpose, consider N_p mixers connected in parallel, and N_s such groups of paralleled mixers connected in series. The normal parallel output becomes the new source for the series group, or $z_{2p} = Z_{1s}$. The input image impedance of each source is Z ohms, or may be made so by the proper use of suitable transformers. The output image impedance of the complete mixer system is z ohms.

The equations *33, 36* and *34* of the parallel case may be rewritten with proper subscripts to give

$$R_p = Z\cdot\frac{N_p - 1}{N_p} \qquad (73)$$



$$Z = z_{2p} \cdot \frac{N_p^2}{2\,N_p - 1} = Z_{1s} \cdot \frac{N_p^2}{2\,N_p - 1} \qquad (74)$$

$$z_{2p} = Z_{1s} = Z \cdot \frac{2\,N_p - 1}{N_p^2} \qquad (75)$$

while equations *3, 5* and *6* may be rewritten for the series groups of parallel mixers with the proper subscripts, giving,

$$R_s = z_{2p} \cdot \frac{N_s}{N_s - 1} = Z_{1s} \cdot \frac{N_s}{N_s - 1} \qquad (76)$$

$$z = z_{2p} \frac{N_s^2}{2\,N_s - 1} = Z_{1s} \frac{N_s^2}{2\,N_s - 1} \qquad (77)$$

$$z_{2p} = Z_{1p} = z \cdot \frac{2\,N_s - 1}{N_s^2} \qquad (78)$$

These six equations may be solved in terms of one another with the objective of eliminating throughout the equations, the two extraneous parameters which are designated as z_{2p} and Z_{1s}. The manner of doing this is indicated below and gives four sets of equations with three equations per set.

From equations *73, 74* and *76*

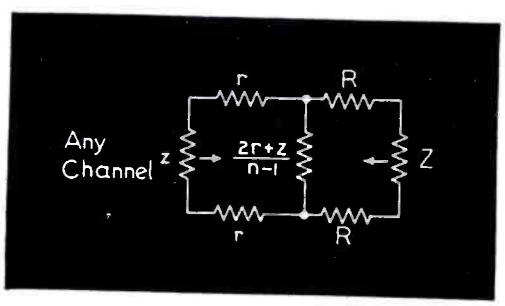
$$R_p = Z \frac{N_p - 1}{N_p} \qquad (79a)$$

and

$$R_p = R_s \frac{N_p}{N_p} \cdot \frac{(N_p - 1)\,(N_s - 1)}{2\,N_p - 1} \qquad (79b)$$

Figures 13 (above) and 14 (below)

Figure 13 illustrates a multiple bridge mixer system of *n* channels in balanced form. In Figure 14 we have the equivalent of Figure 13 on a single channel basis with the faders set for zero insertion loss.



while from *73, 74* and *77*

$$R_p = z \frac{N_p}{N_s^2} \cdot \frac{(2\,N_s - 1)\,(N_p - 1)}{2\,N_p - 1} \qquad (79c)$$

Equations *79* give the requirements that must be met to give the correct value of the series resistance to use for impedance correction of the parallel mixers of the system.

From *74* and *76*,

$$R_s = Z = \frac{N_s}{N_p^2} \cdot \frac{2\,N_p - 1}{N_s - 1} \qquad (80a)$$

while *76* and *77* give

$$R_s = z \frac{2\,N_s - 1}{N_s\,(N_s - 1)} \qquad (80b)$$

Solving *79b* in terms of R_p, N_s and N_p,

$$R_s = R_p \frac{N_s}{N_p} \cdot \frac{2\,N_p - 1}{(N_p - 1)\,(N_s - 1)} \qquad (80c)$$

Equations *80* give the necessary conditions that must be obtained to give the correct value for impedance correction of the series group of parallel mixers. This resistance must be placed in shunt across each of the series groups of mixers.

From *73, 74,* and *76*

$$Z = R_p \cdot \frac{N_p}{N_p - 1} \qquad (81a)$$

and

$$Z = R_s \cdot \frac{N_p^2}{N_s} \cdot \frac{N_s - 1}{2\,N_p - 1} \qquad (81b)$$

while *74* and *77* give

$$Z = z \frac{N_p^2}{N_s^2} \cdot \frac{2\,N_s - 1}{2\,N_p - 1} \qquad (81c)$$

Equations *81* give explicitly the necessary and sufficient conditions to insure that each mixer channel has the required image impedance.

From *79c*

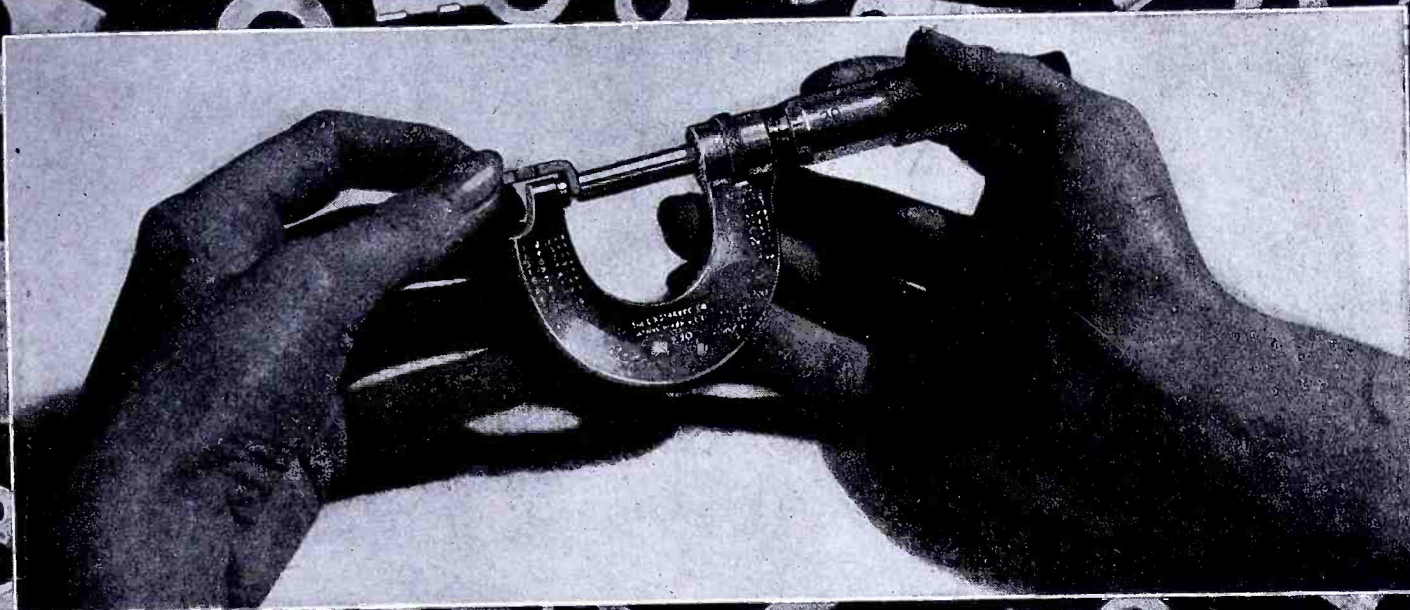


Table 8

Parallel Series Mixer		2	3	4	5	6	7	8	9	10
		No. of Channels, N_p, in Parallel; or No. of Parallel Groups in Series								
$N_s = N_p$	C_{p1}	.50000	.66667	.75000	.80000	.83333	.85714	.87500	.88889	.90000
$N_s = N_p$	C_{s1}	1.50000	.83333	.58333	.45000	.36667	.30952	.26786	.23611	.21111
Insertion Loss	db_{ps}	9.54	13.98	16.90	19.08	20.83	22.28	23.52	24.60	25.57

$R_p = Z \cdot C_{p1}$

Where $C_{p1} = (N_p - 1)/N_p$

$R_s = z \cdot C_{s1}$

Where $C_{s1} = (2 N_s - 1)/[N_s (N_s - 1)]$

$db_{ps} = 20 \log_{10} (2 N_p - 1)$

$= 20 \log_{10} (2 N_s - 1)$

$$z = R_p \cdot \frac{N_s^2}{N_p} \cdot \frac{2 N_p - 1}{(N_p - 1)(2 N_s - 1)} \qquad (82a)$$

From *80b*

$$z = R_s \cdot \frac{N_s (N_s - 1)}{2 N_s - 1} \qquad (82b)$$

and *81c* gives

$$z = Z \cdot \frac{N_s^2}{N_p^2} \cdot \frac{2 N_p - 1}{2 N_s - 1} \qquad (82c)$$

Table 9

Parallel-Series Mixer

C_{p2}

No. of Parallel Groups, N_s in Series	2	3	4	5	6	7	8	9	10
	No. of Channels in Parallel, N_p								
2	.50000	.90000	1.28571	1.66667	2.04545	2.42308	2.80000	3.17647	3.55263
3	.37037	.66666	.95237	1.23455	1.51514	1.79485	2.07405	2.35291	2.63155
4	.29166	.52500	.75000	.97222	1.19318	1.41346	1.6333	1.85294	2.07237
5	.24000	.43200	.61714	.80000	.98182	1.16308	1.34400	1.52470	1.70526
6	.20370	.36666	.52380	.67900	.83333	.98716	1.14072	1.29409	1.44737
7	.17687	.31837	.45481	.58958	.72358	.85714	.99049	1.12366	1.25673
8	.15625	.28125	.40178	.52082	.63919	.75719	8.7500	.99262	1.11017
9	.13992	.25185	.35979	.46639	.57240	.67807	.78355	.88889	.99415
10	.12667	.22800	.32571	.42222	.51818	.61385	.70933	.80470	.90000

$R_p = z\, C_{p2}$

Where

$$C_{p2} = \frac{N_p (2 N_s - 1)(N_p - 1)}{N_s^2 (2 N_p - 1)}$$

C_{s2}

No. of Parallel Groups, N_s in Series	2	3	4	5	6	7	8	9	10
2	1.50000	1.11111	.87500	.72000	.61110	.53062	.46874	.41976	.38000
3	1.12500	.83333	.65625	.54000	.45832	.39796	.35156	.31482	.28500
4	1.00000	.74074	.58333	.48000	.40740	.35375	.31249	.27984	.25333
5	.93750	.69444	.54687	.45000	.38194	.35164	.29296	.26235	.23750
6	.90000	.66666	.52500	.43200	.36667	.31837	.28124	.25186	.22800
7	.87500	.64815	.51042	.42000	.35647	.30952	.27343	.24486	22167
8	.85714	.63492	.50000	.41143	.34920	.30321	.26786	.23986	.21714
9	.84375	.62500	.49219	.40500	.34374	.29847	.26367	.23611	.21375
10	.83333	.61728	.48611	.40000	.33950	.29479	.26041	.23320	.21111

$R_s = Z \cdot C_{s2}$

Where

$$C_{s2} = \frac{N_s (2 N_p - 1)}{N_p^2 (N_s - 1)}$$

Table 10

Series—Parallel Mixer

No. of channels in series, N_s = 2

Insertion Loss in Decibels, db_{sp}

No. of Series Groups, N_p, in Parallel	2	3	4	5	6	7	8	9	10
2	9.54	11.76	13.22	14.31	15.18	15.91	16.53	17.08	17.56
3	11.76	13.98	15.44	16.53	17.40	18.13	18.75	19.29	19.78
4	13.22	15.44	16.90	17.99	18.86	19.59	20.21	20.76	21.24
5	14.31	16.53	17.99	19.08	19.96	20.68	21.30	21.85	22.33
6	15.18	17.40	18.86	19.96	20.83	21.55	22.17	22.72	23.20
7	15.91	18.13	19.59	20.68	21.55	22.28	22.90	23.44	23.93
8	16.53	18.75	20.21	21.30	22.17	22.90	23.52	24.06	24.55
9	17.08	19.29	20.76	21.85	22.72	23.44	24.06	24.60	25.09
10	17.56	19.78	21.24	22.33	23.20	23.93	24.55	25.09	25.57

$$db_{sp} = 10 \log_{10} [(2N_s - 1)(2N_p - 1)]$$

Equations *82* give concisely the relationships which must be met and maintained to insure that the network have the proper output image impedance.

For the special case of $N_s = N_p = N$, equations *79, 80, 81* and *82* take the forms,

$$R_p = Z \cdot \frac{N-1}{N} = R_s \cdot \frac{(N-1)^2}{2N-1}$$

$$= z \cdot \frac{N-1}{N} \qquad (79d)$$

$$R_s = Z \cdot \frac{2N-1}{N(N-1)} = R_p \cdot \frac{2N-1}{(N-1)^2}$$

$$= z \cdot \frac{2N-1}{N(N-1)} \qquad (80d)$$

$$Z = R_p \frac{N}{N-1} = R_s \frac{N(N-1)}{2N-1} = z \qquad (81d)$$

$$z = R_p \frac{N}{N-1} = R_s \frac{N(N-1)}{2N-1} = Z \qquad (82d)$$

The insertion loss of the parallel group is

$$db_p = 10 \log_{10} (2N_s - 1) \qquad (83)$$

and that of the series group is

$$db_s = 10 \log_{10} (2N_s - 1) \qquad (84)$$

The total insertion loss of the parallel-series combined groups is

$$db_{ps} = 10 \log_{10} [(2N_s - 1)(2N_p - 1)] \qquad (85)$$

When $N_s = N_p = N$, *85* becomes

$$db = 20 \log_{10} (2N - 1) \qquad (86)$$

which may also be written as

$$db = 10 \log_{10} (2N - 1)^2 \qquad (87)$$

We define the power ratio,

$$\frac{P_Z}{P_z} = k^2 = (2N-1)^2 \qquad (88)$$

from which,

$$N = \frac{k+1}{2} \qquad (89)$$

Substituting *89* into *79d, 80d, 81d* and *81d,* the set of equations in terms of k and the parameters of the network are found as,

Table 11

No. of Channels in Parallel, N_p

Parallel-Series Mixer

C_{ps1}

No. of Parallel Groups, N_s, in Series	2	3	4	5	6	7	8	9	10
2	1.00000	1.35000	1.71428	2.08333	2.45454	2.82693	3.20000	3.57353	3.94737
3	.74074	1.00000	1.26983	1.54319	1.81817	2.09400	2.37035	2.64702	2.92394
4	.58332	.78750	1.00000	1.21527	1.43182	1.64904	1.86667	2.08456	2.30263
5	.48000	.64800	.82285	1.00000	1.17818	1.35693	1.53600	1.71529	1.89473
6	.40740	.55000	.69840	.84875	1.00000	1.15169	1.30368	1.45585	1.60816
7	.35374	.47755	.60641	.73697	.86830	1.00000	1.13200	1.26412	1.39637
8	.31250	.42187	.53571	.65102	.76703	.88339	1.00000	1.11670	1.23352
9	.27984	.37778	.47972	.58300	.68688	.79109	.89549	1.00000	1.10463
10	.25334	.34200	.43428	.52778	.62182	.71616	.81066	.90529	1.00000

$$\frac{Z}{z} = C_{ps1}$$

Where

$$C_{ps1} = \frac{N_p^2 (2N_s - 1)}{N_s^2 (2N_p - 1)}$$

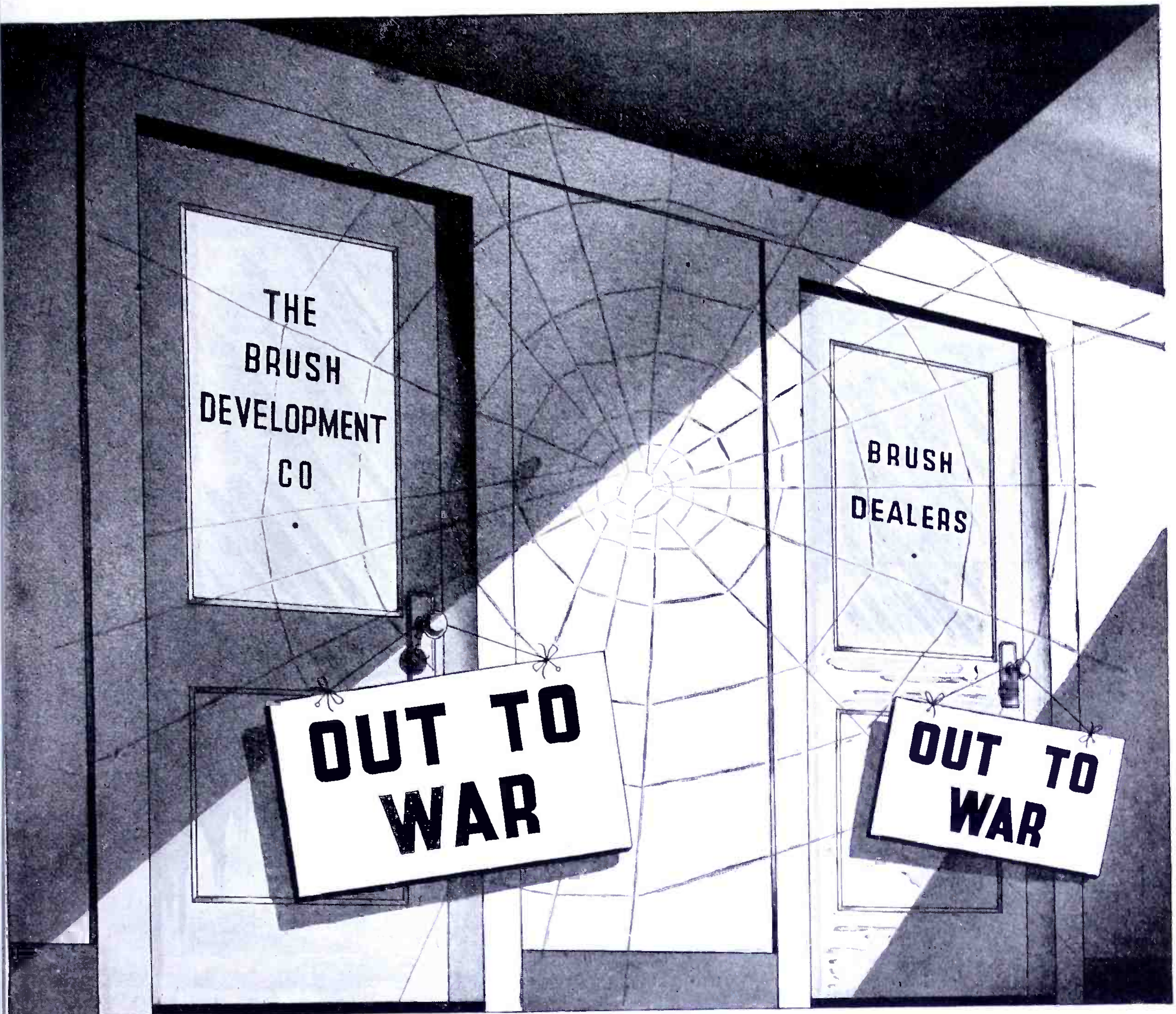

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Table 12

Parallel-Series Mixer

No. of Parallel Groups, N_s in Series	No. of Channels in Parallel, N_p: 2	3	4	5	6	7	8	9	10
	C_{ps2}								
2	.33333	.60000	.85714	1.11111	1.36363	1.61539	1.86667	2.11765	2.36842
3	.44444	.80000	1.14284	1.48146	1.81817	2.15382	2.48886	2.82394	3.15786
4	.500000	.90000	1.28572	1.66667	2.04546	2.42308	2.80000	3.17648	3.55264
5	.53333	.96000	1.37142	1.77778	2.18182	2.58462	2.98667	3.38822	3.78947
6	.55555	1.00000	1.42855	1.85182	2.27273	2.69225	3.11105	3.52934	3,94737
7	.571433	1.02859	1.46940	1.90482	2.33775	2.76926	3.20000	3.63033	4.06026
8	.58333	1.05000	1.50000	1.94437	2.38628	2.82681	3.26663	3.70574	4.14459
9	.59260	1.06667	1.52382	1.97535	2.42429	2.87185	3.31858	3.76472	4.21062
10	.60000	1.08000	1.54284	2.00000	2.45454	2.90771	3.36000	3.81174	4.26316

$$\frac{R_p}{R_s} = C_{ps2}$$

Where

$$C_{ps2} = \frac{N_p (N_p - 1)(N_s - 1)}{N_s (2 N_p - 1)}$$

$$R_p = Z \frac{k-1}{k+1} = R_s \cdot \frac{(k-1)^2}{4k} = z \frac{k-1}{k+1} \quad (79e)$$

$$R_s = Z \frac{4k}{k^2-1} = R_p \cdot \frac{4k}{(k-1)^2} = z \cdot \frac{4k}{k^2-1} \quad (80e)$$

$$Z = R_p \frac{k+1}{k-1} = R_s \frac{k^2-1}{4k} = z \quad (81e)$$

$$z = R_p \frac{k+1}{k-1} = R_s \frac{k^2-1}{4k} = Z \quad (82e)$$

Hyberbolic Function

In terms of the hyperbolic functions of a real variable these four equations may be transformed by the substitution

$$k^2 = e^{2\theta} \quad (90)$$

As was done for the series-parallel case, after which, we obtain

$$R_p = Z \cdot \tanh\frac{\theta}{2} = R_s \cdot \frac{\sinh^2 \frac{\theta}{2}}{2}$$

$$= z \cdot \tanh\frac{\theta}{2} \quad (79f)$$

$$R_s = Z \cdot \frac{2}{\sinh\theta} = R_p \cdot \frac{2}{\sinh^2\frac{\theta}{2}}$$

$$= z \cdot \frac{2}{\sinh\theta} \quad (80f)$$

$$Z = R_p \cdot \coth\frac{\theta}{2} = R_s \cdot \frac{\sinh\theta}{2} = z \quad (81f)$$

$$z = R_p \cdot \coth\frac{\theta}{2} = R_s \frac{\sinh\theta}{2} = Z \quad (82f)$$

Disadvantages of Hyberbolic Functions

The use of hyperbolic functions in the general case is not advantageous because of the increased complexity of the final expressions which make their use much more laborious than the algebraic forms, and therefore are not given here.

Tables

Tables 8, 9, 10, 11 and 12 give the tabulations for the various formulae presented in equations *79, 80, 81* and *82*. Their use should enable the designer to determine easily and quickly the values of any parameters and the necessary and sufficient conditions which must be met between them. By approximation methods, the engineer may estimate to sufficiently good accuracy, the effect of variations in resistances or impedances which make up the network, or are connected to it.

Multiple Bridge Mixers

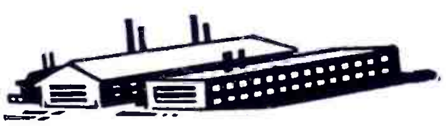
These types of mixers are not very well known, but have some very great advantages in flexibility of usage. The complete derivation of all of the equations with extensive sets of tables and several charts were presented for this case in a previous article of the author in the September, 1943 issue of COMMUNICATIONS. In that article, it was shown how the multiple bridge could be used to feed a number of channels from a common source. If we reverse the bridge, and place attenuators in

(Continued on page 96)

Victory in North Africa . . . victory in the Solomons . . . victory in Sicily . . .

And at home short-sighted workers think a desperate war has become child's play. They relax . . . take a holiday from their jobs . . . chatter idly that the enemy is "done".

What happens then?



Vital production lags . . . production of ships and shells, of tanks and guns and planes . . . young lives in the jungle are snuffed out for lack of material . . . and our friends in Russia and China and Britain suffer because their share is smaller, too.

All because some rosy-eyed people place too much stock in what are only the stepping stones to "unconditional surrender".

No matter how the fortunes of war may turn, Kenyon workers are staying on the job, making good transformers to meet the demands of war plants throughout the nation. This is our modest way of giving thanks to those men who are making the world a safer and happier place in which to live.

E MARK OF *EXCELLENCE*

BUY WAR BONDS

KENYON TRANSFORMER CO., Inc.

840 BARRY STREET
NEW YORK, U. S. A.

IMPEDANCE PROBLEM SOLUTIONS

ON THE SLIDE RULE

by ROBERT C. PAINE

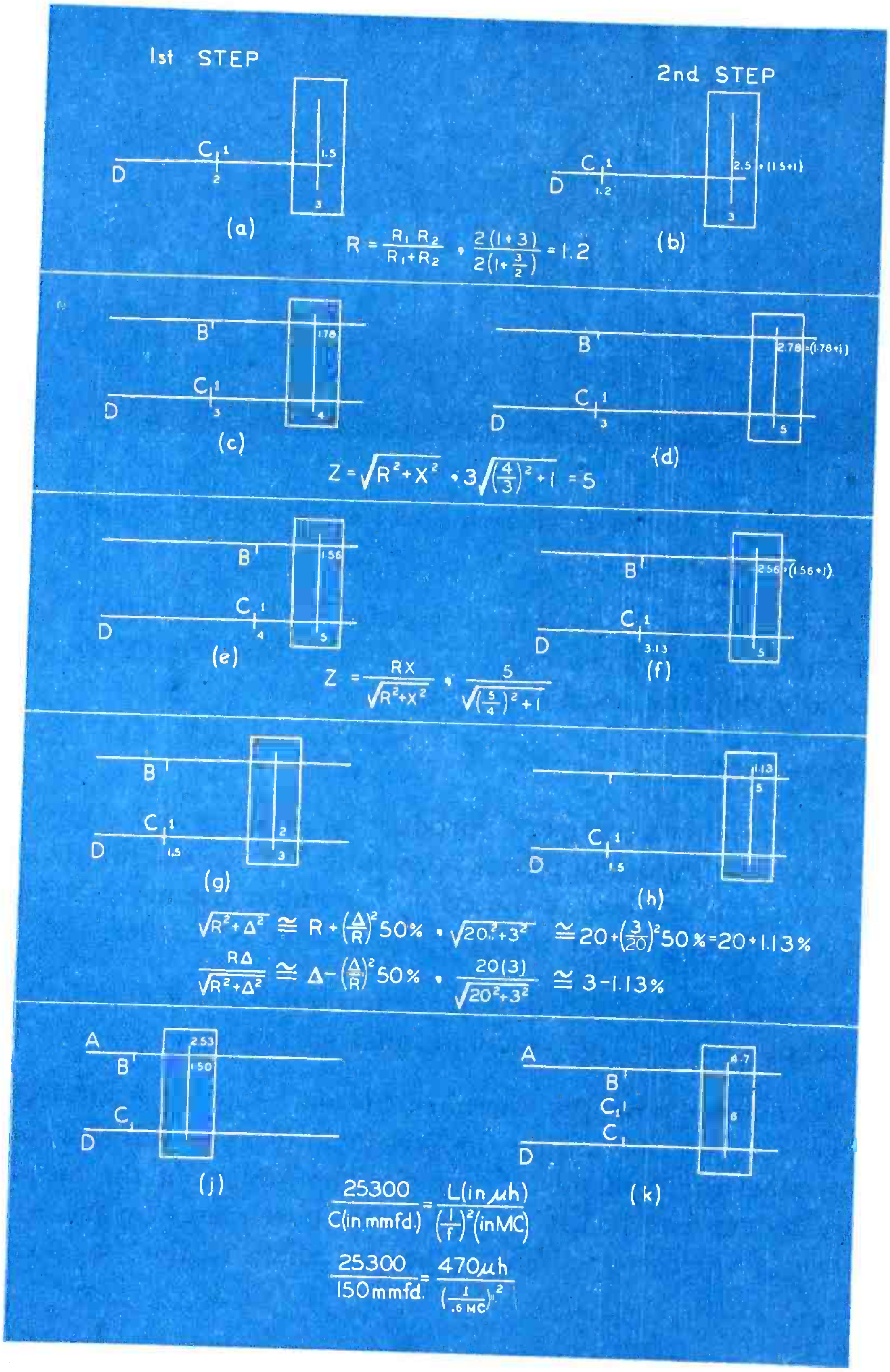


Figure 1

Slide rule operations for solving problems involving mental addition: (a) and (b) parallel resistors, (c) and (d) series resistance and reactance, (e) and (f) parallel resistance and reactance, (g) and (h) approximation formulae for use when a large quantity is combined in quadrature with a small one, and (j) and (k) resonant circuit formula.

SPECIAL slide rules for solving problems of parallel resistances, reactances in parallel and in series with resistances have been analyzed in the July and October issues of COMMUNICATIONS. Special rules are also available for solving resonance problems. For each special application such rules are very useful. However, all these problems can also be solved quite readily on a regular polyphase slide rule by a method suggested some years ago in *Electrical Engineering*. But slide rules sold at the *five-and-ten-cent stores* can also be used for these problems. In fact these rules have the *B* scale (which does not appear on the author's duplex rule).

There are, of course, certain slide rule technique problems that have to be ironed out, to provide suitable adaptation of the rule. For instance, the slide rule cannot ordinarily be used for equations involving addition. But by a method of simplifying mental addition, the slide rule can be applied. Let us take the problem shown in Figure 1, as an example. In Figure 1 appear diagrammatic sketches of the scales and slider of a rule. The two steps in the solution of problems are shown. For instance, the problem of two parallel resistors R_1 and R_2 is solved by the formula $R = R_1 R_2/(R_1 + R_2)$, as shown in Figure 1 (a) and (b). In the example given the parallel resistors are *2* ohms and *3* ohms (or 20 ohms and 30 ohms, etc., as required). In the first step the numerator and denominator are divided through by the lesser number *2*, resulting in *1* and *1.5* to be added in the denominator. This reduces the mental process of addition to its simplest terms, so that errors will be unlikely. In the second step the larger number *3* is then divided by the sum of *1* and *1.5* (found mentally to be 2.5), resulting in the answer 1.2 ohms.

The usual care should be taken with the decimal point, of course. If the problem had involved 30 ohms and 2

SLIDE RULE TECHNIQUE

ohms, the second step would divide 30 by (15 + 1), giving the answer as 1.87 ohms.

Series Circuit Solutions

The solution of a series circuit with a resistance of 4 ohms and a reactance of 3 ohms is shown in Figure 1 (c) and (d). The first step reduces the elements to be added, to *1* and *1.78*. The second step multiplies the square root of the sum ($\sqrt{2.78}$) by *3* to obtain the answer, 5 ohms.

Parallel Circuit Solutions

The solution of a parallel circuit of a resistance of 5 ohms and a reactance of 4 ohms is shown in (e) and (f) of Figure 1. The first step reduces the elements to be added to *1* and *1.56*. The second step divides 5 by the square root of the sum of these ($\sqrt{2.56}$) for the answer, 3.13 ohms.

Special Type Slide Rules

Special type slide rules are not adapted to working reactance problems where one element is more than about 10 times the other. Even on ordinary slide rules the answer is difficult to read. In the case of the series circuit of a resistance and a reactance, the effect of the lesser element is to make the total impedance only slightly more than that of the greater element. Where it is necessary to determine this small increase, it can be found in per cent by an approximation formula shown in (g) and (h) of Figure 1. This is a straightforward operation involving no mental addition. In a parallel circuit the effect of the greater element is to make the total impedance only slightly less than that of the lesser element. The per cent reduction is found in (g) and (h) in the same way as for the series circuit.

Parallel Resistors

For calculating parallel resistors, where one resistor is 100 times the other, a very simple approximation formula is available. $R = R_1 \Delta/(R_1 + \Delta) \cong \Delta - (100\ \Delta/R_1)\ \%$. This formula is useful when a resistance is to be adjusted to a close value by shunting it with a much greater resistance. Even though one resistance is not more than 10 times the other, the error by this method is not large.

Resonance Problems

Resonance problems are also readily solved on an ordinary slide rule. The two steps for a given example are shown in (j) and (k) of Figure 1. Here a CI scale is necessary for the reciprocal value 1/f. In this kind of problem, considerable care with the decimal points is necessary. Thus a special resonance rule has the advantage over the ordinary slide rule.

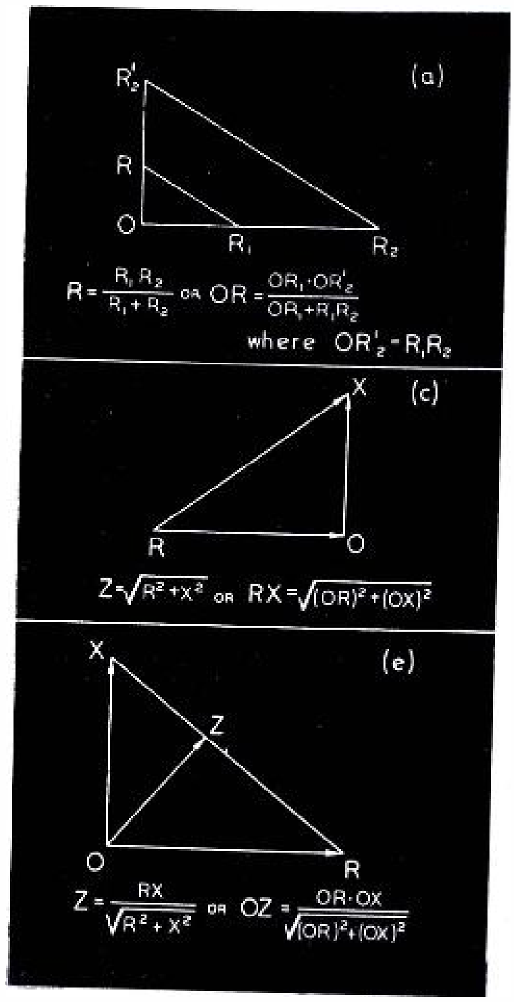


Figure 2
Geometric solutions of series and parallel circuits.

Use of Geometric Solutions

Geometric solutions help to visualize problems. They provide approximate solutions that sometimes prevent serious errors in decimal points, which are possible on a slide rule. Figure *2* provides such solutions for the first three problems shown in Figure 1. These diagrams are lettered to correspond to the slide rule solutions of Figure 1. The diagram of Figure 2 (c) is well known. It is used for the series circuit of resistance and reactance. In (a) of Figure 2 the parallel resistance problem is solved. The lines OR_1 and $R_1\ R_2$ are laid out to scale to equal the values of R_1 and R_2. OR'_2 is laid out at any convenient angle to equal R_2. The line $R_1\ R$ is drawn parallel to $R_2\ R'_2$ and OR is the value of the combination of R_1 and R_2 in parallel. This figure depends on a well known geometric theorem on proportional triangles, $OR/OR_1 = OR'_2/(OR_1 + R_1 R_2)$.

Reactance and Resistance in Parallel

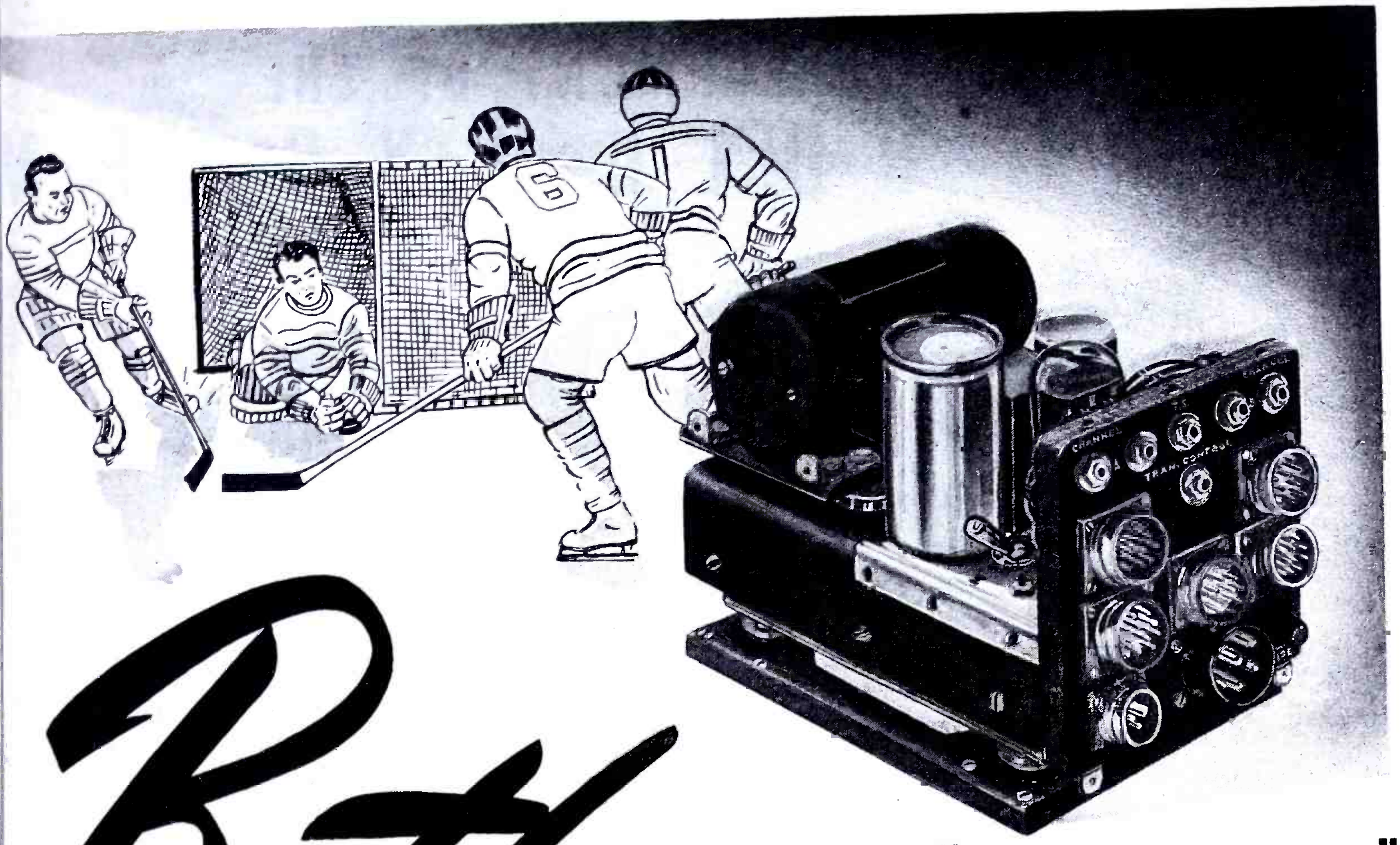
The solution of the problem of reactance and resistance in parallel is shown in Figure *2* (e). The lines OR and OX are laid out at right angles equal to the given values of resistance and reactance, and the line OZ is drawn perpendicular to the hypotenuse RX. The line OZ is the impedance value of the parallel combination at the correct phase angle. This useful diagram unfortunately is not as well known as the series diagram. The diagrams of Figure *2* are drawn to scale with the same values as the corresponding problems of Figure 1.

Use of Algebra

The approximation formulae shown above are derived by straightforward operations in algebra as follows: For the parallel resistances $R = R_1 \Delta/(R_1 + \Delta)$ (Δ standing for a value relatively small compared to R_1). Dividing through, $R = \Delta - \Delta^2/R_1 + \Delta^3/R^2_1$, since Δ is small relative to R, all terms beyond Δ^2/R_1 are considered negligible and R is taken as $\Delta - \Delta^2/R_1$. The percentage decrease of Δ is $(\Delta/R_1)\ 100\%$. For the series reactance and resistance circuit, $Z = \sqrt{R^2 + \Delta^2}$. To complete the square it is necessary to add $\Delta^4/4\ R^2$ to the right hand side of the equation. Then $Z \cong R\ \sqrt{R^2 + \Delta^2 + \Delta^4/4\ R^2} = \sqrt{(R + \Delta^2/2\ R)^2}$. The value of $\Delta^4/4\ R^2$ is so small that it can be considered negligible, so Z is taken as $R + \Delta^2/2\ R$ and the percentage increase of R is $(\Delta^2/2\ R^2)\ 100\%$. For convenient solution on the slide rule, this is taken as $(\Delta/R)^2\ 50\%$. For the parallel reactance and resistance problem $Z = R\ \Delta/\sqrt{R^2 + \Delta^2} \cong R\ \Delta/(R + \Delta^2/2\ R)$ since the radical has the same value as above. Dividing through, $Z = \Delta - \Delta^3/2\ R^2 + \Delta^5/4\ R^4$. . . . Terms beyond $\Delta^3/2\ R^2$ may be considered as negligible, so Z may be taken as $\Delta - \dfrac{\Delta^3}{2\ R^2}$. Then the percentage decrease of Δ is $(\Delta^2/2\ R^2)\ 100\%$, taken on the slide rule as $(\Delta/R)^2\ 50\%$ as before.

Mechanical Addition

In the use of the reciprocal slide rule for parallel resistors, discussed in the July issue of COMMUNICATIONS, the reciprocals are added mechanically for the sum of the reciprocals $1/R_{eg}$ in the same manner as the logarithms of numbers are added on the Mannheim slide rule for multiplying.



Both MUST "TAKE IT"

No sport makes more exacting demands than ice hockey. The professional team must possess both precision and timing and a high degree of ruggedness as well.

Radio amplifiers manufactured for Navy aircraft by Sound Equipment Corporation of California must meet similar requirements. They too combine high accuracy with the sturdiness to "take it" when the going gets tough.

The same engineering and manufacturing skill, which provides this wartime dependability will assure years of faithful service to our peacetime products.

Send for our new booklet "Sound"

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Corporation of California

6245 LEXINGTON AVENUE, HOLLYWOOD 38, CALIFORNIA

Manufacturers of *AIRCRAFT RADIO EQUIPMENT • AMPLIFIERS • PRECISION COILS*

THE DEVELOPMENT OF THE PUSH-PULL SYSTEM

(PART TWO OF A TWO-PART PAPER)

by **DONALD McNICOL**

Past President, IRE

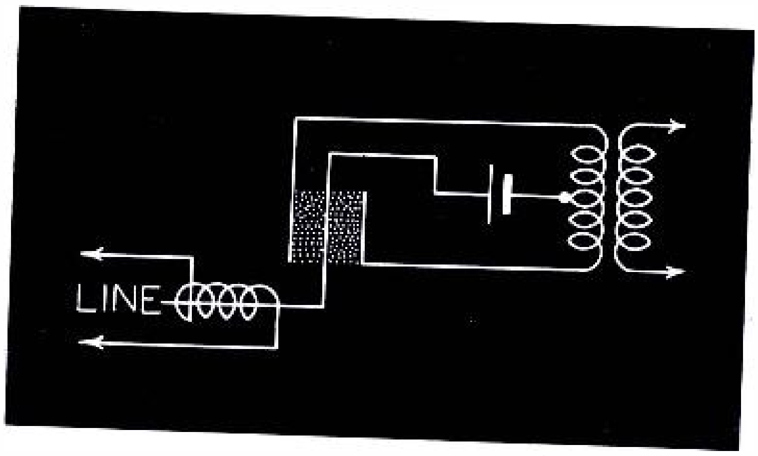


Figure 7
The Grissinger patent, where incoming currents actuate the control member of a double microphone, increasing and decreasing the resistance of the divided sections of the primary.

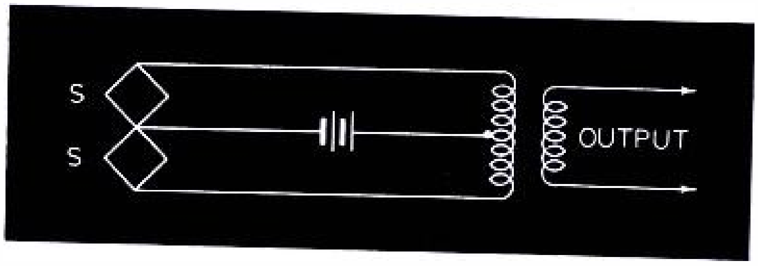


Figure 8
Dixon's system, providing in the selenium cells S, S, variable-resistance circuit elements devoid of microphonic contacts, whereby a beam of radiation swinging right or left from center in response to incoming signals decreases and increases, respectively, the resistance of the two arms of the primary winding. Thus, a distortionless current is set up in the split winding.

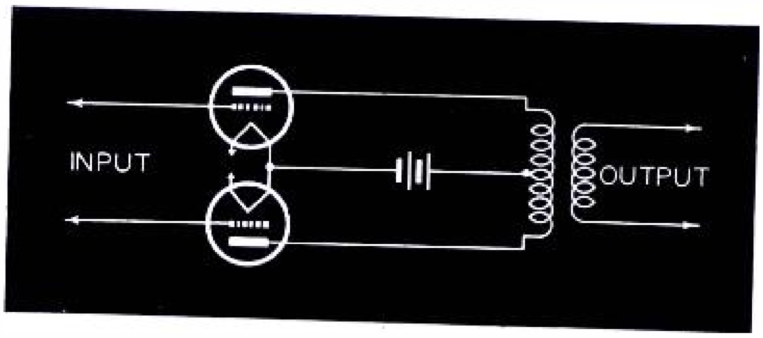


Figure 9
The Colpitts system, where vacuum tubes took the place of the microphonic contacts of the prior art, yielding also uniform, distortionless currents in the arms of the primary winding of the transformer.

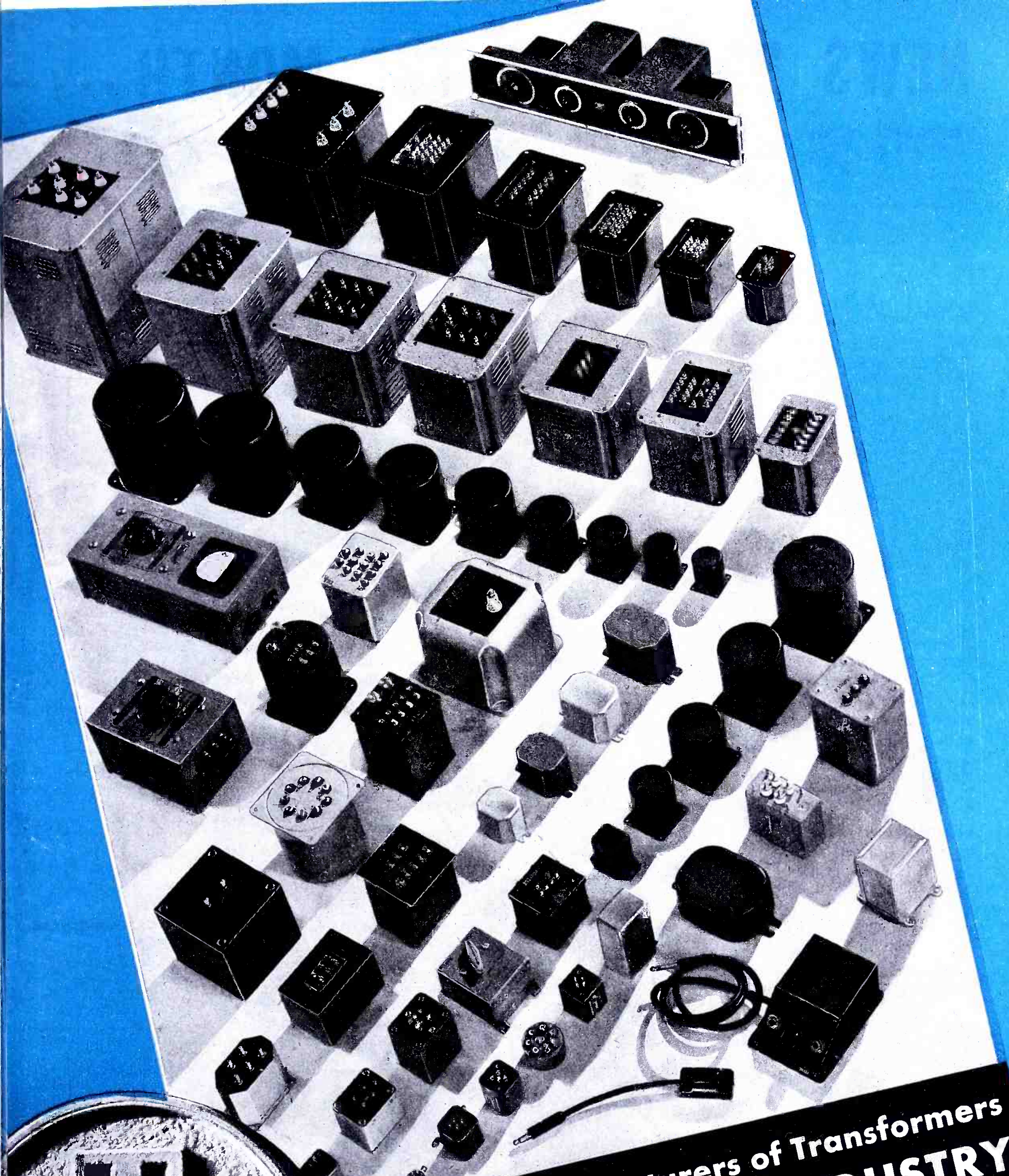
An important step was taken in telephone repeater development by Ellwood Grissinger, in his patent U. S. 1,198,212, issued Sept. 12, 1916 (applied for Feb. 24, 1902), Figure 7. It would appear that it took this application many years to work its way through the maze indicated by even that much of the prior art as is referred to herein. A theoretical circuit of Grissinger's invention discloses practically no variation from that of Kitsee. The double-button principle, the resistance-variation controlled by a magnet in the line, and the center tap on the primary winding of the induction coil, all are present. A difference is in the very ingenious mechanical arrangement by means of which the variable resistance elements are actuated. In his specifications, Grissinger traces the incoming voice current through the connecting coils to the armature, adding: ". . . producing disturbances of the equilibrium of the variable resistance medium thereof, and consequent undulations in the primary of the induction coil of the repeater."

The wording may simply have been unfortunate. The words *disturbances*, and *consequent*, possibly confirm previous experiences with other early double-button contrivances. A careful study of the circuits of the various patents for telephone transmitters, and later for repeaters, discloses that almost from the beginning of the telephone art attempts were made to contrive some method of deriving from the small available current in the primary coil of telephone transmitters, largely increased current in the secondary winding beyond, which included the line circuit. Various of the inventions brought out were ingenious, but most of them introduced distortion in the speech circuit, or failed to remove distortions already there, which rendered clear transmission haphazard. Often there was too much mechanical inertia present. The center tap on the primary winding of the induction coil was a step forward. Current from a d-c source flowing in opposite directions through the winding creates a condition of no-magnetism in the iron core—when the currents are of equal strength. But when the current values change due to resistance variations in the carbon elements of microphones, the magnetized core does a job of pushing and pulling, speeding the current change in the secondary winding, and adding to its strength. The center tap serves somewhat after the fashion of Daedalus' fulcrum; a pull on one side is accompanied by a push on the other side. Various of the devices herein referred to had mechanical means of accomplishing a push-pull action, commonly by means of varying pressure on microphone contacts. Often, such contacts, or such means of varying the resistances of the respective arms of the system were crude, slow, and introduced microphonic noises into the out-put circuit.

New Ideas Required

The chap first to entertain the idea of mechanical motive power for wheeled vehicles was aware that the wheeled vehicles of his time were capable of traveling much faster than oxen or horses could draw them. The idea of the wheels and the vehicles was sound enough, but something new had to be done about power. He knew, of course, that generations of men had been at work upon the idea of breeding horses which could travel more rapidly. What was needed was an entirely new idea. With respect to submarine cable signaling, telephony, and radio, there was a considerable prior art, as we have seen along one line of development. The prior art might afford certain contributions toward what

(*Continued on page* 91)



NEWS BRIEFS OF THE MONTH . . .

IRE WINTER TECHNICAL MEETING, JANUARY 28-29

The Institute of Radio Engineers will hold its winter technical meeting at the Hotel Commodore, New York City, on January 28 and 29.

The American Institute of Electrical Engineers who are holding their technical meetings in the early part of the same week will reserve their communications papers for presentation on the afternoon and evening of January 27.

* * *

DETROLA MERGED WITH INTERNATIONAL MACHINE

International Machine Tool Corporation, Elkhart, Indiana, has been merged with Detrola Corporation, Detroit, under the name International Detrola Corporation.

Officers of International Detrola will be C. Russell Feldmann, president and chairman of the board of directors; Charles H. Foster, vice president; Warren J. Hannum, vice president; John Hancock, treasurer; Harry E. Hamilton, secretary and assistant treasurer; and R. L. Dillon, assistant secretary and controller.

Directors are John Ballantyne, C. Russell Feldmann, Charles H. Foster, John Hancock, Warren J. Hannum, D. M. S. Hegarty, and Frank A. Willard.

* * *

MAJOR ISAAC BRIMBERG OF WNYC DEAD

Major Isaac Brimberg, former chief engineer of WNYC, Municipal Broadcasting System in New York City was killed recently in an accident while on duty.

* * *

KLAUBER WITH OWI

Edward Klauber, former CBS vice president, has joined OWI as associate director. The post has been vacant since last June, when Milton S. Eisenhower resigned to become president of Kansas State College.

* * *

BROWN NOW RCA VICTOR DIVISION ADVERTISING DIRECTOR

Charles B. Brown has been appointed advertising director of the RCA Victor Division of the Radio Corporation of America.

Mr. Brown was formerly NBC director of advertising, promotion and research.

* * *

SPRAYBERRY MOVES TO COLORADO

Offices and facilities of the Sprayberry Academy of Radio will hereafter be located in Pueblo, Colorado. The school was formerly located in Washington, D. C. Frank L. Sprayberry is president of the school.

* * *

SMPE TO HOLD SPRING CONFERENCE IN NEW YORK

The Society of Motion Picture Engineers will hold its 55th semi-annual technical conference in New York City on April 25, 26 and 27 at the Hotel Pennsylvania.

* * *

KEN BURCAW JOINS CAP

Ken Burcaw, jobber sales manager, Radiart Corporation, Cleveland, Ohio has become a flyer in the Civil Air Patrol.

ASA APPROVES STANDARDS FOR RESISTORS, CAPACITORS AND R-F THERMOCOUPLE CONVERTERS

The American Standards Association has just announced approvals of new war standards for three communications components.

Fixed composition resistors (C75.7-1943), are one of the standardized units. The specification covers fixed composition resistors suitable for use in all non-specialized applications, in communications and electronic equipment.

Thermocouple converters (C394-1943), represent the second unit standardized. These converters in their standardized form will be interchangable for use with r-f currents from 120 ma to 10 amperes.

The third standardization covers a revision of the standard on dry electrolytic capacitors (home receiver replacement type) (C16.7-1943—2nd edition), which was first approved February 16, 1943. The specifications cover the basic requirements applicable to dry electrolytic capacitors suitable for use as replacement parts in home radio receivers. The capacitors chosen represent the least number of units necessary at this time for servicing the great majority of home radio receivers. The minimum performance requirements are designed to furnish capacitors which will use as small an amount of strategic materials as possible, will not restrict production and will prove satisfactory from an electrical and service-life standpoint.

* * *

D. T. SIEGEL ELECTED TO ILLINOIS INSTITUTE BOARD

David T. Siegel, president of Ohmite Manufacturing Company, Chicago, was recently elected to the board of trustees of Illinois Institute of Technology.

Mr. Siegel was one of five new members named to the Institute's board. He was elected an an alumni representative to the board, having been nominated by the Illinois Tech Alumni Association.

Mr. Siegel is also a member of the Fixed and Variable Resistor Industry Advisory Committee of the War Production Board.

D. T. Siegel

DISC AND STYLI RESTRICTIONS REMOVED

Restrictions on the transfer of blank re-cording discs and recording needles fo home recording purposes were remove on November 25, by WPB through a amendment to Limitation Order L-265

* * *

STARCH TAKES WAR JOB

RCA Victor chemical engineers at Cam den revealed recently that a derivative of starch, levulinic acid, came to the rescu to break a bottleneck in a soldering op eration. Its wartime job is as a fluxin agent, to which it was recruited when was found that neither rosin nor zin chloride, the agents most commonly used would do the work in soldering steel part together for assembly in radio equipmen

Although zinc chloride is an active flux ing agent, it tends to cause corrosion un less removed by copious washing wit water; while rosin, though free of thi drawback, is not active. It is almost im possible to wash steel parts after th soldering operation. However the starc derivative was found to be more activ than rosin, it being blended with it t form a flux that eliminates the post-wash ing process in its application to certai metals and alloys.

* * *

L. G. PACENT, JR., JOINS POWERS ELECTRONIC

Louis G. Pacent, Jr. has joined the Powers Electronic & Communication Co. Glen Cove, New York, as factory manager. Mr. Pacent, in full charge of production, will be associated with A. J. Buchtenkirch, in charge of engineering under A. J. Sanial, general manager and chief engineer. F. T. Powers, Jr. is president of the company.

The company is now manufacturing a high power electronic megaphone.

* * *

GENERAL ELECTRIC FORMS NEW INVESTMENT COMPANY

A new investment unit, the General Electric Credit Corporation, has been organized under the New York State Banking Law.

The new organization will broaden the scope of activities carried on since 1933 by the General Electric Contracts Corporation, and will include the business of the latter company which was principally financing the sale of consumer goods.

The immediate function of the new investment company will be to provide financing for war construction and production work in connection with contracts which involve the use of G. E. products, or parts produced by others for incorporation in such war products.

Management of the new company will be the same as that of the General Electric Contracts Corporation with G. F. Mosher, president. The main office will be at 570 Lexington Avenue, New York City, and branches will be established in other principal cities.

* * *

SYLVANIA INSTALLS NEW GAS PLANT

A new electrolytic plant equipped with 108 electrolytic cells, high-powered compressor machines, low-pressure and high-pressure storage tanks and a distillery to

(Continued on page 71)

THE INDUSTRY OFFERS . . . — . . . — . . .

PHILIPS SEARCHRAY 150

The second in a series of self-contained, x-ray units for industry, Searchray 150, has been announced by North American Philips Company, Inc., through its Industrial Electronics Division, 100 East 42nd Street, New York City.

This model has been designed for inspection of parts, assemblies and finished products of metal, hard rubber, plastic, bakelite, ceramics, dielectric materials, etc. It permits the taking of radiographs by plant personnel under controlled conditions.

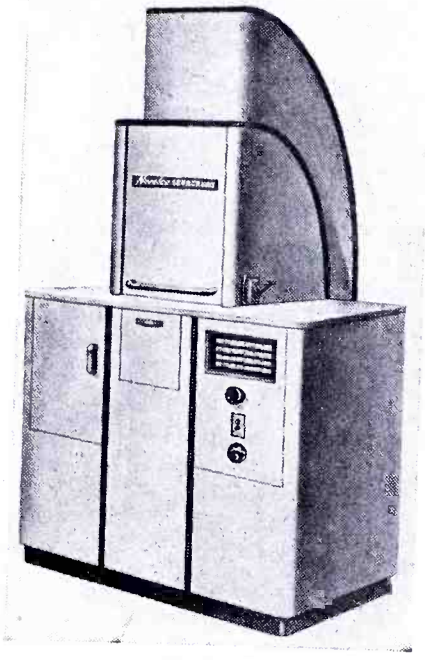
It has a fixed milliamperage over the entire kilovoltage range. An electrical interlock, which interrupts the circuit while the radiographic compartment is open, eliminates danger to the operator from x-radiation.

A continuous kilovolt regulator provides adjustment during viewing operation at any point from 0 to 150 kv, so that depending on density and thickness of the part under observation, greater clarity on the fluoroscopic screen can be obtained. The apparatus can also be set for correct metal thickness on a direct reading scale when radiographs are to be taken.

A cassette tunnel at the bottom of the radiographic compartment makes possible insertion and removal of x-ray film or paper without disturbing the position of the object.

Under this cassette tunnel a flouroscopic screen is mounted. The image of the object can be viewed in a mirror through a folding eyepiece. The operator looks into this while seated in front of the Searchray. This facilitates the positioning of an article before taking a radiograph.

Overall height is 82", the radiographic compartment being 25¾" high, 35" long and 25" deep. For 220 volts, single phase, 60 cycles, a-c. Weight approximately 600 lbs.



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G. E. LECTROFILM FOR CAPACITORS

A new synthetic dielectric material for capacitors, lectrofilm, has been developed in the General Electric laboratory research department.

This material can be applied to the manufacture of most r-f blocking and bypass fixed capacitors.

ANNULAR SOUND DISTRIBUTOR

A new type of annular sound distributor, type L-360 has been produced by the Langevin Company, Inc., 37 West 65th Street, N. Y. City.

This distributor is said to utilize a different principle of sound distribution in that it combines molecular reflection and collision instead of collision alone as in other speakers. The use of this principle is said to result in a uniformity of sound distribution both as to frequency and power over a horizontal plane of 360 degrees and a vertical plane of approximately 40 degrees.

The distributor is 23" in diameter with an over-all height of 25". It will handle power input of 20 watts when equipped with a Jensen U-20 drive unit.

GENERAL ELECTRONICS IONIZATION GAUGE

An ionization gauge that measures the degree of vacuum in a system is now being manufactured by General Electronics, 101 Hazel Street, Paterson, New Jersey. The gauge which is licensed by Litton Engineering Labs, gives a continuous reading and is said to take a variety of tubes with a simple setting.

In operation, the monometer tube (included with each gauge) is connected to the manifold and plugged in. One meter is used for the setting of ionization current. Another gives continuous reading of degree of vacuum Operates on 117 volts, 60 cycles a-c. Has 4 ranges and measures down to .01 micron. Set is furnished complete with connecting cables, and monometer tube, 1-5Y3G, 1-2051, 2-VR150-30, 2-7B4 and 2-7C7 tubes. Available in stationary or portable models.

REINER SQUARE-WAVE GENERATOR

A square-wave generator model 530, d signed for production testing, has be announced by Reiner Electronics Co pany, 152-6 West 25th Street, New Yo City.

This model has a hand-calibrated fr quency scale reading from below 10 cycl to more than 100 kilocycles. The deca multiplier has four steps. The actual fr quency of the output is the dial readi multiplied by the setting of the frequen multiplier. The accuracy of the frequen calibration is said to be 5% over e tended periods.

In cases where great accuracy of fr quency is desired, the instrument can b made to synchronize with any standa frequency generator, provided that a syn chronizing voltage of at least 0.1 volt available. The synchronization can als be made with any other external fr quency source.

The output impedances available a 100-200-500-600-1,000-2,000 ohms. Outp voltage may be varied either in fixed ste or may be continuously varied by mea of the variable voltage potentiomete When the latter is used, the output im pedance is from 0-2,000 ohms. If the out put voltage is varied in steps, the outpu impedance is indicated by the output vol tage selector setting. The maximum vol tage ouput is approximately 200 volts.

Operates on 110-120 volts, 60 cycles a.c. also available for other voltages or lin frequency. Power consumption is 3 watts; fuse protection, 7 ampere. It i 8" in height, 9" in depth, 15" in widt and weighs 18 lbs.

ELECTRIC TACHOMETER

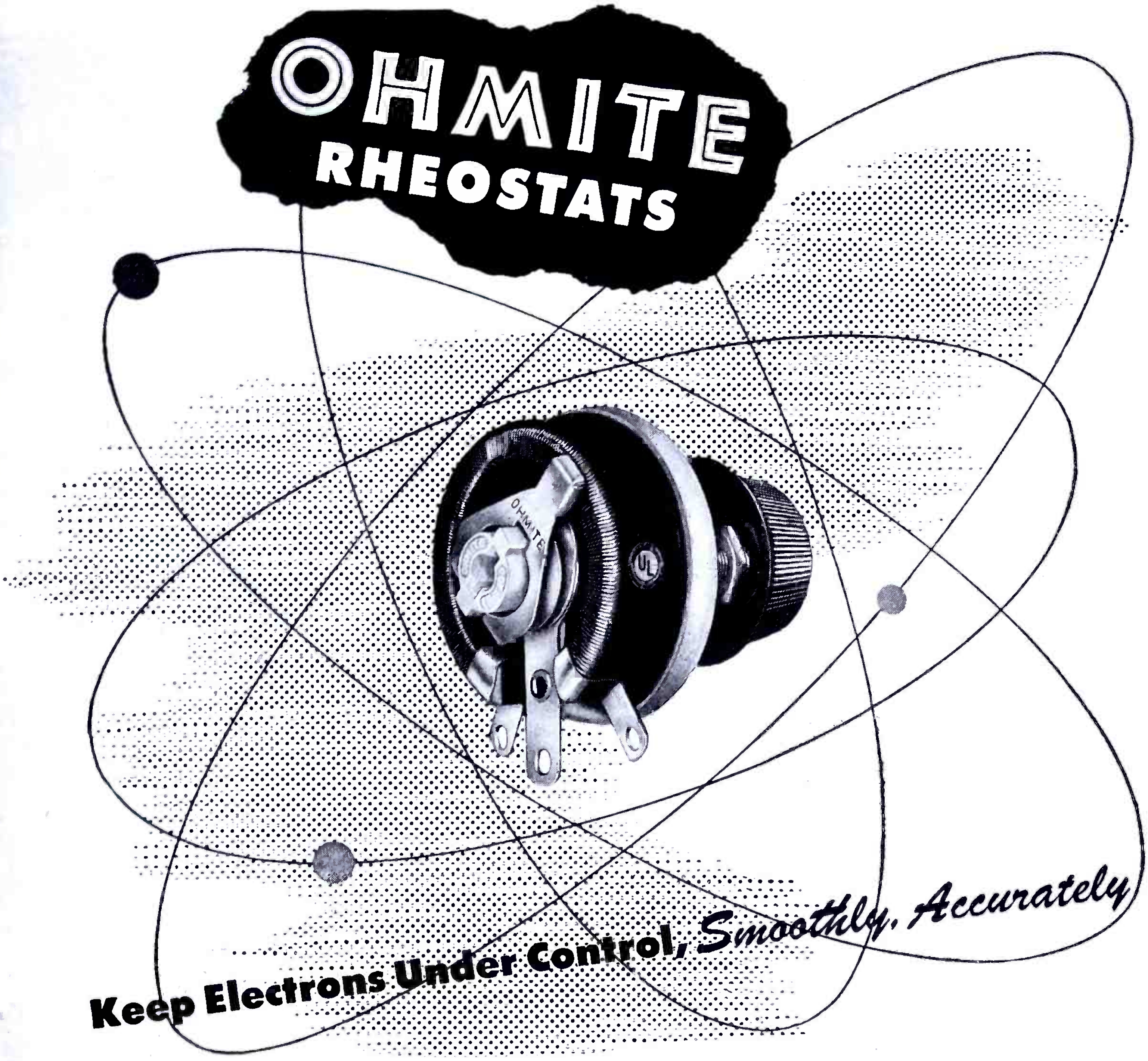
A self-energized tachometer that can be used either as a hand type or separable type has been announced by the Ideal Commutator Dresser Company, 4024 Park Avenue, Sycamore, Illinois.

Essentially this tachometer consists of a small generator, coupled electrically to an electric meter. The generator itself consists of a small, permanent Alnico magnet rotor which is mounted on precision sealed ball bearings and capable of continuous operation at any speed within limit of the meter.

The meter or indicating instrument is a rectifier type, including a sturdy D'Arsonval movement. It is capable of withstanding a momentary overload up to four times the maximum speed indication without damage. The meter is provided with two scales—"Hi" and "Lo."

The generator and meter are made as

(*Continued on page* 81)



Busy electrons obey . . . when you turn the knob of an Ohmite Rheostat. You can always be sure of smooth-action, close-control, trouble-free service. Because of their time-proved design and construction, Ohmite Rheostats serve day-in and day-out in all types of electronic devices—under all kinds of climatic conditions. Ohmite produces ten sizes from 25 to 1000 watts, in straight or tapered windings, in stock or special designs, for every requirement. *Approved types for Army and Navy specifications.*

OHMITE MANUFACTURING COMPANY
4870 FLOURNOY STREET, CHICAGO 44, U.S.A.

BE RIGHT WITH OHMITE
RHEOSTATS · RESISTORS · TAP SWITCHES

SEND FOR CATALOG and ENGINEERING MANUAL No. 40

Write on company letterhead for this helpful 96-page guide in the selection and application of rheostats, resistors, tap switches, chokes and attenuators.

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

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

Personals

SORRY to hear of the recent illness of one of our founders, a charter member and a director since our inception, "Bill" Fitzpatrick. We have missed his reminiscences these past few issues. When you have a chance drop him a line at VWOA headquarters. . . . The same goes for Doc Forsyth, totally blind, and the only wireless operator at Snug Harbor, Staten Island, N. Y. He will enjoy hearing from you. His *leader* will read your letter to him. . . . Ye prexy enjoyed visiting with the Boston VWOA members at the recent Army-Navy "E" ceremonies for the McElroy Manufacturing Corporation. Senator David I. Walsh, chairman of the Senate Naval Affairs Committee and Governor Saltonstall, Governor of Massachusetts, participated in the "E" ceremony broadcast over the coast-to-coast network of Mutual. . . . C. H. Stoup, oldtimer of the days of 1910, threatens to send us stories of the spark days on the Great Lakes. We need 'em CHS, so give 'em priority. He also asks if our secretary is *old man Clark* who ran wireless on the Lakes in those days. Sorry, but he isn't! And incidentally, if anyone has any old pix or data on *Clark Wireless* please lend them to secretary Clark to copy for the Marconi Memorial Library. Will be returned in good order. . . . Oldtimer Pete Boucheron is sure climbing up the ladder. He is now a Captain (four striper) in the Naval Reserve. Our only Naval life member of that exalted degree. Captain *Pete*, alias *BN* wants all vets to drop him a line, via Navy 216, Fleet P. O., New York City. As soon as the typewriter cools off, we'll drop him a note. You, too? . . . Our hearty congratulations to "Bill" Halligan, president of Hallicrafters for winning the second star for the "E" flag. Too bad we were unable to be present at the tenth anniversary surprise dinner tendered Bill in Chicago by the employees. . . . Congratulations are also in order for Ludwig Arnson, president of the Radio Receptor Corporation for winning the "E". We'll see you at the next dinner, LA.

The VWOA Armed Services Party

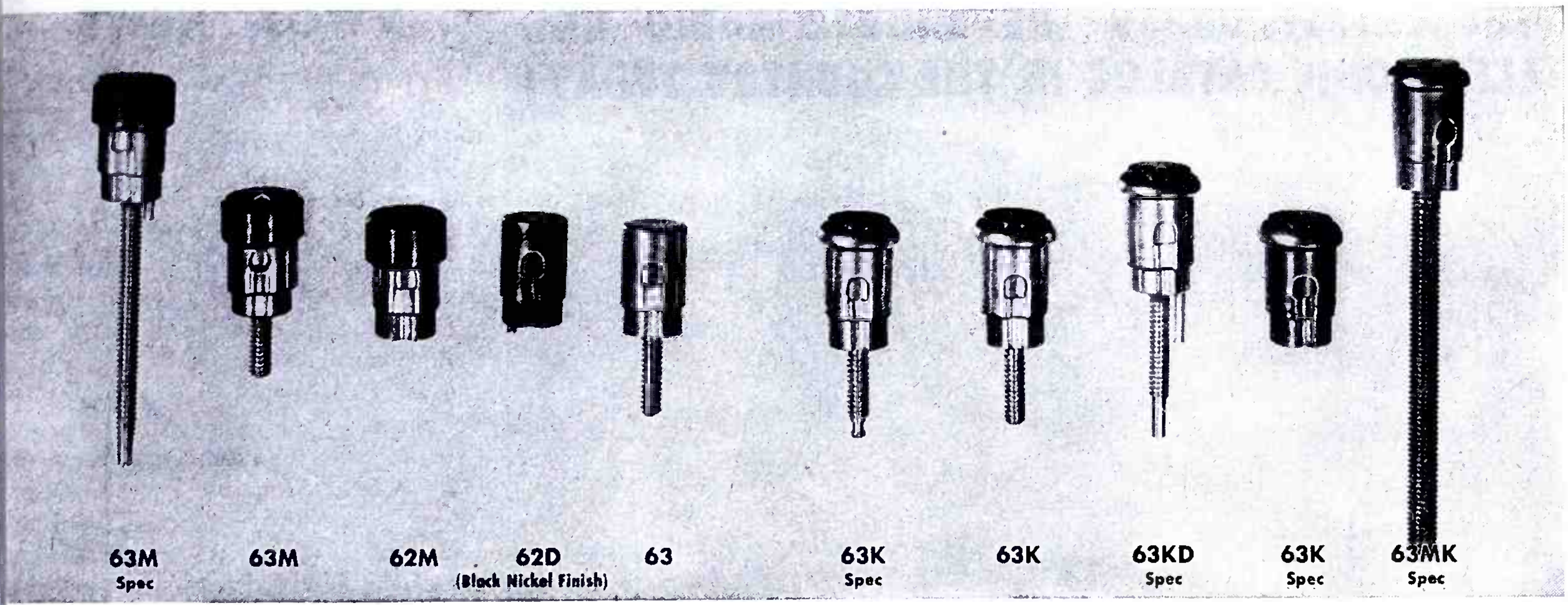
SOME 100 old-time wartime ops of the VWOA played host to representative radio men of today's Armed Services and the Merchant

At the VWOA Armed Services Party in the 77th Division Club.

Marine at the 77th Division Club, 28 East 39th Street, New York City on November 30. By the way put that address down in your address book, for we will have a regular meeting night there each month.

Through the kind efforts of "Jack" Poppele, chief engineer of WOR and the Artist's Bureau of WOR we were entertained royally. At the speaker's table were (from left to right in photograph), . . . Lt. Cmdr. A. F. Wallis, executive officer of the Maritime Radio Training Station at Huntington, N. Y., who told of his experiences at the Messina earthquake for which he received a decoration from the Italian Red Cross; J. R. Poppele; Commander Fred Muller, USNR, chairman of our board of directors; William J. McGonigle, VWOA president and toastmaster, who had to 'cab all the way over from Brooklyn because of a broken foot; Lt. Littenberg, USN, a guest of Cmdr Muller; Lt. Cmdr. McWhorter, also a guest of Cmdr. Muller and the man who was probably first

(*Continued on page 70*)



EBY SPRING BINDING POSTS

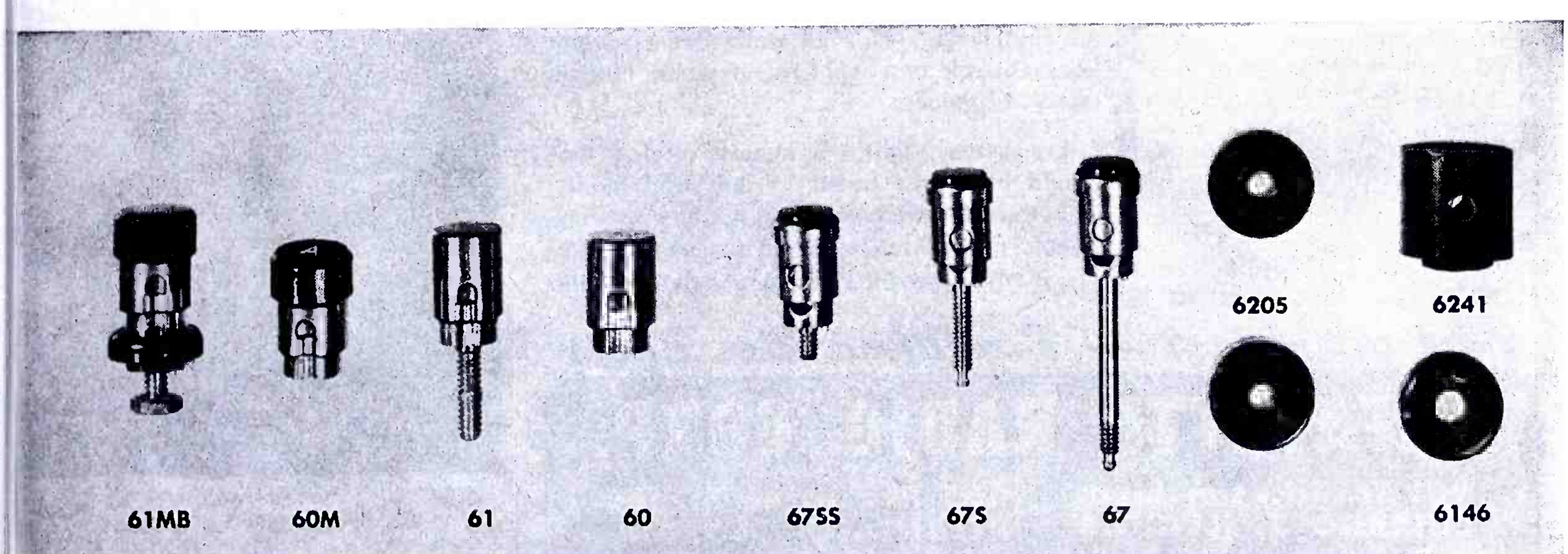
ASSURE A POSITIVE VIBRATION-PROOF CONTACT!

1. The spring — unseen but most important, is designed for long life with minimum pressure loss in service — corrosion resistant.
2. The "D" shaped hole grips the finest wire and holds it in perfect contact. This special Eby construction gives correct, uniform tension across the entire surface of the wire.
3. Eby spring posts have dual guides — makes positive alignment of insertion holes.
4. Made from the highest quality material to meet rigid manufacturing standards and assure maximum electrical conductivity.
5. Recognized standard finishes are nickel, silver, black nickel, and cadmium.
6. Insulating bases, shields, bushings, and spacers in bakelite and ceramic.
7. Cap markings are supplied such as: ANT; REC; GND; HI; A; C; Line; —; +; L1; L2.
8. Most items are carried in stock in sufficient quantity to assure quick preliminary deliveries.

Eby Spring Binding Posts are made to a traditional standard of quality and workmanship, backed by years of experience and a long list of satisfied users. The actual styles shown are illustrative of the wide variety and the great possibility of the use of Eby Spring Binding Posts.

A BINDING POST FOR EVERY USE!

HUGH H. EBY INCORPORATED
18 W. CHELTEN AVE.
PHILADELPHIA 44, PA.



VWOA NEWS

(Continued from page 68)

in the U. S. Navy to receive a distress call, and C. D. Guthrie, supervisor of radio for the Maritime Commission.

Representing the Marine Corps were Staff Sergeant P. G. Bakutes, who trained in radio almost twenty years ago at Quantico, Va., and Corp. Phil Feiler, who also trained at Quantico and just recently returned from the Solomons. From the Army, we had Pete Podell's son, Technical Sergeant Podell; Sgt. Alphonse Pare and Sgt. Frake. The Navy sent Dennis W. Laudon RM3C, who was the lucky winner of the fine McElroy speed key donated by Ted McElroy and Bill Risberg, RM3C. Coast Guard representatives were Wm. A. Irvington RM1C, who was a veteran of the Marine Corps but likes the Coast Guard now, and Radio Striker McDermott. From the Merchant Marine we had Lt. Clifford L. Folsom and Lt. F. C. Krushina, both of whom have seen active service at sea.

Each of these Service men guests were also presented with several cartons of cigarettes, pipe tobacco, and pipes. A good time was had by all!

19th Annual

THE VWOA will celebrate its 19th anniversary with a grand Dinner-Cruise at the Hotel Astor in New York City on Saturday evening February 12, 1944. The North Ballroom, which we usually reserve, has limited facilities, so make your reservations early. See you then!

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TANK TRANSMITTER INSPECTOR

Checking a tank transmitter.
(Courtesy, Western Electric)

NEWS BRIEFS

(*Continued from page* 64)

supply large quantities of chemically pure water which can be processed into hydrogen and oxygen to feed large and small welding machines and reduction furnaces, has been built by Sylvania Electric Products, Inc.

Consuming a gallon of water per cell per hour, this generator is said to be capable of producing 2,000 cubic feet of hydrogen and half as much oxygen per hour. Overhead pipes carry the gas to tube plants. Trucks and huge tanks were formerly used to transfer the gas.

* * *

REEVES HOUSE ORGAN FEATURES "E" CEREMONIES

A special issue of the *Oscillator*, the Reeves Sound Laboratories house organ, featuring the recent "E" award ceremonies, has been released.

* * *

S. H. MANSON IN NEW STROMBERG-CARLSON POST

Stanley H. Manson, sales promotion manager and executive secretary of the Stromberg-Carlson Company labor-management committee, will head a new public relations department. The new division will plan and direct advertising and publicity, sales promotion, dealer and consumer relations, and direct the company's publications.

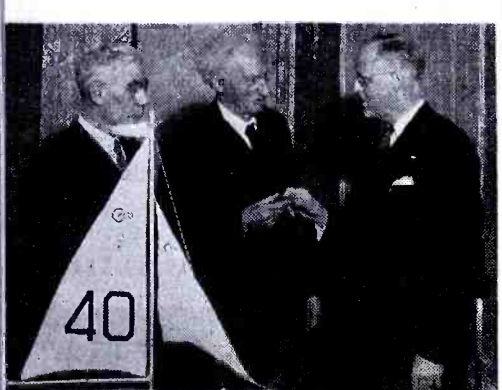
F. Leo Granger succeeds Mr. Manson as radio service manager.

* * *

STEPHEN RYDER HONORED BY ASSOCIATES

The Old Timers Club of Chisholm-Ryder Company, Niagara Falls, N. Y., recently presented Stephen M. Ryder, president of the company with a twin-diamond-studded Old Timers' pin denoting a continuous service in the organization of forty years, the oldest member of the organization, both in length of service and in years. Mr. Ryder is 85.

Premax Products is a division of the Chisholm-Ryder Company.



Left to right: Robert Pearce, president of the Old Timers' Club; Stephen M. Ryder, president of Chisholm-Ryder Co., and George O. Benson, manager of the Premax Products Division, who made the presentation on behalf of the club.

* * *

ASA CELEBRATES SILVER ANNIVERSARY

The twenty-fifth anniversary of the founding of the American Standards Associa-

(*Continued on page* 72)

NEWS BRIEFS

(*Continued from page 71*)

tion was celebrated recently at the annual luncheon meeting of the American Standards Association.

* * *

LAFAYETTE ISSUES 1944 CATALOG

A 104-page catalog for 1944, has just been released by the Lafayette Radio Corporation, 901 W. Jackson Boulevard, Chicago 7, Illinois.

Included are two special forms based on WPB order L265, explaining how needed parts may be secured.

A greatly expanded list of new *Victory line parts*, especially prepared for factory and assembly use, and an eight-page bargain section of values, as well as postal and shipping data complete the booklet.

This edition covers some 50,000 items including a line of communications and public address equipment, test materials, cathode-ray and special purpose tubes, batteries and power supply equipment, radio training kits and code apparatus.

* * *

MISSION BELL RADIO CHANGED TO HOFFMAN RADIO CORP.

The Mission Bell Radio Manufacturing Company, will be known hereafter as the Hoffman Radio Corporation.

H. L. Hoffman is president; P. L. Fleming, former president of Mission Bell, vice president; W. D. Douglas, treasurer; G. G. Davidge, secretary; W. S. Harmon, vice president in charge of engineering; and R. McNeely, sales manager.

The company has its headquarters at 3430 So. Hill Street, Los Angeles, Calif.

* * *

CALLITE BULLETIN ON TUNGSTEN ELECTRODES

A 4-page bulletin describing the application of Callite tungsten electrodes by atomic-hydrogen, helium and argon arc welding has been released by Callite Tungsten Corporation, 540 39th Street, Union City, N. J. The bulletin, No. 154, also gives complete data on the Callite tungsten electrodes available, their physical properties, dimensions and current range in amperes.

* * *

N.U. VISUAL AID VACUUM TUBE CHART

A visual aid vacuum tube chart for instruction purposes has just been published by the National Union Radio Corporation, Newark, N. J.

The chart, measuring 30" by 45", shows all parts of a typical radio tube individually and in relation to the final construc-

•

SILVER SOLDER DISPENSER

An easy-to-make dispenser suggested by John Antkowick, a workman at General Electric, that simplifies the feeding of ribbon-type solder in silver-alloy brazing work.

on. It also contains element classifica-
ons and symbols for diodes, triodes, tet-
odes, pentodes and multi element and
ulti unit types including diode triode,
ouble triode, diode pentode and pentagrid
onverters. Sketches of base pin arrange-
ents and numbering systems for vacuum
bes are also included.

The charts are printed on heavy paper
id are equipped with wooden dowels top
id bottom to facilitate hanging on labo-
tory or classroom walls.

Copies are available through National
nion Distributors, free of charge, to
cognized universities, colleges and Sig-
l Corps instruction centers or at $1.00
ch to individuals outside of the recog-
zed institutions conducting fully ac-
edited radio courses.

* * *

HITMYRE IN NEW G. E. POST

. P. Whitmyre has been appointed as-
stant to R. J. Bahr, purchasing agent
General Electric's electronics depart-
ent, at Schenectady, N. Y.

* * *

ANNON ELECTRIC'S NEW NGINEERING REPS.

even new engineering representatives
ave been appointed by the Cannon Elec-
ic Development Company, Los Angeles,
alifornia.

They are: E. B. Glenn, 801 Healy
ldg., Atlanta, Georgia; Douglas H.
oukota, 10 Light Street, Baltimore,
Iaryland; Ray Perron & Company,
ittle Bldg., Boston, Massachusetts; H.
I. Welch, Crosby Bldg., Buffalo, New
ork; George Sturman, 712 Sixth Ave-
ue S., Minneapolis, Minn.; J. Tinsley
mith, 108 17th Avenue S., Nashville,
ennessee; and J. W. Beneke, St. Louis
gent for E. L. Melton, at 575 Arcade
ldg., St. Louis, Missouri.

* * *

OHN MECK STRESSES NEED OR DISTRIBUTORS

postwar merchandising policy em-
hasizing the need for distribution only
hrough established jobbers has been an-
ounced by John Meck Industries, Ply-
outh, Ind.

In discussing this decision, Mr. Meck
aid, "After careful study of the field, we

(*Continued on page* 74)

•

ACCIDENTS CAN'T HAPPEN HERE

(*Courtesy, RCA*)

A vacuum tube accident-proof device on a press used for forming the leads of radio tube stems. By means of two mirrors at either side in front of press, a beam of light is reflected across front of press, close to the dies, and back to a phototube in control unit. Should the worker accidentally extend her fingers into the press, interruption of the light-beam locks the mechanism with the dies open.

NEWS BRIEFS

(*Continued from page 73*)

came to the conclusion that the radio parts jobber holds so irreplacable a position in the distribution picture that any program which failed to take full cognizance of these facts would not be to the best interests of dealers, consumers or ourselves as manufacturers."

* * *

UNIVERSAL MICROPHONE INSTALLS NEW DEPARTMENTS

Universal Microphone Co., Inglewood, Cal., has installed two new plant departments. One department will be composed of 35 company inspectors headed by supervisor John Nettleton. Another, now forming, will provide an assembly line for the new Signal Corps lip microphone.

* * *

VICTOR SAW CATALOG

A general loose-leaf type catalog on saws, 43-V, has been released by the Victor Saw Works, Inc., of Middletown, N. Y.

The entire line of Victor standard steel hack saw blades; high-speed steel *Mol* type blades; high-speed steel class-A type blades; and high-speed steel 18-4-1 blades are covered, including both hand and power blades. For each type of blade tables of working specifications are given suggesting the proper hand or power blade for practically every kind of metal sawing operation. Attention is also given to the selection and use of flexible back band saws, and the new Victor outline band saw. A special section is devoted to the Victor hack saw frame, with illustrated instructions for its proper use to get the best results in cutting various metals.

* * *

FRITSCHEL AND MANDERNACH NAMED G. E. TUBE SALES MANAGERS

E. H. Fritschel has been named sales manager of transmitting tubes, and H. J. Mandernach, sales manager of receiving tubes in the G. E. tube division. Both men are located in Schenectady, N. Y.

* * *

CENTRALAB CAPACITOR BULLETIN

The bushing mounted capacitor used in high frequency circuits where a capacity ground to the chassis and a *lead thru* is desired, is fully described with a dimensional illustration in a bulletin form 586, released by Centralab, division of Globe-Union, Inc., 900 East Keefe Avenue, Mil-

●

SOLDIERS' MUSICAL KIT

(*Courtesy, Signal Corps*)
Equipment used in the Special Service Division, 1943, *B Kit*, that is issued at the Port of Embarkation on a basis of one to each 120 men.

●

aukee 1, Wisconsin. The back of the ılletin is devoted to engineering data on entralab's 830 and 831 style silver mica ıpacitors.

* * *

LTMAYER NOW WITH MEC-RAD

new division, the Mec-Rad division, as recently formed by the Black Indusies, 1400 East 222nd Street, Cleveland, hio, to manufacture precision type ansmission lines and radiation comonents.

The new division will be under the dict supervision of John Altmayer, chief ngineer. Theo. R. Finke will be develoment and production engineer.

Black Industries also operates Black oring and Machine Company, specialists precision jig boring, and Black Drill ompany, makers of "Hardsteel" drill sed for drilling hardened steels (Rockell C 40 or harder) without annealg.

* * *

CA DYNAMIC DEMONSTRATOR OR STUDENTS

practical circuit diagram demonstrator esigned for laboratory and classroom inruction is now being produced by RCA. is available to schools and training asses on a priority basis.

Known as Dynamic Demonstrator III, embodies a complete, operative, sixbe superheterodyne radio receiver exanded on a plane surface so that all ciruits and parts are readily visible and ccessible for study.

The background of the Demonstrator divided into five principal sections—ower, oscillator, radio frequency, audio equency and intermediate frequency. ach section is marked by a large color lock, the colors conforming to those on ie test leads on the RCA chanalyst, hich can be used in conjunction with ie Demonstrator for service problems.

* * *

LECTRONIC ENTERPRISES WINS "E"

lectronic Enterprises, Inc., Newark, J. J., has been awarded the Army-Navy E."

* * *

VARNER APPOINTED G. E. PLASTICS IVISION CHIEF ENGINEER

rank W. Warner has been named sucessor to Henry M. Richardson as chief ngineer of the plastics divisions of G. E.

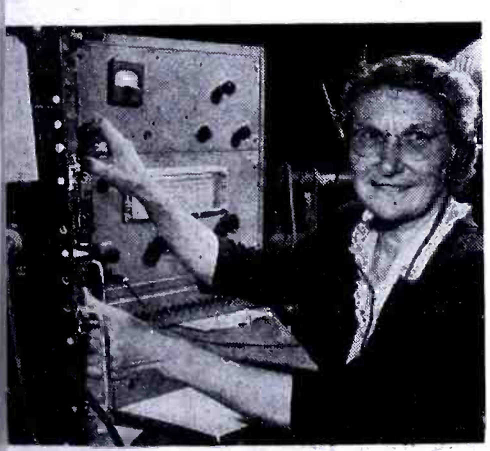
* * *

IRCRAFT MARINE MOVES

he general offices and engineering of-

(*Continued on page* 76)

ELECTRONICS WAR WORKER



Mrs. Louise Oeser engaged in calibrating radio transmitters at General Electric. She has two sons, a son-in-law and a granddaughter serving in the armed forces.

NEWS BRIEFS

(*Continued from page* 75)

fices of Aircraft-Marine Products, In are now located at 1523 N. 4th Stre Harrisburg, Pa.

* * *

STACKPOLE CATALOG

A 36-page catalog with data on fixed a variable resistors, switches, and ir cores has been published by The Stac pole Carbon Company, Electronic Co ponents Division, St. Marys, Pa.

The catalog, RC6, contains comple listings on the various types of Stackpo insulated and non-insulated cores, et reactance charts as well as time consta charts for series circuits.

Other features include detailed listin and dimension diagrams of slide, line, a rotary-action switches; ⅓-, ½- and watt fixed resistors, as well as variab resistors in standard and midget sizes.

* * *

GROVES RESISTOR BULLETIN

A 4-page sales bulletin covering the ge eral characteristics of cement coat power wire-wound resistors (grade class 2), with temperature rise a physical dimension charts has been pu lished by the Groves Corporation, Ca Gerardeau, Missouri.

* * *

R. A. HACKBUSCH REJOINS STROMBERG-CARLSON OF CANADA

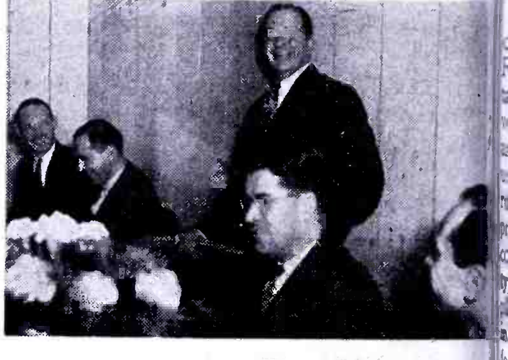
Ralph A. Hackbush, vice-president charge of radio and director of the rad division of Research Enterprises, Lt founded in 1940 by the Canadian gover ment to undertake research and the man facture of radio optical glass and oth war equipment, has rejoined the Stron berg-Carlson Company of Canada in new capacity as vice-president and ma aging director.

Mr. Hackbusch was recently electe vice-president of the Institute of Rad Engineers. He has served as chairman the Toronto section.

* * *

EMPLOYEES TOAST HALLIGAN ON HALLICRAFTERS 10TH YEAR

The Old Timers' Club of the Hallicrafte Company recently celebrated the tent anniversary of the company with a su prise dinner in honor of W. J. HallYgan president and founder.



* * *

LOW FREQUENCY CRYSTAL DEVELOPED AT JAMES KNIGHTS

Maurice A. A. Druesne and Jame Knights of The James Knights Compan Sandwich, Illinois, have developed an patented a new type of low-frequenc crystal. The designers say that th crystal can be ground to better than on part per million per degree Centigrad drift; has unusual activity, and has bee made to vibrate both on the low mod d high modes so that dual frequency ystals of this particular cut can be adily produced. It is also said that by ntour grinding the crystal can be lowed or raised in frequency, and consently the exact adjustment of frequency easily accomplished. The crystal can used in either air-gap mountings or n be plated and clamped at the nodal int. Frequencies as low as 10 kilocles and as high as 300 kilocycles are d to have been produced.

* * *

IND MAN LEADS IN PRODUCTION F AIRCRAFT ACCESSORIES

arence I. McPherson, blind crystal isher at Aircraft Accessories Corporan, Kansas City, Kans., achieved a proction record recently when he ground per cent more crystals than any of the ner expert finishers with whom he rks. The products of his sensitive finrs are so good, the manager of the crys laboratories reported that 95 per cent them passed inspection.

* * *

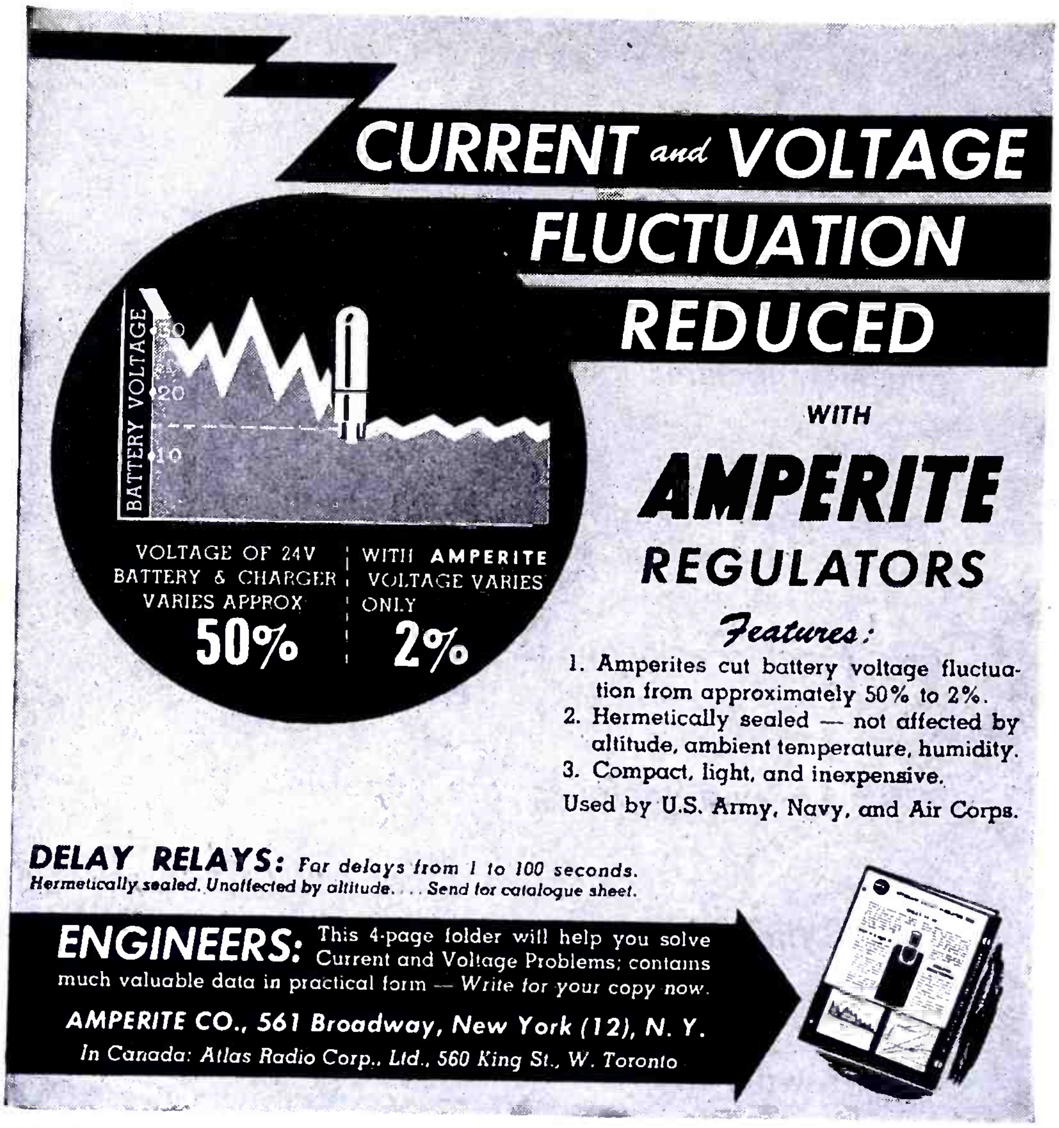
. E. SAVES 850,000 POUNDS OF TIN

fore than 850,000 pounds of tin have een saved by G.E. since Pearl Harbor s a result of changes adopted in solders nd babbitt alloys.

General Electric today is using a series f soldiers, depending on the application. For general-purpose work a solder conaining 20 per cent tin, 1.25 per cent siler, 1.5 per cent antimony, and the balnce lead may be employed. It can be sed with noncorrosive fluxes such as osin on aniline phosphate, and on bare, re-tinned, or cadmium-plated surfaces. A orrosive flux, such as the zinc chloride ypes, is used for bare steel and zinclated copper or steel. It is being used n wire form, both solid and rosin-cored, or all types of electrical connections which ormerly were made with solders ranging rom 40 per cent tin, 60 per cent lead to 0 per cent tin, 40 per cent lead. About he only change in technique required to se the lower tin solder is to use a hotter soldering iron since the 40 per cent tin solder melts at 455 F and the 20 per cent tin solder at 518 F.

A silver solder, containing 2.5 per cent silver and the balance lead, and melting at 579 F is used chiefly for applications requiring high rupture strength at elevated temperature. This solder does not

(*Continued on page* 78)



NEWS BRIEFS

(Continued from page 77)

flow and wet as readily as pure tin. It calls for a corrosive flux on bare surfaces but rosin flux can be used on pretinned surfaces. It is used chiefly for soldering rotor binding bands.

Two compositions are being used for pretinning or dip-soldering in solder pots but neither is recommended for soldering-iron work. One consists of 10 per cent tin and 90 per cent lead, and melts at 567 F; the other has 10 per cent tin, 1.5 per cent silver, and 88.5 per cent lead. The second has somewhat better spreading creep qualities. Zinc chloride (corrosive) type flux is used, with subsequent washing to remove flux residue.

A solder containing 30 per cent tin, 2 per cent antimony, 1.25 per cent silver, and 66.75 per cent lead is used for soldering wiped joints. While it handles well, it is more susceptible to porosity than a 40 per cent tin, 60 per cent lead wiping solder.

General Electric has not found it possible to change to low tin solders for every application. Soldering commutator winding joints still requires 100 per cent tin solder. Such joints are subjected to moderately high temperatures for a soldered joint and are under high stress, demanding a solder with high temperature rupture properties. The necessity for use of a noncorrossive flux also limits the choice of solders to those which wet and flow readily with a rosin flux.

* * *

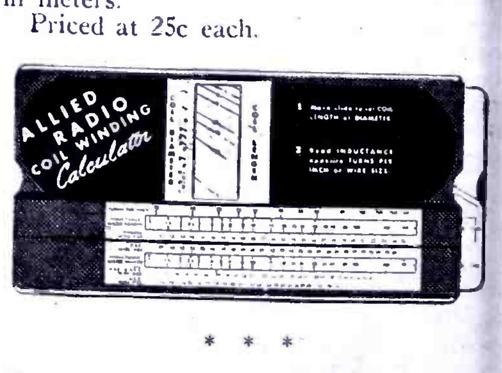
ALLIED RADIO CALCULATOR

A slide-rule type rapid calculator for inductance, capacitance, and frequency components of series or parallel tuned r-f circuits as well as inductance, turns-per-inch, wire type, wire size, coil diameter and coil length for single layer-wound solenoid type r-f coils has been released by Allied Radio Corporation, 833 West Jackson Boulevard, Chicago 7, Illinois.

All values, in either case, are found with a single setting of the slide and are said to be accurate to within approximately 1% for coils ranging from ½" to 5½" in diameter and ¼" to 10" in length. All possible combinations within these limits are shown.

Wire types and sizes include 11 to 35-gauge plain enamel, 11 to 36-gauge ssc, dsc, and scc, and 12 to 36-gauge dcc. The rule is also engineered to indicate turns-per-inch from 10 to 160; inductance from 0.1 to 15 microhenries; capacitance from 3 to 1,000 mmfd; frequencies from 400 kc to 150 mc with equivalent wavelengths in meters.

Priced at 25c each.



* * *

LOUISE NEWTON PROMOTED AT WIS

Louise Newton, control operator for the past year at WIS, Columbia, South Carolina, has just been appointed chief control operator. She is the first woman chief in South Carolina. The control room oasts another woman operator, Anna urgess.

* * *

TARS ADDED TO ALL FOUR AYTHEON "E" FLAGS

tars have been added to the Army-Navy E" pennants flying over the four Rayneon Manufacturing Company divisions.

* * *

ATEST TYPE AN CONNECTOR ULLETIN

10-page supplement on type AN electrial connectors has been released by the annon Electric Development Company, os Angeles. Supplement contains layits of new insert arrangements, tabular atter and special plugs. Pages are in ose-leaf form to be used in current annon general catalogs.

* * *

. A. CROSSLAND NOW G. E. ECEIVER SALES MANAGER

. A. Crossland has been named manager f sales of the G. E. receiver division. In is capacity, Mr. Crossland will be responsible for all sales matters of the divion. For the present he will divide his me between Bridgeport, Conn., and chenectady, N. Y.

* * *

YLVANIA ADDS 18TH PLANT

new plant for the production of elecronic manufacturing and testing equipient will soon be added to the facilities f Sylvania Electric Products Inc.

P. G. Pilkinton, manager of equipment evelopment with headquarters at the Emporium plant of the company, will upervise the new factory which is to be nder the direct charge of C. B. Eckel.

* * *

RCA BOOK ON ELECTRONICS IN INDUSTRY

A 44-page booklet entitled *Electronics In Industry* has just been released by RCA. It is profusely illustrated in color, and written in non-technical language.

* * *

LATIN-AMERICAN COUNTRIES HONOR PALEY AND CHESTER

The Order of Cristobal Colon, highest civilian decoration of the Dominican Republic, and one of the oldest and most important of Latin American orders, has been conferred upon William S. Paley, president of the Columbia Broadcasting System, and Edmund A. Chester, CBS director of Latin American relations.

Paley received the cross of the order with the rank of Commander, and Chester the rank of Officer.

* * *

G. E. STOCKHOLDERS SURVEYED ON POSTWAR RADIO

Questions on postwar receiver requirements appeared in an illustrated questionnaire mailed to 227,000 G.E. stockholders recently.

The information requested covered types of radio desired after the war, kind of radio now owned, f-m interests, etc.

* * *

FRANK M. FOLSOM ELECTED RCA V-P AND DIRECTOR

Frank M. Folsom, who served as Chief of the Procurement Branch of the Navy Department, has been elected a vicepresident and a director of Radio Corporation of America. He assumes his new duties January 1, 1944, and will be in charge of the company's manufacturing division, RCA Victor, with principal

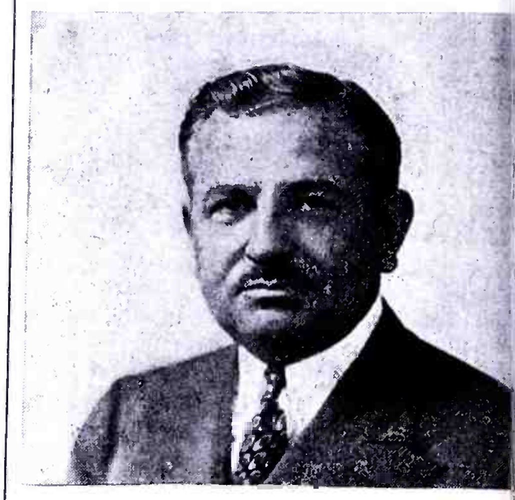
(*Continued on page* 80)

NEWS BRIEFS

(*Continued from page 79*)

plants in six cities and headquarters a
Camden, N. J.

George K. Throckmorton has resigne
as an RCA vice president and directo
Mr. Throckmorton, present head of th
RCA Victor Division, is retiring for rea
sons of health, but will continue as
consultant to the company.



Frank M. Folsom

* * *

G. A. GUSTAFSON NOW G. E. PLASTICS DIVISION MFG. MANAGER

G. A. Gustafson has been appointed manu
facturing manager of the plastics division
of the G. E. appliance and merchandis
department. Mr. Gustafson's headquar
ters are at 1 Plastics Avenue, Pittsfield
Massachusetts.

* * *

FISHER RESEARCH LAB BULLETIN

A 16-page booklet describing marin
equipment has been published by th
Fisher Research Laboratory, 1961 Uni
versity Avenue, Palo Alto, California.

Described in the booklet are communi
cation receivers, transmitters, directio
finders, utility equipment, power supplie
and antennas.

The Fisher Laboratory which is owne
and managed by Gerhard R. Fisher, also
produces M-scope pipe and cable locators
M-scope water and oil leak detectors
M-scope well survey equipment; com
munication equipment for fire trucks
utility cars, emergency trucks, railroad
cars, etc.; and communication equipment
for transmission along pipe lines and
power cables.

* * *

WESTERN ELECTRIC COMMUNICADE

Three huge dioramas, with sound effects
illustrating the production and use of
communications equipment, were dis
played recently by Western Electric to
employees and visitors in New York and
New Jersey.

The dioramas which will go on tour
reveal the importance of communications
equipment on the home and war fronts
and illustrate the variety of functions
the equipment serves.

* * *

DR. CRAIG'S NEW TELEVISION SYSTEM REVEALED IN NEW YORK

Dr. Palmer H. Craig, professor of Elec
trical Engineering, University of Florida,

(*Continued on page 94*)

HE INDUSTRY OFFERS . . . —

(*Continued from page* 66)

stinctly separate elements and coupled gether by a precision made bayonet ck. A 5' cord complete with coupling ig is provided, but a cord up to several indred feet long (of proper size wire) n be used without introducing an appreciable error in scale reading.

Size of generator is 1⅝" dia. x 3¾" ng (including ¾" shaft extension); ight 8 oz. Size of meter is 3" x 4¼" x ½"; weight 20 oz. Size of complete it is 3" x 7½" x 2½" (including ¾" aft extension); weight 3 lbs. Available two sizes, for 0 to 2,500 rpm and 0 to 00 rpm.

* * *

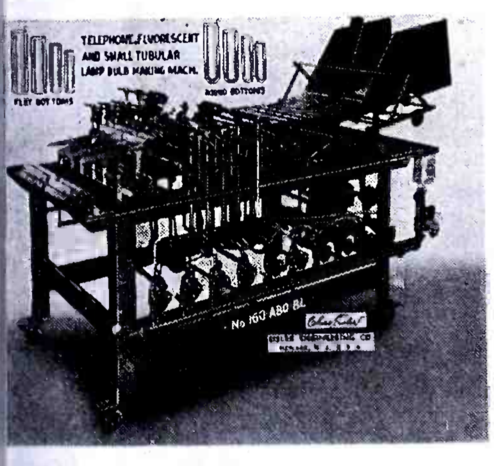
LASS TUBE BOTTOMING MACHINE

glass tube bottoming machine has been oduced by the glass machinery department of the Eisler Engineering Co., ewark 3, New Jersey.

In the machine the glass tubing, cut to uble required length, is placed into a chanically agitated feeder and then rwarded piece by piece. The tubes rried automatically in forward direcn, and at the same time kept continuy in rotation about their own axes by llers underneath, pass an arrangement gas burners which preheat the place of e tubing where a flat or round bottom s to be formed. Additional small rollers e provided pressing slightly on top of e tubing to hold them in proper posion during the following operation of ttoming. The number of these burners pends on the outside diameter, the wall ickness and quality of the tubing. After eheating, a special cut-off burner dides the glass tubing in two pieces.

The flat bottom is then made by pressg the cut tubes gently against a preated steel plate, called *bottomer*. A ecial device combined with a properly aped mould, inserted in place of the rmerly used steel plate, are employed, hen round bottoms are required.

The machine, driven by a ½ hp motor, adjustable for handling tubes in the nge of 4" to 10" length and ¼" up to ½" outside diameter. Production depends on the size of work and is approxiately between 800 to 500 pairs of vials er hour.



* * *

RUNNING GEAR HYDROCARBON CLEANER

An emulsifiable type cleaner, known as Running Gear, designed for quick removal of oils and solid particle dirts and greases, especially those which are very hard and caked on, has been produced by

(*Continued on page* 82)

THE INDUSTRY OFFERS . . .

(*Continued from page* 81)

the Technical Processes Division of Co onial Alloys Company, Colonial Phil delphia Building, Philadelphia 34, Pa.

It is said to be applicable to metals general and large machines, and par and assemblies, prior to repairs or r finishing.

Where the metal is to be bonderize Running Gear is said to be useful to for it does not passivate the metal su faces. It may be used as a solvent eith in an open tank or in a degreasing m chine, to be followed by an alkaline d for purposes of plating, anodizing, etc.

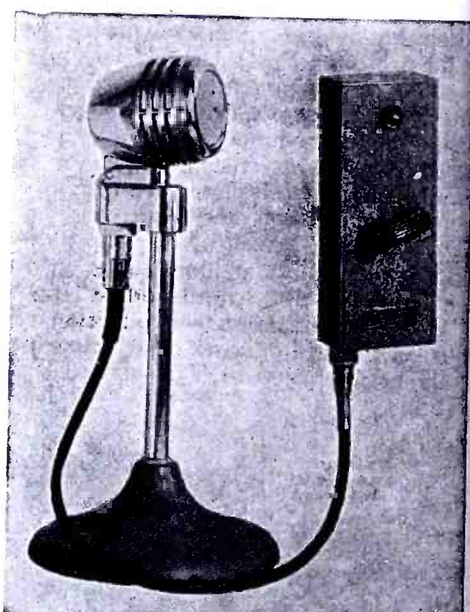
* * *

MICROPHONE CONTROL BOX WITH BUSY SIGNAL

A relay and busy signal control bo model P566, for connection to micr phones, has been announced by Executon Inc., 415 Lexington Avenue, New Yor

The device provides an instantaneo method of cutting in on central pla sound systems. Busy signal light elim nates interruption from other microphone in the same system. Talk-switches pr vents accidental broadcasting of unwante sounds, provides automatic plate voltag relay control, and automatically cuts o music broadcasting when paging is de sired.

Suitable for wall mounting, the unit i housed in a gray crackle finished meta cabinet, 6½" x 2⅝" x 1⅜". Connection are made to terminal strips located insid the case.



* * *

G. E. VACUUM SWITCHES

Four new vacuum switches have been announced by the G. E. tube division.

The contacts of the switches are mounted in a vacuum and thus are said to be relatively free from the effects of corrosion and arcing, and unaffected by dirt or oxidation. The vacuum-type construction also gives the switches a high current rating for their size and permits them to handle enough power to operate equipment at greatly reduced voltages.

No self-contained coil or other operating mechanism is built into the switches. Movement is obtained from the mechanism to be controlled or from other apparatus to suit the application. This movement ın often be provided by a slow-moving um or by the movement of a thermo-at. Air or liquid bellows, a rod-linkage stem, or almost any other means can used to operate switches of this type. An external fulcrum is eliminated by e use of a flexible diaphragm which ansmits movement to the contacts and ts as a natural fulcrum point for the erating arm. The contacts close with-ıt vibration, making it possible to ount these switches on or near delicate struments.

* * *

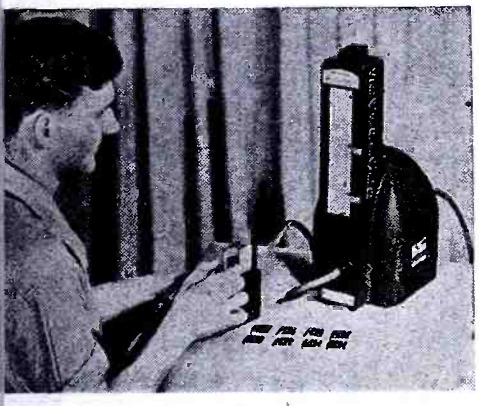
UARTZ CRYSTAL GAUGE

or gauging quartz crystals as to size, ıt-of-round, taper and bell mouth at any ction of its length or at any point on e diameter within its length, the Shef-ld Corporation, Dayton, Ohio, have veloped an instrument known as Pre-sionaire. The principle of air flow, in-ead of air pressure, is used to permit latively low pressures during the gaug-g operation.

Interchangeable spacer blocks are in-rted in the fixture to permit the check-g of several basic sizes. Crystals of ıown size are used as masters to set the ointers, and the top marker represents e minimum limit; the bottom marker, e maximum limit. If the float rises to point between the markers, the part is ithin tolerance limits.

Eight of the spacing blocks of various zes are shown in the illustration. The ole in the center permits the passage of r. A spacing block may be seen mounted the fixture connected to base instru-ent.

Precisionaire can also be used to check lass, metal, plastics or other material, ith tolerances ranging from .0001" to 05".



* * *

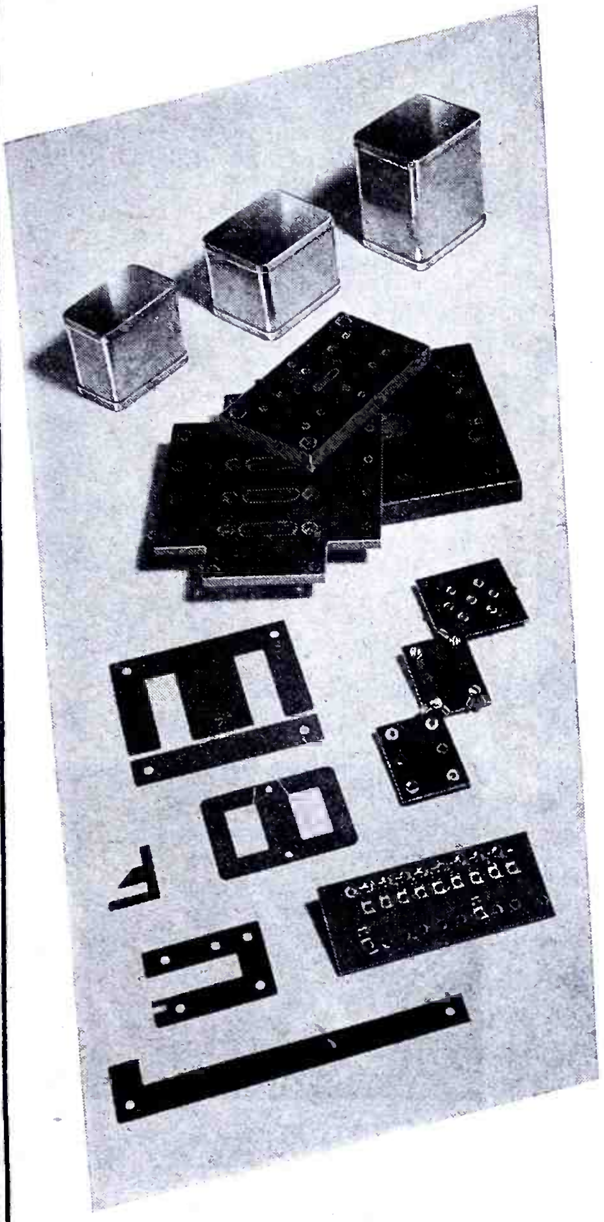
CA R-F BEAM AMPLIFIER AND MULTIPLIER PHOTOTUBES

Two new tubes, an 829-B push-pull r-f eam power amplifier and a 931-A multi-lier phototube (9-stage electrostatically ocused type) have been produced by RCA.

The 829-B has a total maximum plate issipation of 40 watts. It is recommended specially for use in r-f power amplifier quipment. Having the same size and eneral appearance as the 829 which it eplaces, the new 829-B differs in that it as not only a higher plate-voltage rating 750 volts) but also an improved me-hanical structure to permit use of the ube in applications involving considerable ibration.

The 829-B is said to permit full power utput with very low driving power. For xample, a single tube operated in push-ull class C telegraph service is capable

(*Continued on page* 84)



THE INDUSTRY OFFERS . . . —

(*Continued from page 83*)

of handling a power input of 120 watts with less than a watt of driving power at frequencies as high as 200 megacycles.

The 931-A has the same size and general appearance as the 931 which it supersedes, but differs in that its current amplification has a minimum value 6 times higher, and an average value more than 3 times higher for the same voltage per stage. At 3,750 angstroms, the 931-A has a sensitivity of 1,800 microamperes per microwatt of radiant flux at 100 volts per stage, whereas the 931 had a corresponding value of 532 microamperes per microwatt.

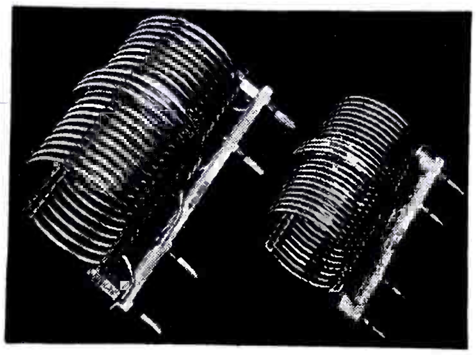
The 931-A is recommended for use in light-operated relays, sound reproduction from films, facsimile transmission, scientific research utilizing low light levels, etc.

* * *

B & W COILS FOR ELECTRONIC HEATING

An assortment of standard and special type coils for electronic heating applications, is now being offered by Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.

The standard heavy duty coils are said to meet many electronic heating applications up to 1 kw.



* * *

SYNTHETIC SHELLAC DEVELOPED

The development of a synthetic shellac was recently announced by the Arthur D. Little Laboratories, 30 Memorial Drive, Cambridge 42, Mass.

The new compound was developed by C. G. Harford, and is made from available domestic materials.

The new shellac is being manufactured under the name *Zinlac* by William Zinsser and Co., New York.

* * *

WESTINGHOUSE PORCELAIN-CLAD CAPACITORS

Solder-sealed porcelain-clad, type FPC Inerteen capacitors, for high voltage d-c applications where space is limited, have been developed by Westinghouse.

The capacitor elements are hermetically sealed in a tubular, wet-process porcelain body with solder sealed end closures (from 7,500 volts up to and including the 200,000-volt class). The end closures act as the capacitor terminal by connecting the element leads at opposite ends, utilizing the porcelain tube as insulation.

By eliminating the large metal case and bushings required by metal case capacitors, the new porcelain-clad capacitors

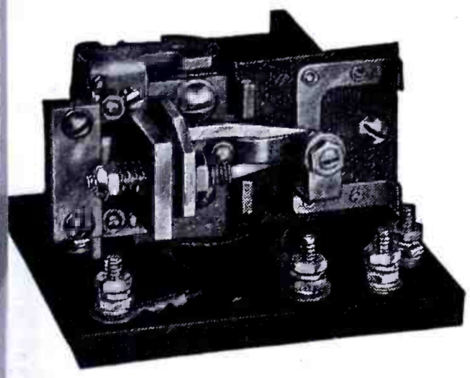
lp maintain minimum over-all dimen-
ons. Larger types are furnished with or
thout cast mounting flanges. Where
stings are used, the capacitors are
lder-sealed; then castings are cemented
with mineral-lead compound.

* * *

RUTHERS-DUNN NAP-ACTION RELAY

sensitive type relay, 79XAX, with ap-action contacts is now available om Struthers-Dunn, Inc., 1321 Arch St., hiladelphia, Pa. Contact pressure of is relay is said to remain constant de- ite slow variations in the coil current in hich it is connected. Then, when the il current reaches a certain point, the ntacts operate with a positive snap tion.

The relay is said to operate on as little 10 milliwatts in its coil circuit. It is commended for highly sensitive vacuum be applications, as well as in detecting erloads at low current levels.



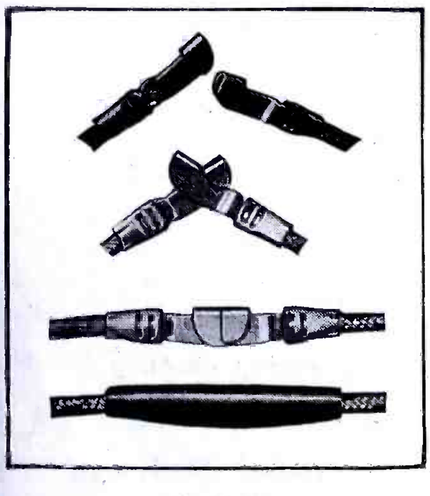
* * *

-M SOLDERLESS SPLICING TERMINAL

solderless splicing terminal with in- ulation support which affords a splice or connecting wires until intentional uick disconnection is desired has been eveloped by Aircraft-Marine Products nc., 1521-31 North Fourth Street, Har- isburg, Pa. Precision installation tools nake all three crimps in one operation.

Only two identical parts are required to nake a connection. The tensile strength f the splice is said to be greater than at of the wire itself, yet the assembly an be uncoupled when desired. A four- oint *knife-switch* wiping action is said o assure minimum contact drop through he coupling.

Bulletin 27 covers the details of the MP splicing terminal.



* * *

CLARK ADJUSTABLE COUNTERBORE

An adjustable blade counterbore and potfacer has been announced by the Rob- rt H. Clark Company, 3424 Sunset

THE INDUSTRY OFFERS . . . —

(*Continued from page* 85)

Boulevard, Los Angeles 26, Calif. The counterbore and spotfacer blades are adjustable to any diameter within the broad limits of the tools.

An exclusive no-burr feature is incorporated into these new tools, according to the manufacturer. Each of the interchangeable pilots is so designed that burrs are prevented from forming at the edge of the pilot hole, thereby avoiding *locked* pilots and the resulting damage to the tool and the work.

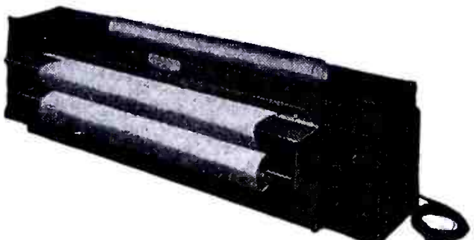
A range of 8 sizes covers fractional and decimal diameters from 9/16" to 5½" and provides interchangeable pilots from 3/16" to 5¼" in diameter. The cutting blades are removable for easy resharpening or replacement.

The tool is equipped with Tan Tung blades, a tough, non-ferrous cast alloy for metal cutting, developed to fill the gap between conventional high-speed steel and cemented carbides. It will machine all kinds of rolled, forged, or cast steel, iron, aluminum, brass, copper, bronze, and some hard materials formerly considered non-machinable with steel tools.

* * *

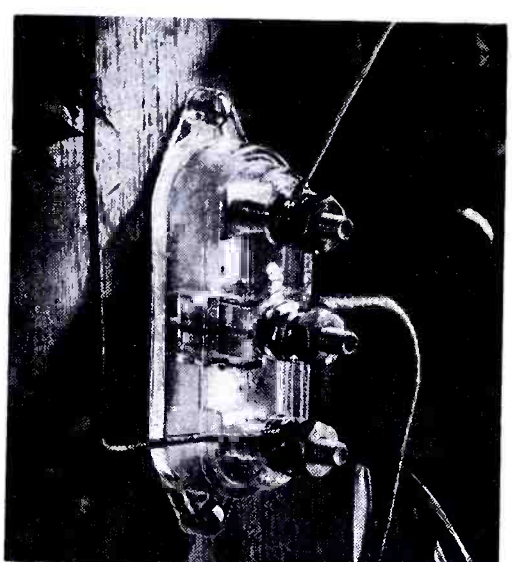
PECK AND HARVEY TABLE-TYPE CONTINUOUS PRINTERS

Two table-type continuous printers have been developed by Peck & Harvey, 4327 Addison Street, Chicago, Illinois. They are known as the "B-1" and "B-2" models, producing blue prints or direct process black and white prints up to 44" wide in any lengths at a speed up to 42" per minute.



* * *

PLASTIC LIGHTNING ARRESTER



Lightning arresters are now housed in transparent plastic. In the presence of electrical discharges during thunderstorms, the glow of a small neon tube visible within the transparent housing indicates a satisfactory connection between aerial and ground. These plastic housings are made of Tenite, a product of Tennessee Eastman Corporation, Kingsport, Tenn. Housings are molded by Sterling Plastics Company, Union, N. J., and manufactured by L. S. Brach Manufacturing Corporation, Newark, N. J.

[I]NTERPOLATION OSCILLATOR

(*Continued from page* 21)

[si]gned frequency will result in a read[in]g on either the high or low side of [th]e *0* point, depending upon the direc[ti]on and amount of deviation.

When handling known frequencies, [a] procedure chart can be set up for [a]ny number of representative frequen[ci]es as follows:

[F]requency	Scale	Preset	MV* order
[2,]735 kc.....	Green	5.0	10
[2,]740 kc.....	Red	2.5	8
[2,]922 kc.....	Red	2.0	10
[2,]986 kc.....	Green	4.0	10
[2,]748 kc.....	Green	2.0	10

With the receiver and interpolation [o]scillator turned on, the dial of the [o]scillator is preset to the indicated [p]oint and the signal tuned in on the [r]eceiver to zero-beat; the dial of the [o]scillator not being changed to accom[p]lish this. The signal is removed and [th]e standard turned on. This results [i]n another beat note being heard which [i]s the difference between the interpola[t]ion oscillator and the nearest har[m]onic of the frequency standard. The [d]ial of the bfo or interpolation oscil[l]ator can now be adjusted to zero-beat [w]ith this signal. This zero-beat point [w]ill usually be found near *0* on the [d]ial; its proximity to *0* depends upon [t]he amount and direction of deviation. Deviations read on the *green* scale are [h]igh, and those on the *red* scale are [l]ow.

In the measurement of 2,748 kc we note from the procedure chart that the interpolation oscillator dial is preset at 2.0 or 2,000 cps in the *green* scale. A frequency of 457 kc results. It is produced by the interpolation oscillator and injected into the i-f channel of the receiver. In accordance with the above procedure the signal is now tuned to exact zero-beat and, of course, the hfo in the receiver will have been tuned to 3,205 kc or a frequency 457 kc higher than 2,748 kc. The signal is now removed and the standard turned on. Since the nearest mv harmonic point is 2,750 kc it is necessary to lower the frequency of the interpolation oscillator 2 kc or 2,000 cps so as to restore the zero-beat condition. Zero-beat will then be found at *0* point on the dial or 455 kc. This is the difference between 3,205 kc, the frequency to which the hfo is tuned, and 2,750 kc.

It can now be readily seen why any deviation of the signal from its assigned frequency can be directly observed either above or below the *0*

*Multivibrator order.

(Continued from page 87)

point. As an example, let us assume a 2,748 kc signal, 120 cps low, or 2,747.880 is being measured. With the interpolation oscillator preset at 2.0 in the *green* scale or 457 kc, the hfo in the receiver will be at 3,204.880 when the signal is tuned in to zero-beat. Now, after removal of the signal, in order to restore the zero-beat with the 2,750 kc signal from the frequency standard, the interpolation oscillator must be tuned to 454.880 kc. And this point is found to be 120 cps from *0* point on the low side or in the *red* scale.

This method thus removes the problem of arithmetical computation of frequency when measuring known frequencies. This is, of course, the case in most frequency measurement work of this nature. The equipment can, however, be used in the measurement of any unknown frequency by substantially reversing the process as outlined. Either the signal or the nearest harmonic of the frequency standard can be tuned in at zero point on the dial, and the direction and amount of frequency difference read from the dial when the zero-beat is established with the other element. This, of course, involves adding or subtracting this difference from the harmonic point and the necessary prior establishment of the frequency of the harmonic in use. In this case the computations are not eliminated. As an example let us assume that an examination of the calibrated dial of the receiver and the 100 kc harmonics of the standard, has disclosed that the signal being measured, lies between 9,100 and 9,200 kilocycles. After the 10 kc order has been switched on and the harmonics counted, we find that the signal is between 9,120 and 9,130 kc, but closer to 9,130 kc. The interpolation oscillator can now be turned on and set to the zero point. The 9,130 kc harmonic of the frequency standard is tuned into zero-beat and the standard turned off. The signal is again applied and the zero beat with it established by varying the frequency of the interpolation oscillator. The difference frequency as read from the dial of the interpolation oscillator will be 1,900 cycles and in the *green* scale. The subtraction of this frequency of 1,900 cycles from 9,130 kc discloses that the unknown frequency is 9,128.-100 kc. This, of course, is only one of the ways in which the unit could be utilized in the measurement of signals of unknown frequency.

Calibration of the oscillator can be accomplished in several ways. Perhaps the most satisfactory is the application of the output signal into the antenna terminal of the receiver. Successive beats with harmonics of the standard are thus obtained. For instance, the second harmonic of the oscillator output can be beat against the frequency standard output harmonics at 900, 910 and 920 kc to obtain fixes at 450, 455 and 460 kc. This can be extended up to the 20th harmonic of the oscillator where it is possible to obtain strong check points every 500 cycles and to the 50th harmonic where points will be found every 200 cps. In lieu of this, the unit can be calibrated against an already accurately calibrated audio oscillator.

Little practice and prior knowledge of frequency measurement technique appear to be necessary to obtain the maximum possible accuracy from this system.

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S-T RELAY SYSTEMS

(*Continued from page* 19)

put not in excess of that necessary to render a satisfactory service.*

Par. 4.36 Required Experimentation. The licensee of each STL broadcast station is required to conduct experimentation with regard to the following:

(*a*) Design of equipment and power required to render a satisfactory service.

(*b*) Design and adjustment of directional transmitting antennas.

(*c*) Design and location of receiving antennas.*

Par. 4.37 Supplemental Report With Renewal Application. A supplemental report shall be filed with and made a part of each application for renewal of application and shall include statements as to the following items:

(*a*) Total hours of operation.

(*b*) Continuity of service; causes and duration of any interruptions.

(*c*) Power required to deliver satisfactory signal at receiver.

(*d*) Data on design, adjustments, and operation of directional receiving, and transmitting antennas.

(*e*) Interference to service resulting from other stations or other sources.

(*f*) Cost of transmitter and receiver installation and expense of operation.

(*g*) Overall fidelity of equipment, frequency and amplitude.*

By the Commission.

(Seal) T. J. Slowie, Secretary.

(F. R. Doc. 41-1889; Filed, March 13, 1941; 3:27 p.m.)

[2]The abbreviation "STL" is derived from "studio transmitter link."

*Par. 4.31-4.37, inclusive (with exception noted in the test) issued pursuant to the authority contained in sec. 4. (i), 48 stat. 1068; 47 U.S.C. 154 (i).

DUPLEX SPEAKER

(*Continued from page 23*)

quency unit, because of unloading when the maximum rating power is applied in the cross-over region.

The Dividing Network

Figure 3 is a photograph of the duplex speaker and its dividing network. These networks use iron cored reactors capable of being operated over a wide voltage range with negligible change in their inductance value. The networks are not affected by their proximity to other apparatus. The assembly shown has been used with various shapes and sizes of resonated baffles, but most satisfactory results have been achieved when a baffle, with a volume of 6 to 9 cubic feet, was used. A 6-cubic-foot baffle when properly ported* will permit good response down to 60 cycles. A 9-cubic-foot baffle will permit good response down to approximately 40 cycles. Care must be taken in the construction of the baffle to prevent *breathing* effects from the pressures built up in it at the lower frequencies. The inner wall of the baffles must be covered with sound absorbent material to prevent reflections which would give a *hangover* or *echo* effect.

Reflections

At a distance of two feet from the new unit, all frequencies being reproduced appeared to come from a single source. The high frequency radiation angle of 60° by 40° is small enough to avoid reflections from the baffle as the sound leaves the high frequency horn but is still ample to permit the listener to move about with considerable freedom.

Use of Speaker for Monitoring

The uniform characteristics which can be maintained from unit to unit should make this duplex speaker very useful as a monitoring standard. The elimination of vertical spacing between the source of high frequencies and the source of low frequencies brings about a point source of reproduction which is found to be quite realistic and helpful in the critical judgment of quality.

*The port is used to allow the energy which is radiated from the rear of the cone to be admitted out the front side, in phase with that portion of the energy coming from the front of the cone.

The effect of this port is to maintain a more constant acoustic impedance down to the cut-off of the enclosure.

The area of the port is a function of the size of the box enclosure and the mechanical resonance of the loudspeaker unit.

CRYSTAL ORIENTATION

(*Continued from page* 31)

proper manner to get a completely random abrasive pattern on its surface before etching. The etch must be carefully controlled. The etch pattern seen on the XY-plane over the pin hole light source will show the X-axis locations by joining the three spots slightly displaced from the apices of the triangle pattern with three lines. Using the rodometer the quartz is set into a swivel fixture so that an X-axis is parallel to a swivel axis. Now, if the quartz is rotated about this axis which is set parallel to the saw blade, BT-cut wafers may be cut at the proper angle.

The sawing operation results in a wafer which is either the proper size for the final oscillator plate or requires trimming or *dicing*. In order to choose areas in a wafer which are untwinned, it is necessary to etch the wafer in ammonium bifluoride.

In a subsequent issue, the next steps in crystal manufacture will be analyzed.

(*Photos by John Derbyshire*)

References

X-rays and Crystal Structure, W. H. and W. L. Bragg.

Crystallography and Practical Crystal Measurement—Vol. 1 and 2, A. E. H. Tutton.

A Study of Crystal Structure and Its Applications, Wheeler P. Davey.

The Physics of Crystals, Abram R. Joffe.

The Nature, Origin and Interpretation of Etch Figures of Crystals, A. P. Honess.

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PUSH-PULL

(*Continued from page* 62)

was desired, and most of all put a finger upon certain features that it was important to avoid.

Distortionless Operation

A patent was issued to T. B. Dixon (U. S. 1,197,460) on September 5, 1916 (applied for on February 5, 1908; renewed January 24, 1916), which presented an inertialess, distortionless method of availing of the advantages of the divided primary-winding of an output transformer. Instead of employing a slow-acting, pressure-contact scheme (as in breeding and raising faster horses) to obtain the push-pull effect in the induction-coil or transformer, Dixon invented the method of directing beams of distortionless radiation upon co-operative banks of selenium cells (S, S, Figure 8), each cell or bank of cells being in circuit with one side of the tapped primary. The inertialess selenium cells took the place as variable resistance elements of the prior art's carbon buttons or pockets of granules. All the advantages, therefore, of the push-pull, split-primary arrangement of the transformer became available for signaling, without being loaded with sluggish moving-parts, and without current distortions which produced frying and hissing in the output circuit. Dixon had reason for believing that he had produced a push-pull hookup that performed with fidelity. Inasmuch as a radiated beam of a known frequency, or frequencies, was employed to affect the resistance of, and thereby the currents in the respective windings of the primary winding, Dixon called his device a radioelectric relay.

The immediate service use made of Dixon's invention was in bettering the performance of submarine telegraph cables; in 1915-1916 at the Bay Roberts, Newfoundland cable station, and

(*Continued on page* 92)

PUSH-PULL

(*Continued from page* 91)

1917-1920 at the Hamel, Long Island cable terminal.

The Audion

In the meantime a converging line of inventive effort gave to the world the *audion*. Broadly, the *audion* was invented in 1907, discovered in 1912, and rediscovered about 1915-1916. For years amateurs tinkered with it, boys tried it to replace crystals for wireless reception, and then about five years after its birth the experts began to take it seriously. Then came a flood of *inventions*.

De Forrest's Audion

We shall not here follow de Forest's *audion* to its triumphant achievements. Rather we shall record that at this time our old friend *push-pull* was presented with a choice of gadgets to accomplish its beneficent purpose.

The Colpitts Circuit

A patent of interest, and germane to our study of push-pull, was that of E. H. Colpitts which gained patent status under the label: "Original No. 1,137,384, dated April 27, 1915. Serial No. 839,318, filed May 18, 1914. Application for re-issue filed April 9, 1917. Serial No. 180,871." This patent, like the princelet of the silver spoon, had the fortune to arrive in a home where opportunities were practically unlimited. Few radio engineers are unfamiliar with the vast applications made of this push-pull arrangement (Figure 9) in the manufacture of radio receivers, radio transmitters, talking-pictures, telephony, and so on.

Push-pull, when it arrived untrammeled, was a lusty bidder for fame. As we have seen it, it had a long and honorable ancestry. Its utility is established and is unquestioned. As to who is entitled to the laurel as first to invent an assembly of parts and circuits which constituted a true *push-pull*, doubtless there is substance for debate and argument. The answer is one in which the inventors themselves have interests. Design and operating engineers in the communications services are thankful that for forty years patient tinkers, investigators and physicists pursued the quest until, as Andy Brown would say: "Everything is under control!"

TELEVISION SURVEY

(*Continued from page* 34)

Institute of Radio Engineers and the Radio Club of America, on December 1 by Mr. DuMont and Dr. Goldsmith. The report revealed the multipath problem in television broadcasting, which causes multiple pattern in received pictures. Extensive use of the photographs and motion pictures illustrated the appearance of these patterns or ghosts. Schematics and charts were also presented to explain other field strength data.

In the deliberations of the NTSC before the adoption of standards in June 1941, very little attention had been given to these reflected images. It was generally assumed, said Mr. DuMont and Dr. Goldsmith in discussing the report, that if a picture of 525-line definition was faithfully transmitted and a suitable receiver was employed, the resulting image would show no appreciable loss in detail. It was quite understandable how this reasoning prevailed. For the only transmitter in operation then was transmitting on a frequency between 44 and 50 mc and relatively few receivers were in operation. And in addition the picture was not viewed too critically. However, pointed out Dr. Goldsmith and Mr. DuMont, with the elimination of this channel to make room for f-m, and with television broadcasting operating on frequencies between 50 and 84 mc, it has become apparent that secondary images are quite a problem to the telecaster.

Generally speaking, the greatest difficulty has been experienced with secondary images within a radius of about 8 miles from the transmitters, explained Mr. DuMont and Dr. Goldsmith. This is to be expected in an area of tall buildings, bridges and other structures. Difficulty is also experienced outside this congested area, where the receiving antenna is blocked by hills or buildings, or is located between transmitter and prominent hills. Signal strengths of above 500 mv at the receiver have generally been obtained at distances up to 35 miles from WNBT and W2XWV, and up to 20 miles from WCBW, said Dr. Goldsmith and Mr. DuMont. The report also showed that signal strengths of 100 mv were adequate in quiet locations.

The subject of man-made interference was also discussed. Dr. Goldsmith and Mr. DuMont pointed out that diathermy interference was not particularly objectionable during the tests, except in isolated cases. However, they said, it may become a serious problem after the war if the use of such equipment is greatly increased, and proper measures such as assigned operating channels or preferably adequate shielding, are not taken. Automobile ignition interference was not found serious within a forty-mile radius from the transmitter, explained Dr. Goldsmith and Mr. DuMont. Where it is serious, it can be overcome by antenna relocation, they said. Practically no difficulty was experienced from atmospherics, that is, static, or thunderstorms, they explained.

Seven types of ghosts were analyzed. These were: fixed, smear, racing, pulsating, negative, bouncing pattern, and synchronizing.

The *fixed ghost* is an additional and generally weaker pattern or patterns, displaced usually to right of main pattern. It is caused either by a reflecting object near receiver or near transmitter, or at some intermediate point, and can be considerably reduced by directive antennas using reflectors. Some improvement has been accomplished by using two antennas and feeding output into a phasing arrangement to cancel out secondary image.

In the *smear ghost* no separate and distinct test patterns are displaced, but vertical wedged lines appear blurred or lack crisp definition. Such loss of high-frequency resolution may be expected when the receiver is located at a point where practically no direct energy is received. Instead nearly all the energy comes over paths reflected from nearby objects.

The *racing ghost* has a main image of good intensity, with ghost patterns of relatively weak intensity which appear to travel rapidly across the main image when receiver is in motion. The probable explanation is reception of signals from an extended headland, scattering reflections from any portion of headland, as well as direct signal from transmitter.

The *pulsating ghost* is a ghost image that is displaced to right of main image. It varies up and down in intensity while the main image remains nearly fixed in intensity.

The *negative ghost* is quite unnsual. For under some conditions, a main image, say of a black signal, was observed while a ghost image displaced some distance to right was in white or of reversed polarity.

The *bouncing pattern* offered a rather clean pattern, with practically

(*Continued on page* 95)

NEWS BRIEFS

(*Continued from page* 80)

discussed a new system of television in New York recently.

This system involves no scanning. The objects being televised reflect light on all elements of the camera screen for the full duration of each frame, said Dr. Craig. Thus only a minute fraction of the presently required illumination is apparently needed.

According to Dr. Craig, the wavelengths used in standard broadcasting today are suitable for the system and the video signal has the same service range as would any audio signal for the power and frequency of its transmitter. Dr. Craig pointed out that the present commercial allocation need not be disturbed. The frequencies above 1600 kc are suitable. The bandwidth required at present with the Craig system, is 60 kc. Dr. Craig implied however, that refinments may bring this down to 40 kc or less.

* * *

SHAKEPROOF SUGGESTION BOOK

Discussion of fastening problems and their solutions appears in a brochure published by Shakeproof, Inc., 2501 North Keeler Avenue, Chicago, Illinois.

* * *

EXECUTONE BULLETIN

A four-page folder illustrating and discussing inter-office communication systems has been released by Executone, Inc., 415 Lexington Avenue, New York 17, New York.

The bulletin features a catalog-survey chart to provide an analysis of inter-office communication requirements.

* * *

BURKE TERMINAL BLOCK FOLDER

A four-page folder describing terminal blocks has been released by Burke Electric Company, Erie, Pennsylvania.

Data presented include dimensions, number of wires that can be used, etc.

* * *

GENERAL RADIO OPENS CHICAGO OFFICE

An engineering office at 920 South Michigan Avenue, Chicago 5, Illinois, has been opened by the General Radio Company. Lucius E. Packard, who in the past three years has been in charge of the New York office, will be in charge.

Martin A. Gilman will be at the New York office, 90 West Street.

The telephone number of the Chicago office is WAbash 3820 and that of the New York office is COrtlandt 7-0850.

* * *

DIAL LIGHT CATALOG

A 24-page catalog describing an assortment of pilot light assemblies and accessories has been released by the Dial Light Company of America, Inc., 90 West Street, New York 6, New York.

Data on incandescent lamps, socket assemblies, jewels, and numbers, letters and trade marks available for pilot light assemblies, are included in this catalog.

* * *

CLARK CUTTING TOOL FOLDER

An 8-page folder describing seven adjustable cutting tools including a counterbore and spotfacer, 3-blade adjustable hole cutter, 2-blade adjustable surface facer, 2-blade adjustable flycutter, adjustable gasket cutter and a thread tool grinding fixture has been released by Robert H. Clark Company, 3424 Sunset Boulevard, Los Angeles, Calif.

* * *

BOLDT NOW AD MAN AT AMERICAN PHENOLIC

K. F. (Ben) Boldt has been appointed advertising and sales promotion manager, American Phenolic Corporation, Chicago.

Mr. Boldt was recently with Rock-Ola Manufacturing Corporation.

* * *

J. W. WHITESIDE NOW G. E. TUBE DIVISION BUYER

J. W. Whiteside has been appointed buyer in the tube division of the G. E. electronics department. His headquarters will be at Schenectady.

* * *

JERRY KANE JOINS UNIVERSAL MICROPHONE

Jerry Kane, formerly in the research laboratories of The Turner Co., Cedar Rapids, Iowa, has joined the staff of the Universal Microphone Co., Inglewood, Calif., as electro-acoustic engineer. He will be assigned to assist in current war microphone production as well as in postwar planning.

* * *

DR. TIMOSHENKO NOW WITH TEMPLETONE RADIO

Dr. Gregory Timoshenko, formerly Associate Professor of Electrical Engineering at the University of Connecticut, is now with Templetone Radio Company, Mystic, Conn., in a research capacity.

TELEVISION SURVEY

(*Continued from page* 93)

no displaced ghost pattern. Such an interesting effect could be produced where the receiver gets no direct signal from the transmitter but gets two approximately equal intensity signals over approximately equal paths from widely separated reflecting objects.

The *synchronizing ghost* takes the form of a *tear out* of the pattern horizontally and cyclically. On the oscillograph the synchronizing signals seemed to go up and down in intensity, while the major video components remained relatively unchanged. A possible cause might be the beats in and out of phase of secondary path signal which arrives displaced in time, approximately the duration of the horizontal synchronizing signals' period. The bobbing up and down of the synchronizing components may also be related to those causes of negative ghost patterns.

The survey indicated that the lower frequency channels provide the least multi-path interference in a metropolitan territory such as New York City. And reasonably good reception was found from all three New York stations at distances beyond five miles and up to the distance where signal level becomes too low for satisfactory receiver operation.

THE GONIOMETER

(*Continued from page* 42)

average deviation of the actual points of minimum coupling from the desired points (0, 90, 180, and 270 degrees) is nearly zero. In general the actual points will be within 0.5 to 1.0 degree of the desired points, and much closer at the lower frequencies.

The sinusoidal characteristic, test *2*, is performed by resonating the primary and secondary circuits, loading both secondaries with the load resistance for which it was designed, feeding power in from a transmitter, and measuring with a vacuum tube voltmeter the voltage across each load resistor for various settings of the goniometer dial. It is important, especially when the external loading impedance includes reactive elements simulating a loop antenna, to take precautions that no appreciable coupling exist between the two secondary loads. The input current to the goniometer primary is held constant for all dial settings so the induced voltage in each secondary is proportional to the mutual coupling. Since the secondary circuit is tuned to resonance, all this

(*Continued on page* 96)

(*Continued from page 95*)

voltage appears across the circuit resistance, by far the greater part of which is in the external load. Consequently although the load resistance may change somewhat due to heating and cooling as the dial is turned, the readings are still accurate. The principal effect of such change of resistance is to require a little more adjustment of the transmitter output to maintain constant primary current.

The third test, of input resistance, is performed most easily by means of a radio frequency bridge, with both secondaries properly loaded and all circuits tuned in their intended manner.

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MIXERS AND FADERS

(*Continued from page 56*)

each of the input and output circuits, a complete mixer system results. Figure 13 of the present paper shows in schematic form how this type of bridge would appear when used as a mixer in balanced form, while Figure 14 shows the equivalent of the multiple bridge mixer on a single channel basis with faders removed. Since these networks are designed on an image basis, it is only necessary to add the loss of the fader to the losses shown in Table 3 of the article referred to, to obtain the total overall loss of each individual channel of the system.

Lattice Mixers

The lattice type of mixer is little known or used, perhaps partly because of inherent complexity of circuits in the generalized case, and because of the necessity of maintaining a fairly high degree of balance between the bridge arms. This is relatively easy in the case of purely resistive terminations, but becomes increasingly difficult as complex impedances are added to the circuit.

As a mixer, the lattice or bridge network becomes a special case of the general bridge in which all of the arms of the network are equal to Z ohms. Figure 15 shows in schematic form a lattice type bridge mixer, which gives a total of four channels in and two channels out. Used in this manner, the impedance of all channels both in and out are equal.

This may be more readily seen by

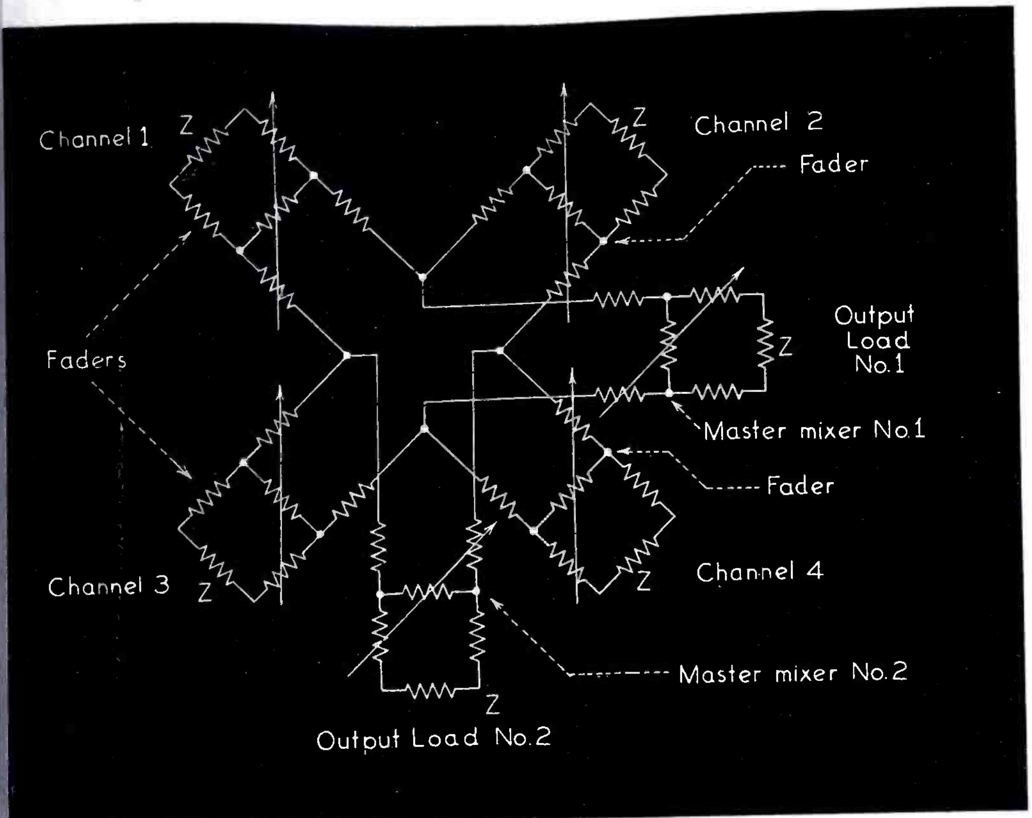


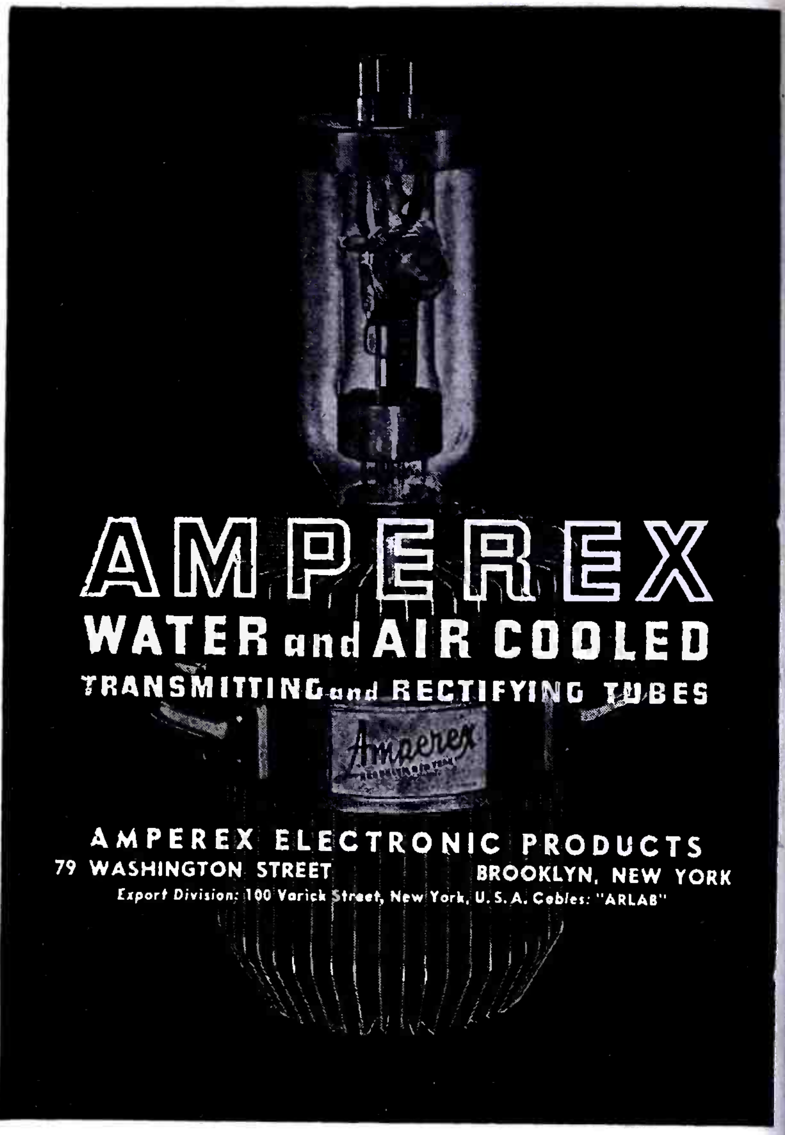
Figure 15

attice type bridge mixer system of four channels and two outputs.

eferring to the equivalent of Figure 5 which is shown as Figure 16. The Γ network equivalent is symmetrical nnd when terminated with equal impedances, Z, the image impedance seen looking into the network from either end is

$$Z = \frac{1}{3} Z + \frac{\frac{4}{3} Z \left(\frac{1}{3} Z + Z \right)}{\frac{4}{3} Z + \frac{1}{3} Z + Z} = Z \qquad (91)$$

(*Continued on page* 98)



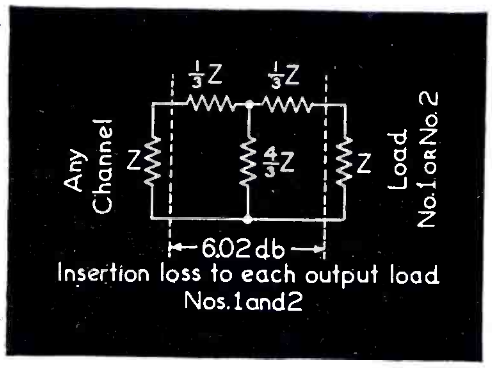


Figure 16

Equivalent of Figure 15 on an individual channel basis with faders set for zero insertion loss.

which is an identity.

Since the terminating impedances are equal, the insertion loss of each channel is

$$db_L = 20 \log_{10} \frac{\frac{4}{3}Z + \frac{1}{3}Z + Z}{\frac{4}{3}Z} \qquad (92)$$

$$= 20 \log_{10} 2 = 6.02 \text{ decibels.} \qquad (93)$$

This is the insertion loss that will be obtained from each channel input to output, exclusive of the fader losses. These must be added to the insertion loss to give the total loss overall per channel.

Because the output branches are conjugate pairs of the network, high losses will occur between them which approach infinity as the impedance matching approaches perfection. Losses of 30 to 70 decibels are not too

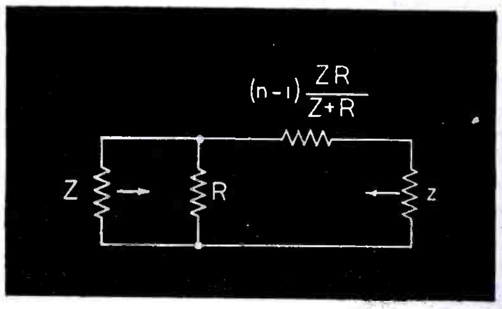


Figure 4 (November issue)

Here we see the equivalent of the multiple bridge mixer on a single channel basis with the faders removed.

This table appeared in the November issue discussion and is shown here to facilitate application of data given in this installment on multiple bridge mixers. Note correction of insertion loss from 8.54 to 9.54.

Table 3

Series parallel mixer		2	3	4	5	6	7	8	9	10
$N_p = N_s$	C_{s1}	2.00000	1.50000	1.33333	1.25000	1.20000	1.16667	1.14286	1.12500	1.11111
$N_p = N_s$	C_{p1}	.66667	1.20000	1.71430	2.22222	2.72727	3.23077	3.73333	4.23529	4.73684
Insertion loss	db_{sp}	9.54	13.98	16.90	19.08	20.83	22.28	23.52	24.60	25.57

No. of channels, Ns in series; or No. of series groups in parallel

$R_s = Z \cdot C_{s1}$ where $C_{s1} = N_s/(N_s - 1)$
$R_p = z \cdot C_{p1}$ where $C_{p1} = N_p(N_p - 1)/(2N_p - 1)$
$db_{sp} = 20 \log_{10}(2N_s - 1) = 20 \log_{10}(2N_p - 1)$

difficult to obtain with moderate care in design and wiring.

As long as the impedance relationships are not disturbed, this means that such things as trouble from clicks, noise, and crosstalk which occur on one of the output channels will not be transmitted back into the other output. Thus, freedom from interaction effects because of the characteristic properties of this type of mixer may be beneficial from a service hazard standpoint.

By the reciprocal properties of the network, we may reverse the direction of transmission and get a two channel input system feeding four outputs. Freedom from interaction effects on the output channels would still be effected in pairs only, but not between all four output channels.

By the conjugate properties of these networks, taken in pairs, we may also obtain a three channel mixer in and three channels out, negligible circuit interaction of output channels again occurring in pairs.

Another useful application of these circuits is in talkback systems using a speaker and microphone in close proximity to each other. Ordinarily, unless highly directional microphones and special placement of speakers is resorted to, feedback action takes place and frequently causes howling or singing or a highly unstable condition. Switching is usually resorted to in order to overcome this difficulty. By placing the speaker equipment on one of the branches and the microphone equipment on the conjugate of the speaker branch, we may connect either two or three studios, offices or shops together without causing acoustical feedback or howling with ordinary

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The table covering series mixers which was analyzed in the November issue and is referred to in this concluding installment.

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Table 1

		No. of Channels									
Series mixer for:		**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Z and n assigned	C_{Rs1}	2.00000	1.50000	1.33333	1.25000	1.20000	1.16667	1.14286	1.12500	1.11111	$R = Z \cdot C_{Rs1}$
Z and n assigned	C_{zs1}	1.33333	1.80000	2.28576	2.77778	3.27273	3.76923	4.26667	4.76470	5.26316	$z = Z \cdot C_{zs1}$
z and n assigned	C_{Rs2}	1.50000	.83333	.58333	.45000	.36667	.30952	.26786	.23611	.21111	$R = z \cdot C_{Rs2}$
z and n assigned	C_{Zs2}	.75000	.55555	.43749	.36000	.30555	.26531	.23437	.20988	.19000	$Z = z \cdot C_{Zs2}$
Loss of each channel	db_s	4.77	6.99	8.45	9.54	10.41	11.14	11.76	12.30	12.79	$db_s = 10 \log_{10}(2n-1)$

Where: R = Value of resistance to be added in shunt across each channel
Z = Mixer input impedance of each channel
z = Mixer common output impedance
n = No. of channels of the mixer
db_s = Insertion loss of each mixer channel in decibels
$C_{Rs1} = n/(n-1)$; $C_{zs1} = n^2/(2n-1)$
$C_{Rs2} = (2n-1)/n(n-1)$; $C_{Zs2} = (2n-1)/n^2$

care in the use of the circuits. Since the loss of the network for equal terminations is 6.02 decibels, and for singing, this path would occur twice, the amplifier gain would have to supply a total of 12.04 decibels net to start singing even though the connections were direct at each studio. The minimum acoustic loss between the microphone and speaker in each studio must be at least equal to half of the net gain between the microphone in any one studio and the amplifier in any other studio, where the net gain is the difference between the actual overall gain of the channel equipment in terms of acoustical output power, minus the network insertion loss of 6.02 decibels, minus any loss in any fader or attenuator equipment, if any is used in conjunction with the network.

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Table for parallel mixers, discussed in the first portion of this paper and referred to, too, in this concluding installment.

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Table 2

Parallel mixer for:		No. of Channels 2	3	4	5	6	7	8	9	10	
Z and n assigned	C_{Rp1}	.50000	.66667	.75000	.80000	.83333	.85716	.87500	.88889	.90000	$R = Z \cdot C_{Rp1}$
Z and n assigned	C_{zp1}	.75000	.55555	.43749	.36000	.30555	.26531	.23437	.20988	.19000	$z = Z \cdot C_{zp1}$
z and n assigned	C_{Rp2}	.66667	1.20000	1.71428	2.22222	2.72727	3.23077	3.73333	4.23529	4.73684	$R = z \cdot C_{Rp2}$
z and n assigned	C_{Zp2}	1.33333	1.80000	2.28576	2.77778	3.27273	3.76923	4.26667	4.76470	5.26316	$Z = z \cdot C_{Zp2}$
Loss of each channel	db_p	4.77	6.99	8.45	9.54	10.41	11.14	11.76	12.30	12.79	$db_p = 10 \log_{10}(2n-1)$

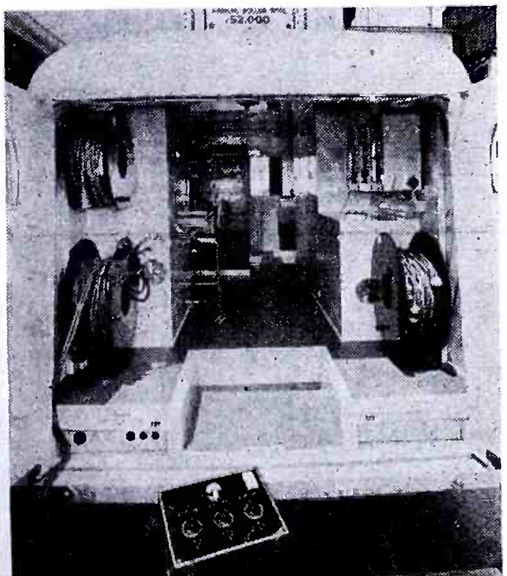
Where: R = Value of resistance to be added in series with each channel
Z = Mixer input impedance of each channel
z = Mixer common output impedance
n = No. of channels of the mixer
db_p = Insertion loss of each mixer channels in decibels
$C_{Rp1} = (n-1)/n$; $C_{zp1} = (2n-1)/n^2$
$C_{Rp2} = n(n-1)/(2n-1)$; $C_{Zp2} = n^2/(2n-1)$

MOBILE RECORDING STUDIO

In a paper presented by J. L. Fields of RCA at the 54th semi-annual conference of the Society of Motion Pictures Engineers in Hollywood recently, a completely self-contained and self-powered recording studio on wheels was described.

In this compact assembly is a two-channel mixer amplifier and a main amplifier cabinet which includes a voltage amplifier, compressor and high and low pass filters, and the recorder. Five motors are available for the recorder to permit operation from as many different sources of power as may be required. Because power requirements have been made, low battery operation is possible, too.

A desk for the mixer panel is provided in the front deck of the coach just behind the right side of the windshield, with a removable stool for the mixer which can be placed in a floor socket to the right of the driver's seat. The microphone preamplifiers are contained in a compartment under the right side of the deck opening from the front of the coach.



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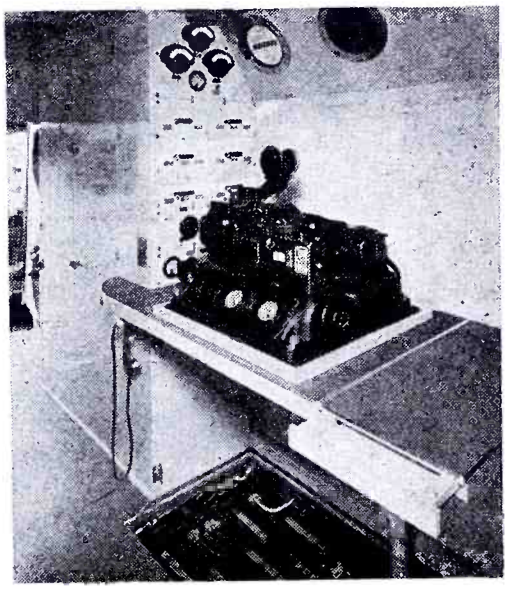
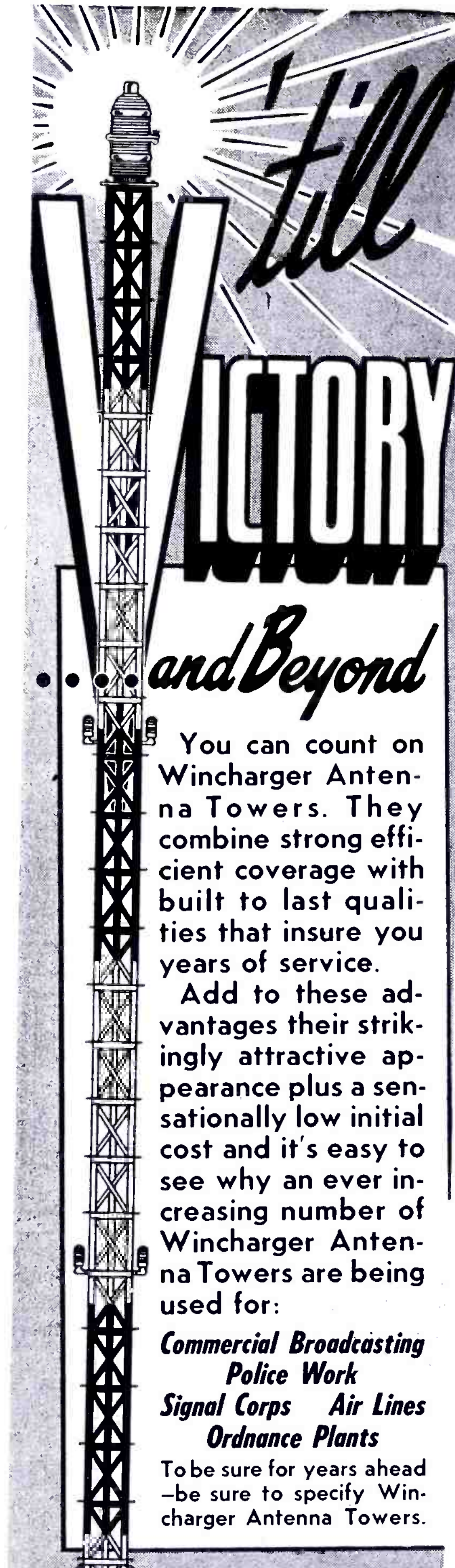
At left, a view of the portable recording studio, looking forward toward the front of the coach through open double doors in the rear. At right, we have an interior view of the mobile studio.





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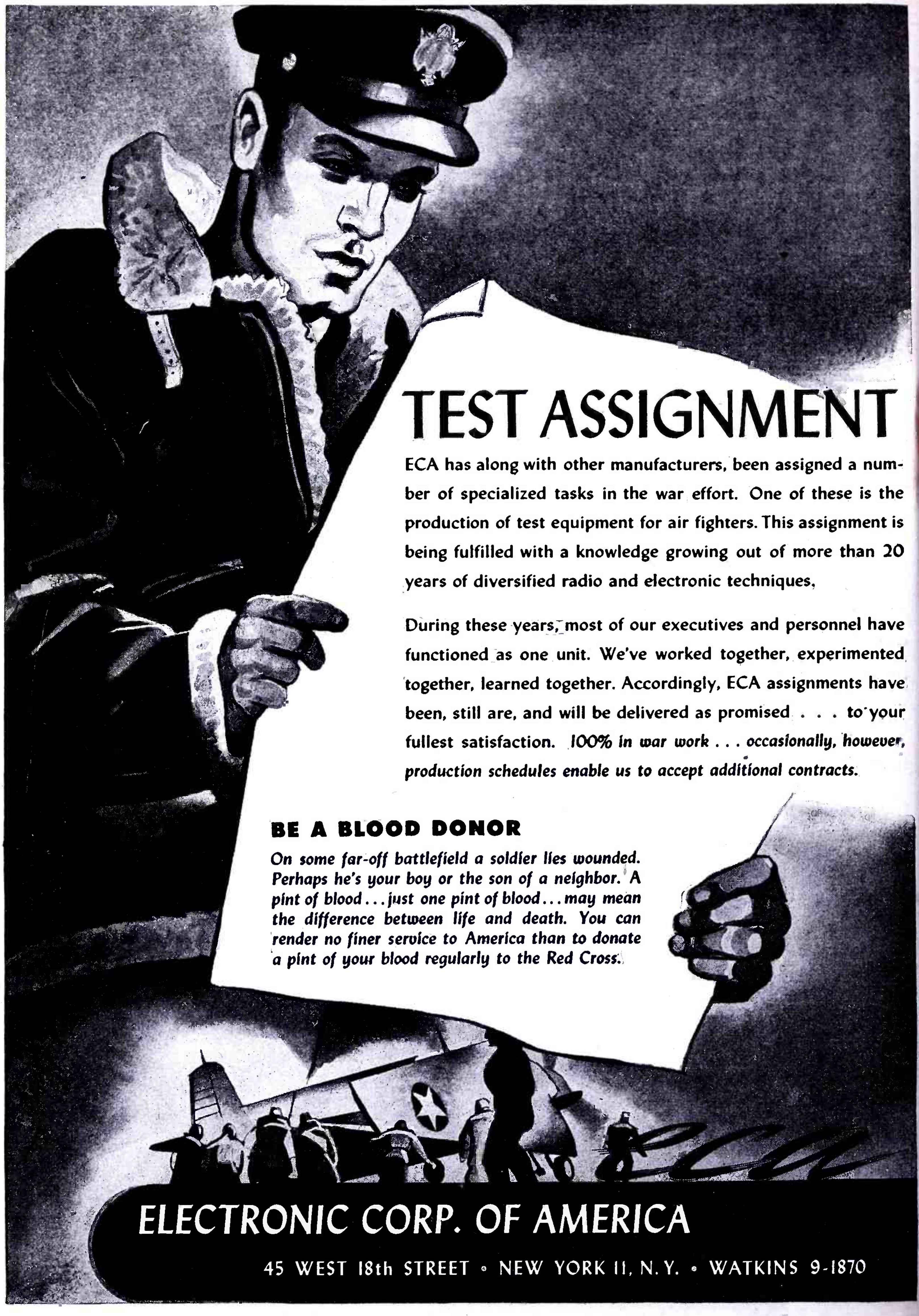
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The General Radio Company's wide experience in oscillator design and General Radio quality construction are your assurance of satisfactory oscillator performance.

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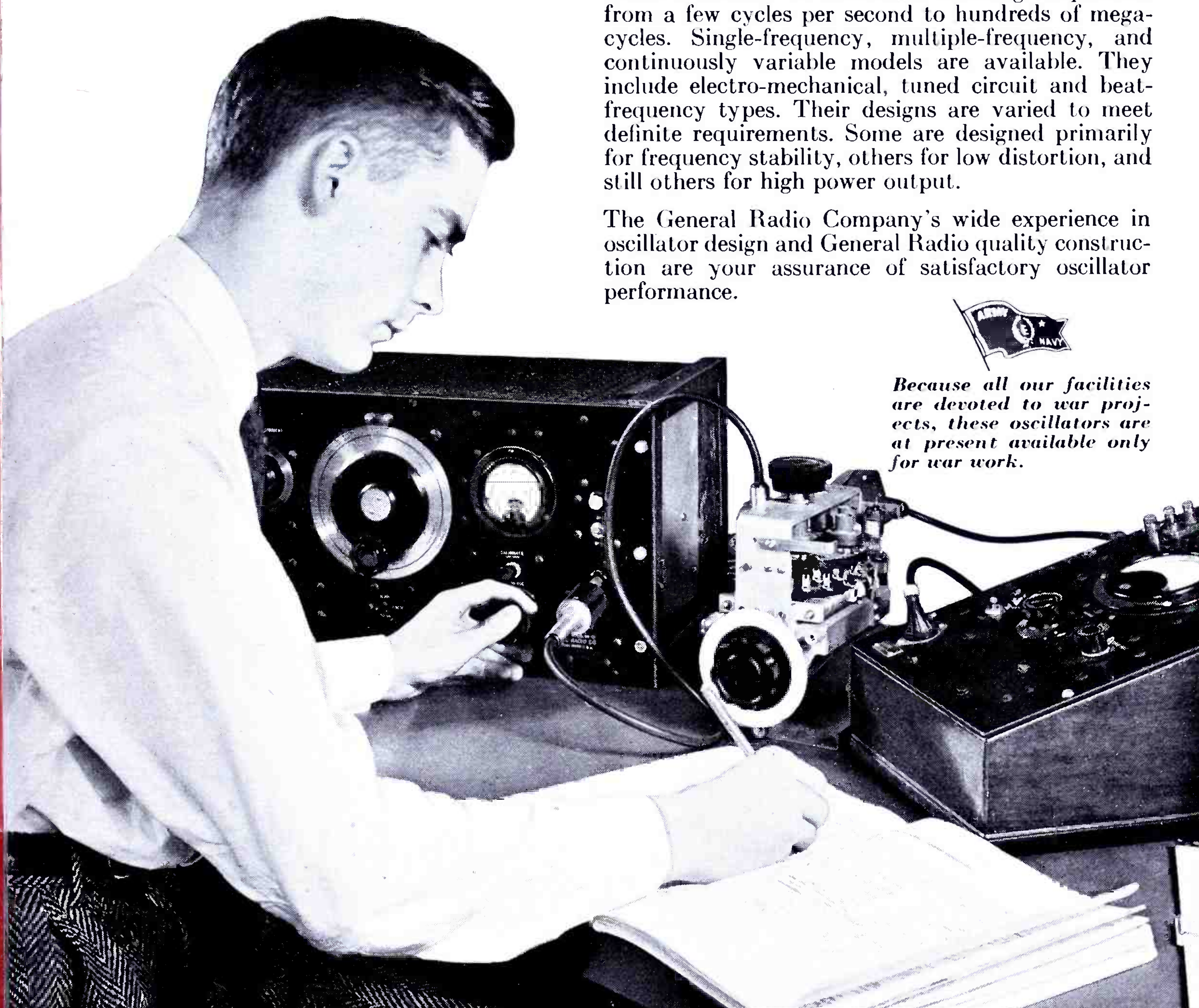

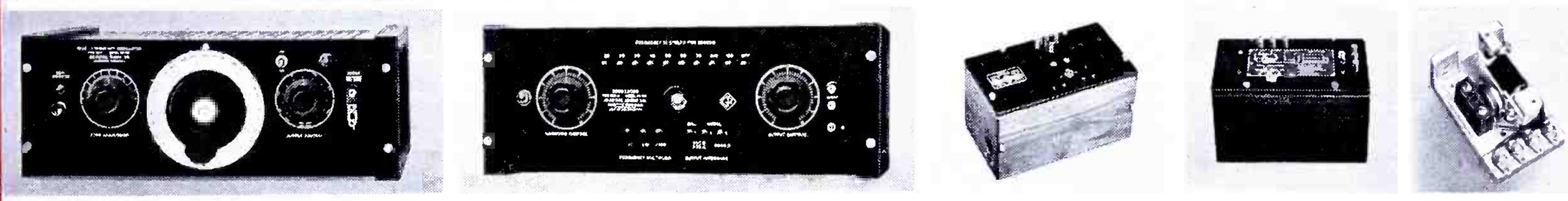

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