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OCTOBER 1943

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★ ★ *Edited by M. B. Sleeper* ★ ★

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There goes the air raid alarm. And here they come, the fighter pilots . . . scrambling madly for their waiting planes. You'd hurry too if you were in their shoes, because time grows mighty important right then. Only a split second can make all the difference between getting upstairs in time. and maybe not getting off at all.

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COMBINED WITH: APPLIED ELECTRONIC ENGINEERING

VOL. 3 — OCTOBER, 1943 — NO. 11

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Advertising correspondence, copy, and cuts should be addressed to the advertising office at New York City.

THIS MONTH'S COVER

Formation flying is not merely a matter of skillful piloting. It is made possible by co-ordinated action in response to commands given by radio-telephone.

Radio plays a still greater part in the night-time formation flying of bomber squadrons.

Soon, however, lessons learned from military applications will be put to still wider use for commercial and private flying. This may well prove to be the largest of the new fields for peacetime radio development and expansion. In this, FM will have an important rôle.

WHAT'S NEW THIS MONTH

MOST discussions of things to come in the radio industry are concerned with home radio receivers. We don't hear much about the business of manufacturing and selling broadcast stations. To be sure, there are only a few companies building transmitting equipment, and the sales are limited, compared to the number of set manufacturers and their unit volume. Still, neither could continue in business without the other.

In fact, any future plans of radio set producers should give consideration to developments in the broadcast transmitter field.

This group is comprised of Collins, Federal, Gates, General Electric, RCA, REL, Western Electric, and Westinghouse.

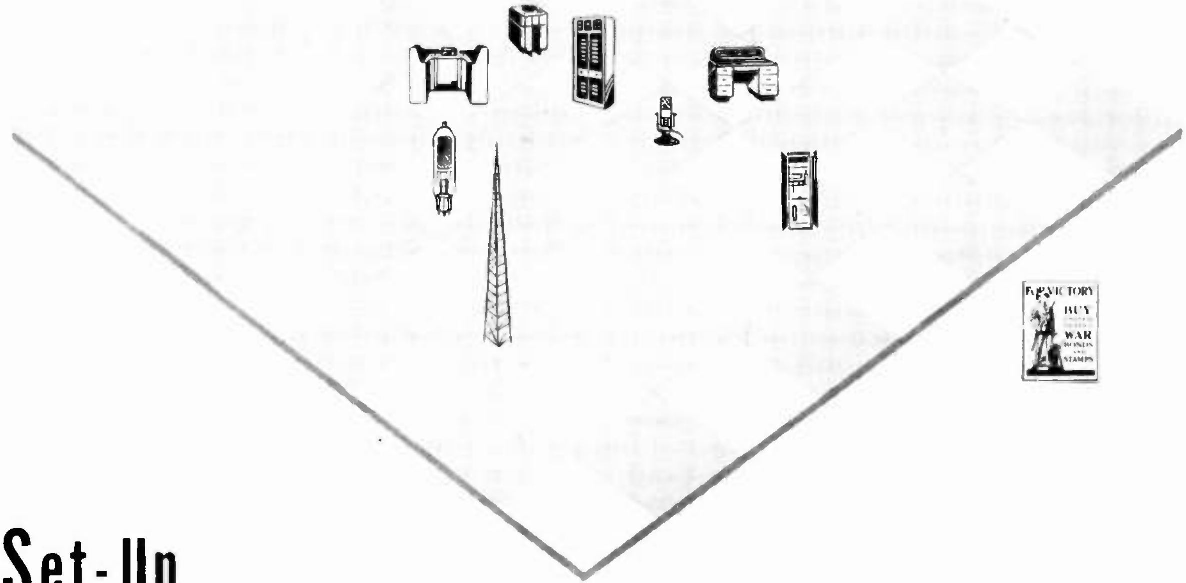
First to break the silence imposed by wartime preoccupation with military production is General Electric. At a recent luncheon in New York City, to which trade paper editors were invited, G.E. executives spoke very frankly of their analysis of future broadcast station expansion, and their plans to participate in this field.

Dr. W. R. G. Baker first reviewed the formation of the Radio Technical Planning Board, the organization of which was inspired by the remarks of FCC Chairman Fly, at the 1942 Rochester meeting of the RMA and IRE. Now organized to consider and analyze the transmitting frequency allocation needs of all radio services, the RTPB is working to formulate definite policies, plans, and recommendations for presentation to the FCC which will represent the industry's best thinking.

Then, coming down to G.E.'s own plans for the future, Paul L. Chamberlain, in charge of transmitter sales, announced a reservation plan for the postwar purchase of broadcasting equipment. Details of this plan have such significant implications to set manufacturers and the trade, as well as to broadcasters that the highlights are set forth here. It is interesting to note that while AM transmitters are included in the plan, the emphasis is distinctly on FM installations.

Under the G.E. plan, present or prospective broadcasters can make equipment reservations merely by purchasing and depositing United States War Bonds in an amount depending upon the power of the transmitter in question. Since prices will not be established until produc-

(CONTINUED ON PAGE 57)



Set-Up

RCA is in a unique position to anticipate and serve broadcast station equipment needs.

Here are some of the reasons why:

RCA makes and sells receivers.

RCA makes and sells tubes.

RCA has a well-qualified engineering department experienced in the design of broadcast equipment.

RCA operates the world's greatest electronic laboratories.

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Results show in RCA service to the industry.

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. RCA Victor Division,* RADIO CORPORATION OF AMERICA, *Camden, N. J.*

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★ *RCA's line of apparatus includes more of the equipment necessary for the efficient operation of modern broadcasting stations than that of any other manufacturer.*

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

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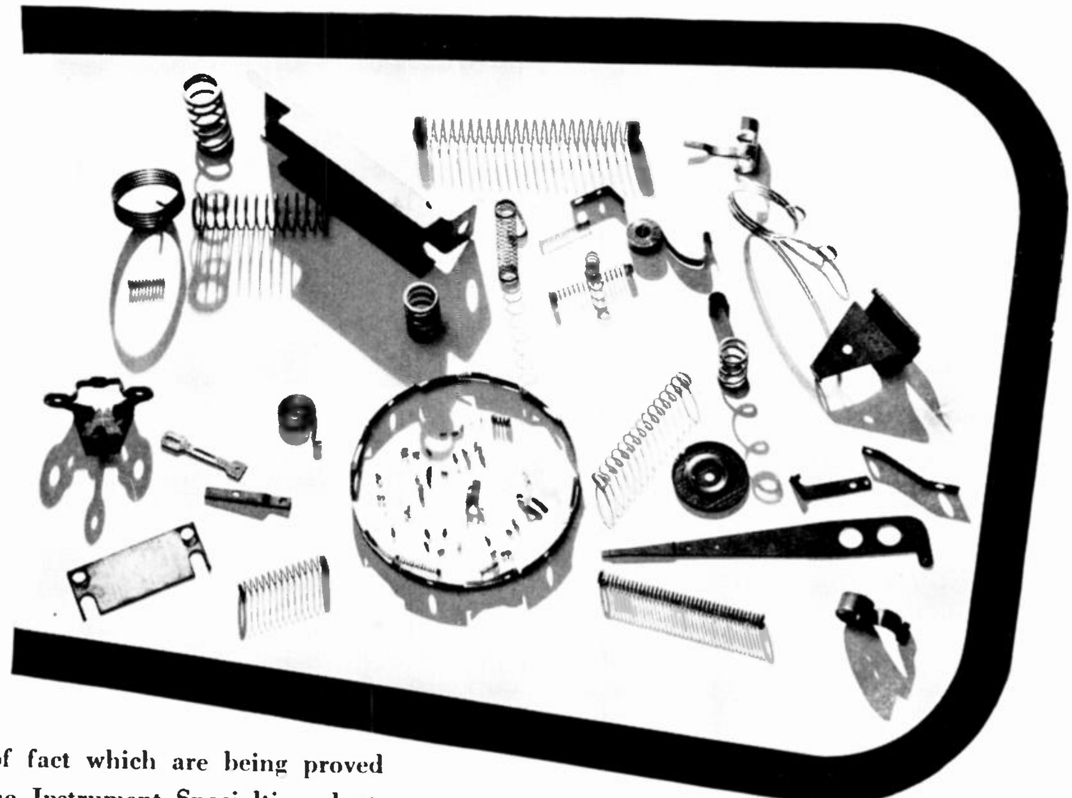
At the risk of seeming boastful, there are springs illustrated below — taken from long runs in our plant, which have not been duplicated in quantity by any other method than by "Micro-processing." And every one of these beryllium copper springs is serving a highly critical wartime purpose.



It has taken eight hard years of research and production for us to sift the essential fact from the non-essential; to take the "wonder" out of every run and replace it with "assurance." It has taken some of the toughest problems a war could pose for us to prove that beryllium copper springs in the ultimate require a special technique to make them behave as they should.

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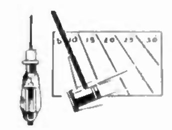
"How would you like to be hit several times with a hammer?"



Pity the Hytron tubes struck several sharp blows by a heavy, swinging hammer during the Bump Test. Only by such rough treatment, can rugged Hytron tubes suitable for the shocks of mechanized warfare be selected.

Even this trial is not enough. These quality tubes must withstand many other mechanical shock tests during which the stability of electrical characteristics is carefully measured while the tubes are tortured by scientifically simulated jolts and vibrations which might occur in actual combat.

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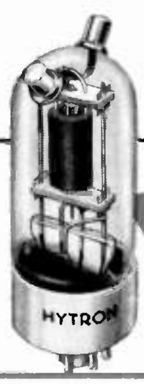

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THAT STARTS A GREATER SPENDING CRAZE!
UP UP UP UP UP
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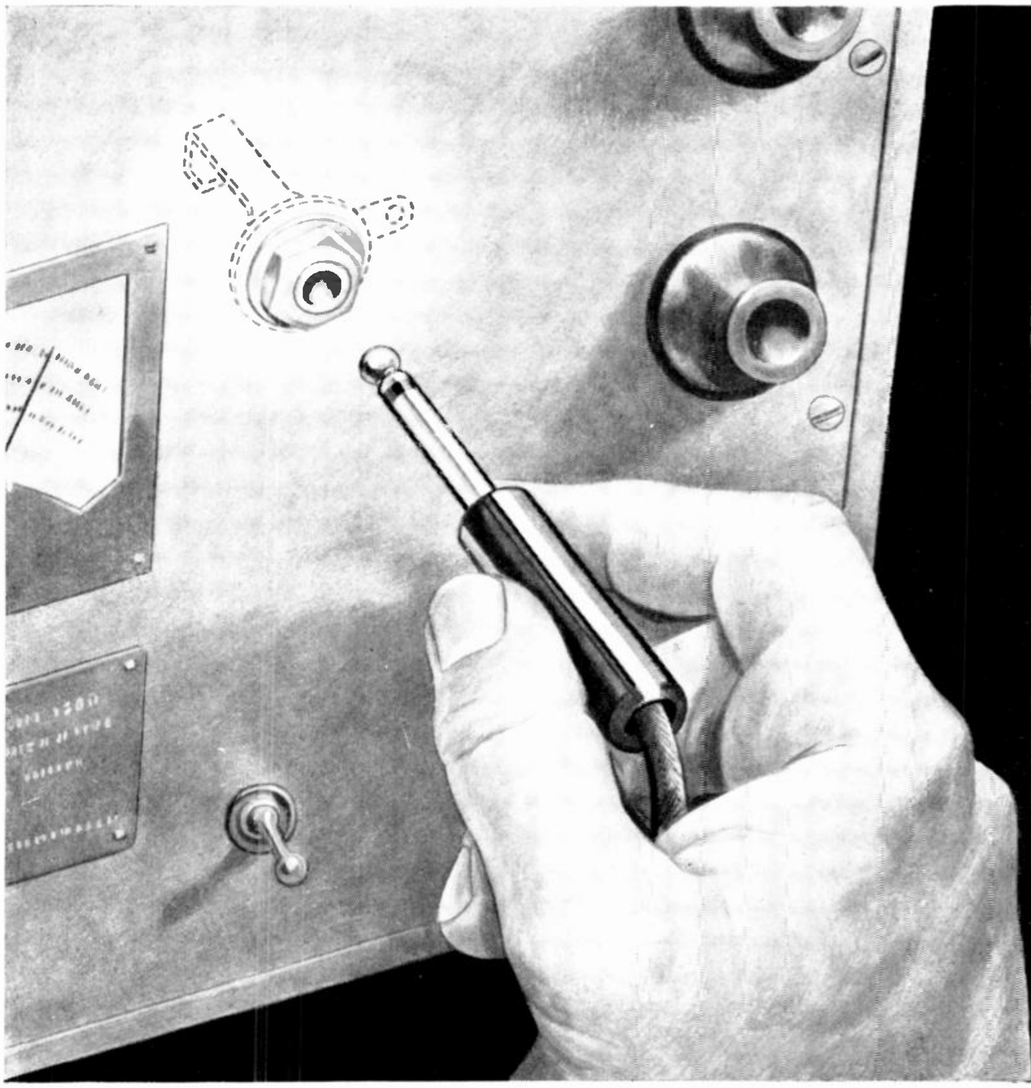
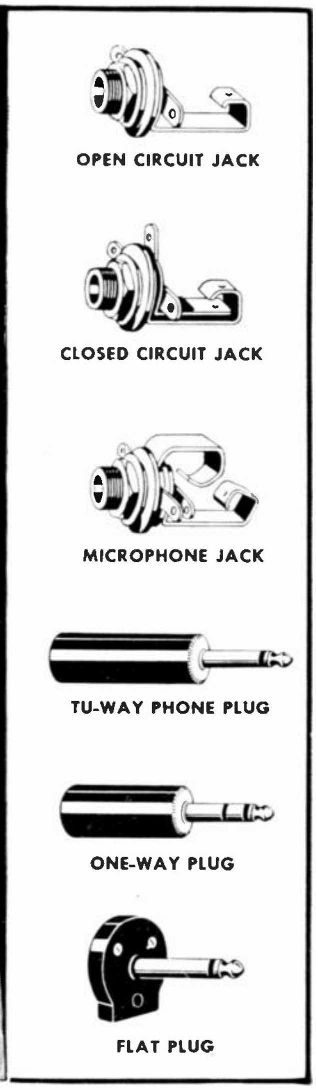
AND IT ALONE CAN WRECK A NATION!
LET'S ALL STOP PRICES GOING HIGHER
BE A SAVER-NOT A BUYER!





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POSTWAR HOME RADIO DESIGN

Plans to Revive Prewar Models May Be Upset by New Features and Types of Sets which Newcomers Will Capitalize in Bidding for Business

BY MILTON B. SLEEPER

WHAT will the first postwar radio sets be like? Will manufacturers simply revive their 1941 models? Or will they bring out new sets which represent the wartime progress of radio, and the newest thinking on the subject of functional design?

From past experience, it might be assumed that whatever they say now is only for the purpose of feeling out competitors. Any definite plans, if they have been made, will be subject to last-minute revisions in the light of what others do.

Discussions of this subject now must be purely speculation. However, it is useful to appraise the situation in terms of its possibilities and the factors which may control or influence decisions.

WPB Actions ★ The WPB may settle the entire question if it is permitted to do so, when the time comes to resume civilian set production. It is conceivable that materials will be released to a selected number of manufacturers for the production of a specified number of sets to retail at a fixed ceiling price. In that case, it is reasonably certain that they would be cheap sets, perhaps in the $19.95 or $24.95 bracket.

This would be most unfortunate, if it should happen, because it would deny the public the advantages of developments and improvements which are available as contributions to the greater enjoyment of radio programs. It would simply set the industry back by the number of years that production has been suspended.

Setting low ceiling prices would prohibit the inclusion of FM receiving circuits with limiters and audio systems capable of doing justice to the quality of FM broadcasting.

Employment would be held down, for labor, including that expended on components and cabinets, is the largest item of cost in home radio sets. Wages would be set back to the prewar rate of $12 to $16 per week.

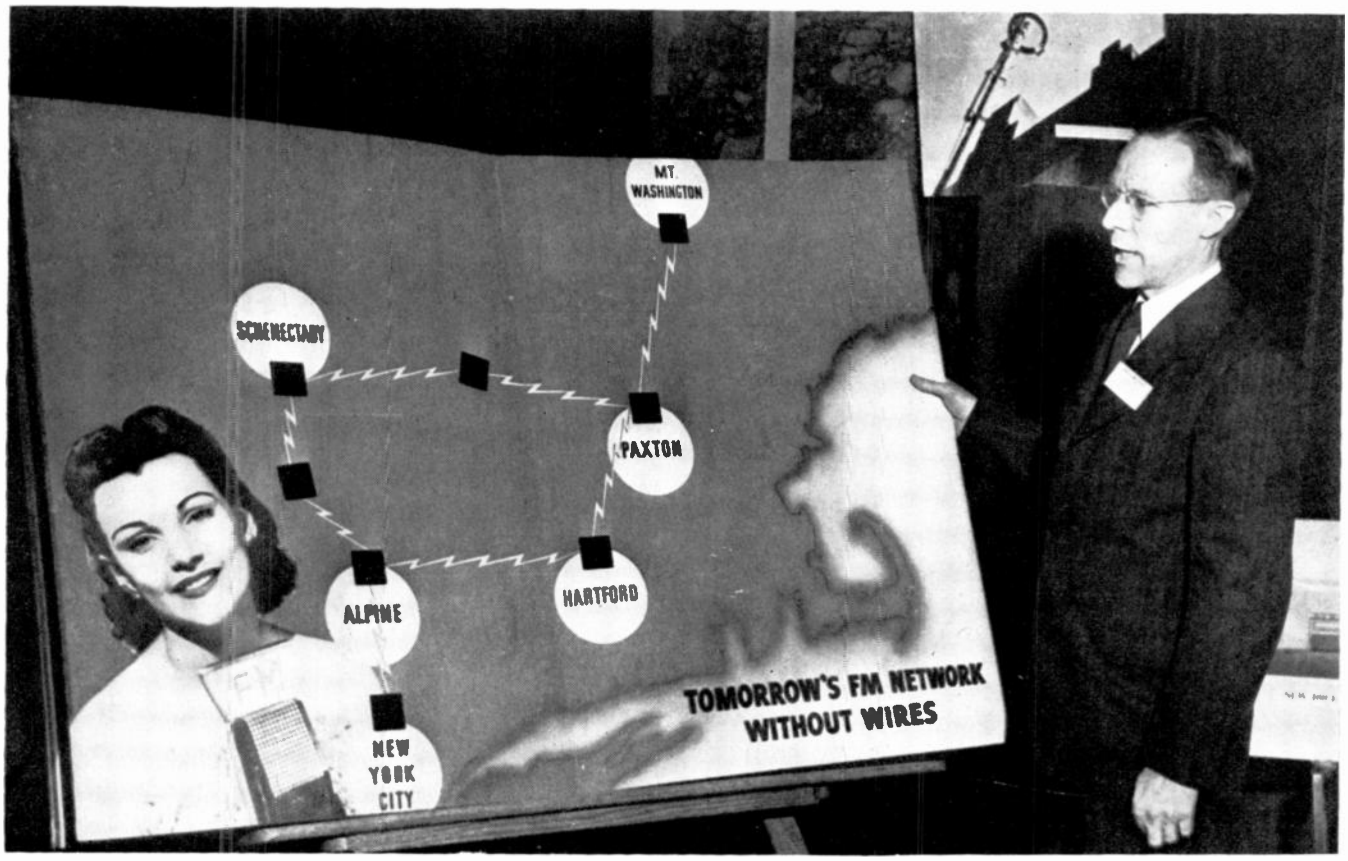
From every angle, manufacturers, workers, retailers, and the public would suffer if control by the WPB or any other Government agency puts the industry back into the junk-box status in which it struggled for so many years, and from which it was finally emerging at the time of Pearl Harbor.

It would be better to delay the revival of civilian set production until the manufacturers can be permitted to work out their own plans without price restrictions.

A hasty release under limited conditions would be a false start indeed, and costly to everyone concerned.

New Sets from Old Tools ★ There may be sound reasoning behind the announced intentions of the automobile industry to start their production with prewar tools now held in storage. But radio manufacturers can hardly do that. There aren't enough tools involved to justify it, in the

(CONTINUED ON PAGE 47)



W. R. DAVID, IN CHARGE OF BROADCAST TRANSMITTER SALES AT G. E., EXPLAINS SETUP OF FM RADIO RELAY STATIONS TO REPLACE REBROADCASTING METHOD WHICH HAS BEEN IN USE FOR OVER A YEAR TO FORM A SIX-STATION FM NETWORK

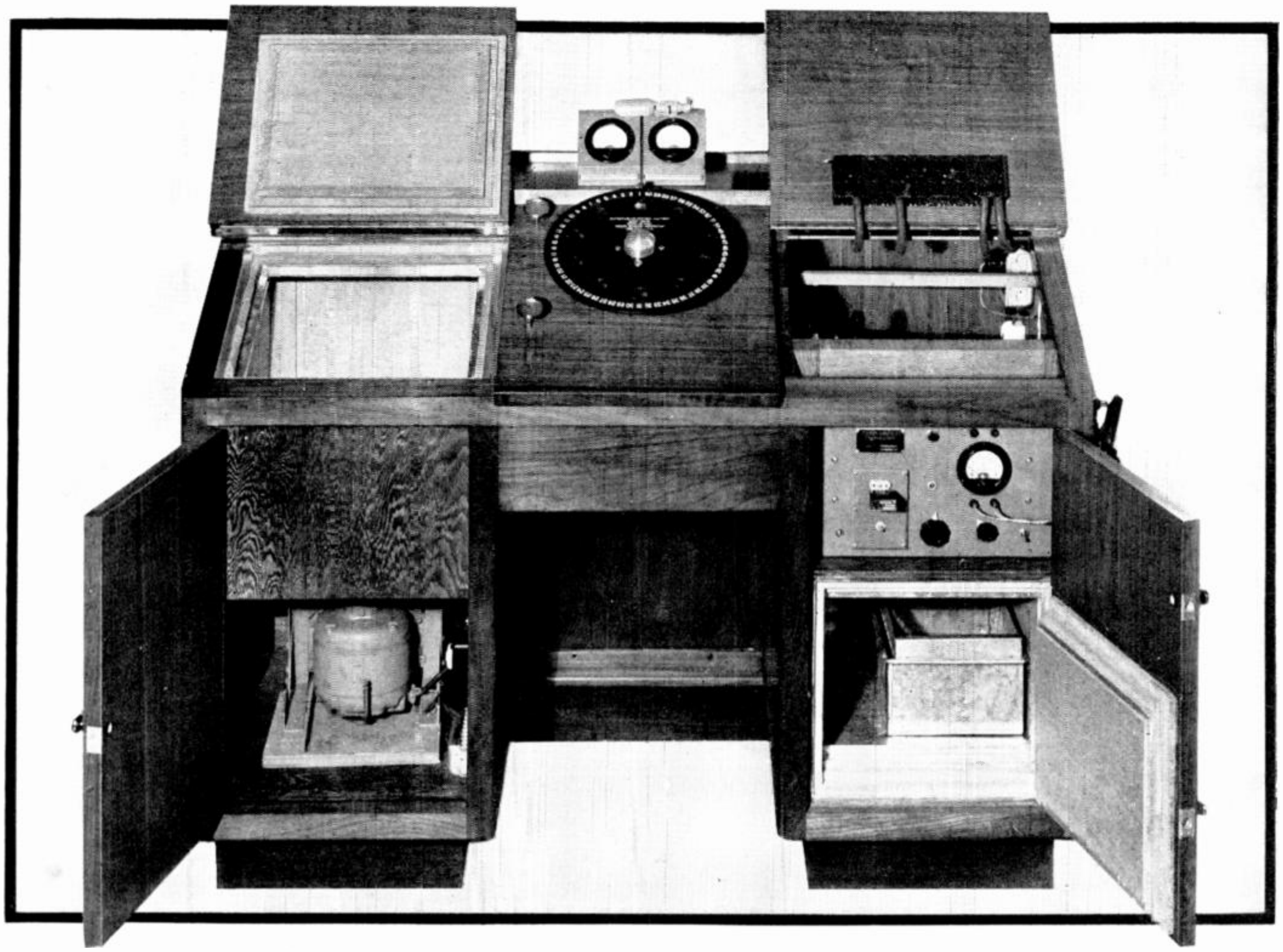


FIG. 1. UPPER LEFT CHAMBER CONTAINS DRY ICE. OSCILLATOR CIRCUITS ARE ON THE RIGHT. CENTER DISC ROTATES CRYSTALS

TEMPERATURE TESTS FOR QUARTZ CRYSTALS

How Crystals Are Checked for Activity and Frequency at —55° to 90° C.

BY A. HASS*

ALL the engineering effort put into a piece of military radio equipment can be wiped out by the failure of a quartz crystal to maintain its frequency over the range of operating temperatures it encounters in service. And that might well be the least loss, for our men and materiel are under the control of instructions conveyed by radio.

In a broadcasting station, for example, the temperature characteristic of a quartz crystal is a less critical factor, since circumstances are such that a crystal can be mounted in a constant-temperature chamber. In mobile and aircraft equipment, however, crystals are exposed directly to the ambient temperature. Consequently, experience has shown that, to assure satisfactory performance under service conditions, they must be selected under tests which subject them to a temperature range from —55° to +90° C. During the tests they must maintain both frequency and activity within extremely close limits in order to meet the requirements of military use.

The full significance of this test is appreciated when it is considered that any given crystal has either a negative or a positive characteristic. That is, the frequency changes only in one direction. It would be much easier to meet deviation limits if it varied up and down during a temperature run.

Production Testing ★ Temperature tests are necessarily slow when they must cover a wide range. In fact, they proved to be an extremely serious bottleneck to the production load of military needs put upon crystal manufacturers. The type of crystals manufactured at Hudson American must be checked every 2° from —55° to +90°. This is a total of 73 readings on every crystal. It is plain, then, that we were able to manufacture crystals at a higher rate than we could test them, since time is required to warm or cool the crystal between readings!

The manner in which we solved this problem is made clear in the accompanying photographs. With the equipment illustrated, it is possible to check sixty crystals in the same length of time that is required to test one crystal.

Description of Equipment ★ This equipment is divided into two sections, 1) the variable temperature compartment and, insulated from it, 2) the oscillator and power supply compartment.

The former contains a fan to circulate the air, a chamber to hold dry ice, another in which heating coils are mounted, and a circular mounting that carries 60 crystals. The second section, so constructed that it remains at room temperature, holds the X oscillator to which each crystal is connected in turn, a standard reference crystal and its oscillator, and a mixer and

*Chief Engineer, Hudson American Corporation, 23 West 43rd Street, New York City.

FIG. 2. OPERATOR CALLS OUT READINGS TO RECORDER, AND WATCHES THERMOMETER

amplifier with its output running to the deviation meter on the top of the cabinet.

Fig. 1 shows the general arrangement. A motor-driven fan is mounted under the dry-ice compartment, while the heating coils are located at the rear of the center section. The rate of temperature change can be controlled by manipulating the high- and low-heat switches on the front of the cabinet, Fig. 2. A storage compartment for dry ice is provided at the right. There are two thermometers at the left of the wheel, Fig. 1. One indicates the temperature of the chamber. The bulb of the other is sealed in a crystal holder, so as to indicate the temperature of the crystals in the holders mounted on the wheel.

Details of this wheel are shown in Fig. 3. The unit appears upside-down in this photograph, for the large disc is actually used by the operator to swing from one crystal to the next. The clips take 60 crystals, each position being identified by a number on the large disc, and by a stop on the detent device.

All the electrical circuits are located at the right. The panel visible in Fig. 1 carries the standard reference crystal and its activity meter. Other elements comprising the circuit in Fig. 6 are at the rear. The standard oscillator circuit, Fig. 6, feeds the 6SC7 mixer, to which the output of the X crystal oscillator, Fig. 4, is also connected. The output of the mixer is then fed to a 6SJ7 and on to a 6F6, operating as a saturated amplifier. In this manner, the difference in activity between two crystals is prevented from affecting the reading of the deviation meter. This meter is connected across the rectifier. Thus it can be calibrated directly in cycles difference between the standard and the crystal under test. The full-scale reading is 2,500 cycles.

Plate voltage for the standard frequency oscillator is furnished by a degenerative network comprising a 6B4G triode as a current control, a 6SJ7 grid bias supply for the 6B4G, and a VR105-30 for a constant bias for the 6SJ7 tube. This regulatory circuit is supplied by a conventional rectifier and filter system.

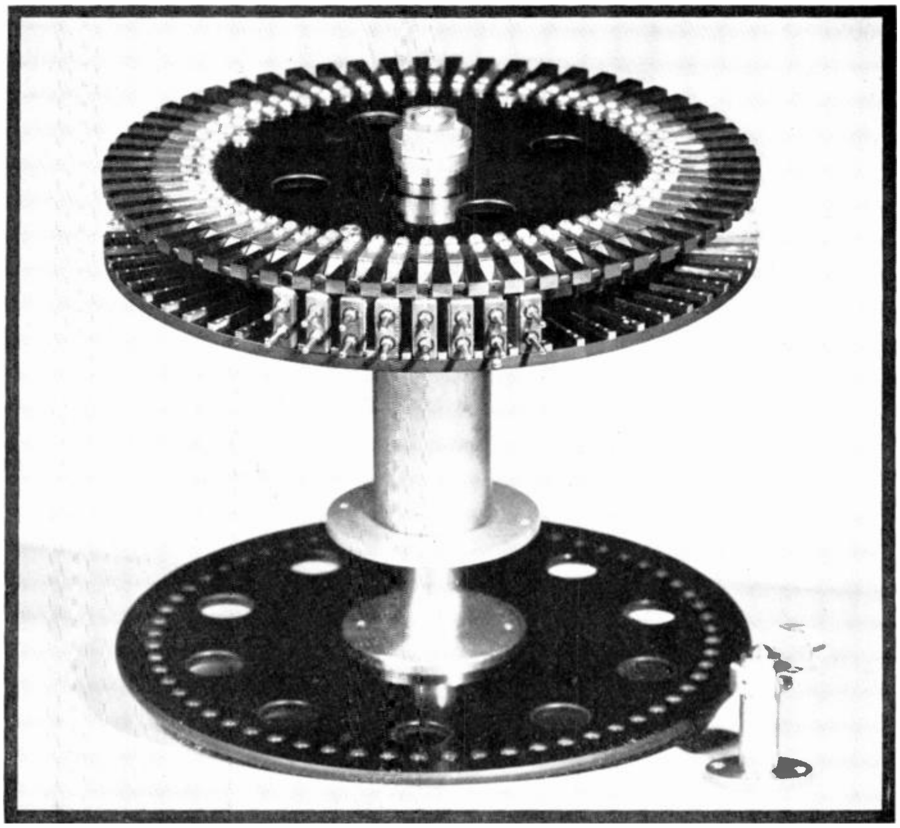
If the line voltage increases, the voltage at the contact arm of the variable resistor connected to the 6SJ7 control grid also rises. The plate current of the 6SJ7 increases accordingly, and the negative voltage at the 6B4G grid rises, thereby reducing the 6B4G plate current and the output voltage drops. This action is revised when the input potential drops, and the effect is instantaneous.

A separate regulated voltage supply for the 6F6 saturated amplifier is provided by a VR150-30 and a VR105-30, resistance-connected to the 5Z4.

Correlation of Oscillators ★ Before crystals can be tested, it is necessary to adjust the X oscillator and the standard oscillator to exact conformity with a master standard. When the two oscillators in the test equipment have been correlated accurately, a standard crystal will produce the same activity reading when inserted in the crystal wheel or in the socket of the standard oscillator, located in the right hand compartment.

Either of two methods can be used for correlating, the heterodyne method or the oscilloscope method. The latter seems to be preferred, however.

FIG. 3. SPRING CLIPS HOLD 60 CRYSTALS. DETENT DEVICE ALIGNS CRYSTAL FOR TEST



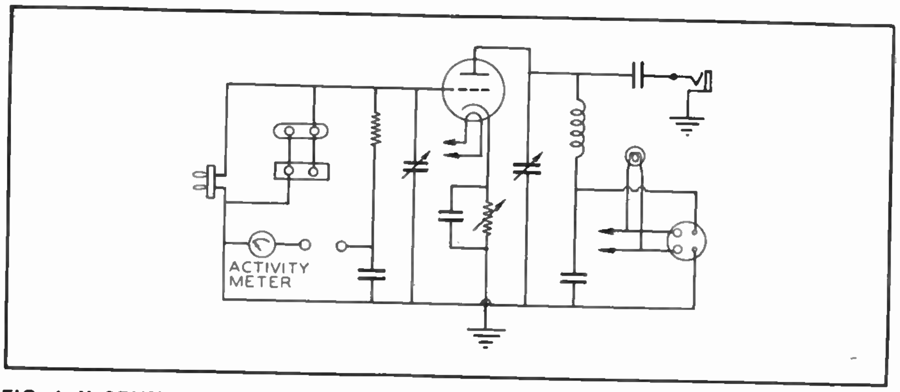


FIG. 4. X CRYSTAL OSCILLATOR. CONTACTS AT LEFT ARE FOR THE CRYSTAL WHEEL

It will be described here because it is applicable to other purposes, as well. The operation is carried out in the following steps:

1. Set up a communications receiver with a 10 kc. multivibrator standard connected to the antenna terminals. Connect the vertical plates of an oscilloscope to the output of the receiver, and the horizontal plates to a standard audio frequency signal generator.

2. Plug a standard crystal into a master standard oscillator, and adjust the latter for maximum reading on its own activity meter. Record this reading. Tune the receiver accurately to the crystal frequency. Then vary the setting of the audio frequency generator until a Lissajou ellipse appears on the oscilloscope screen.

3. Remove the standard crystal and plug it into the standard oscillator of the crystal testing equipment. Adjust the plate condenser of the 6C5, Fig. 6, for maximum activity, as indicated on the meter. Then adjust the grid condenser until the Lissajou figure reappears. Since this activity reading will not correspond with the value previously recorded, the variable resistor in the 6C5 circuit must be set to obtain the required value. However, changing the resistor will upset the Lissajou figure. It is necessary to go through these steps again until the activity is the same as that originally recorded, and the Lissajou figure is obtained on the oscilloscope. When the adjustment is exactly right, changing either of the condensers or the resistor will cause only a slight variation of activity.

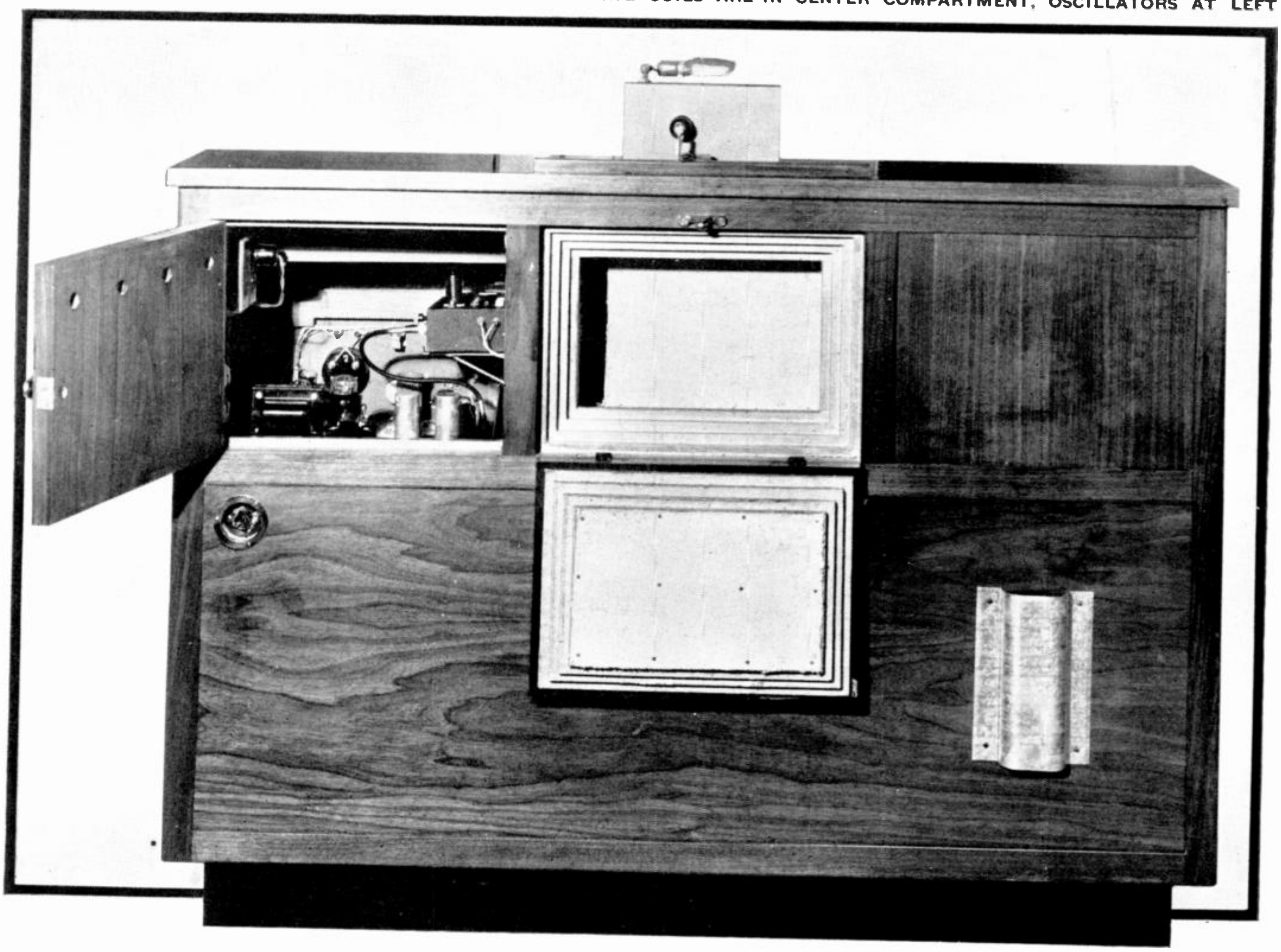
4. Finally plug the standard crystal into the extra holder connected to the X oscillator, and adjust it in the manner described above. The accuracy of the whole test depends upon the care with which these settings are obtained.

Crystal Checking ★ Once the electrical adjustments have been made, the crystal checking is only a matter of skillful manipulation and visual accuracy in reading the meters. Women operators are selected for this work. The first step, of course, is to load the crystals in the clips. This is done by touch, the wheel being accessible through the ice chamber.

About 25 lbs. of dry ice are put in the left hand compartment, and the fan is turned on. Approximately 30 minutes are required to bring the crystal temperature down to −50° C. Then the ice is removed.

The operator starts with the wheel in position for No. 1 crystal, calls out the activity and frequency deviation indicated by the two meters on the top of the cabinet,

FIG. 5. REAR OF THE CRYSTAL TESTING CABINET. HEATING COILS ARE IN CENTER COMPARTMENT, OSCILLATORS AT LEFT



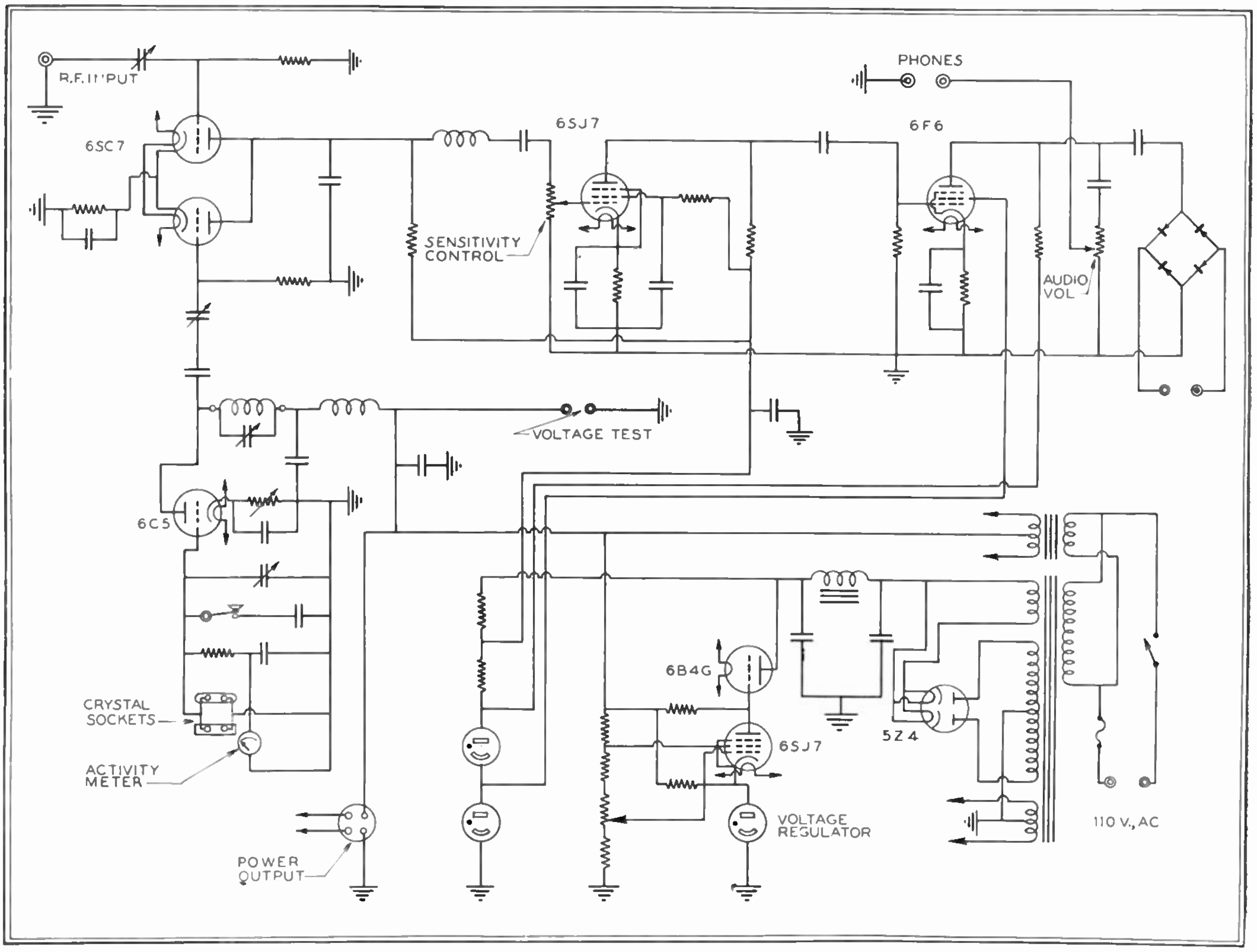


FIG. 6. STANDARD CRYSTAL OSCILLATOR, MIXER, AND AMPLIFIER. DEVIATION METER IS CONNECTED TO RECTIFIER AT RIGHT

and repeats this for one crystal after another. An inexperienced girl requires nearly two minutes to check 60 crystals, but a skilled worker can do it in well under a minute. In a 2-minute interval, the temperature rises 2°, and the whole process is repeated.

When the run is started, the cover of the ice chamber is opened to start the steady rise of the crystal temperature. At −10°, a 300-watt heater element is turned on. This is increased to a 600-watt element at 0°, and to 900 watts at +10° C. The fan is kept running at all times.

There is a definite knack to handling the wheel and calling out the readings, as well as to manipulating the heater controls so as to keep the temperature rise in step with the checking. However, experience has shown that the know-how can be acquired quickly, with the net result that a speed of testing can be achieved that is far beyond that obtainable from any other method now in use.

ELECTRICAL INSTRUMENT PRODUCTION SOARS

FIGURES released by H. P. Sparkes, chairman of NEMA's Electrical Measuring Instrument Section, show that the production of measuring instruments of various types has increased from 700,000 units in 1940 to an estimated total of 28,000,000 in 1943.

Schedules for 1944 have been set at 39,000,000 units, or 55 times the 1940 production. This tremendous increase is due to the fact that a large bomber may carry as many as 250 electric meters, a battleship requires about 1,000, a submarine 150, and even a tank has 10 meters. In fact, these instruments guide every machine of war that flies, floats, or runs on the ground.

In February, 1942, at a meeting of 68 representatives of the Army, Navy, Air Force, WPB, and instrument makers laid out a plan for the increased production required. Among the steps taken immediately through the WPB's Radio and Radar Division was the issuance of limitation orders eliminating a great number of non-essential instrument types, and standardizing on a limited number which could be handled on a mass-production basis.

Barriers of commercial competition were swept away. Such companies as Weston and Sangamo Electric joined hands, and Sangamo facilities were converted to Weston designs. The Westinghouse Company worked with Simpson Electric and others on producing such devices as blind navigation instruments. General Electric turned over their designs to be used by subcontractors.

In peacetimes, over 100,000 types and variations of specialized meters were manufactured, but with the advent of war, this number started to increase at an alarming rate.

To achieve the required production goal, it was clear that this condition would have to be changed drastically. Accordingly, NEMA and the American Standards Association set up a special committee under the chairmanship of R. B. Shepperd, of WPB's Simplification Bureau. This committee drew up a simplification standard which eliminated about 85% of the previous instrument variations.

This, of course, is only a part of the story of the means by which our military requirements were met. Some of the details, such as developing an adequate domestic source for jewelled bearing, are amazing stories in themselves.

GLASS-BONDED MICA RADIO INSULATORS

Manufacturers' Recommendations for Design Factors and Tolerances for Glass-Bonded Mica Parts

BY H. R. WILSEY*

A WAR STANDARD on Glass-Bonded Mica Radio Insulators, C75.6–1943, one of a group of standards for components of radio equipment used by the Armed Forces, has now been completed.

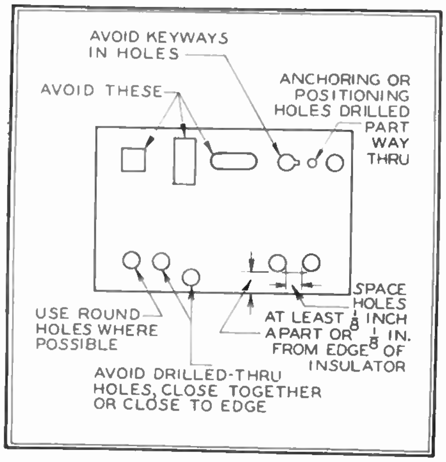


FIG. 1. TYPES OF HOLES AND OPENINGS

Engineering representatives of the Armed Forces and the radio industry have worked jointly under the auspices of the American Standards Association on this standard. Because of the low electrical loss of this material as compared with other insulating materials currently used, this standard on glass-bonded mica should be of particular value to those concerned with FM and other ultra-high frequency applications.

Despite a tremendous increase in the use of glass bonded mica for insulating purposes in high frequency radio and electronic equipment during the past three years, the lack of information on the part of many engineers on design criteria to be used for this new material has hampered its full effectiveness. Glass-bonded mica is finding widespread use under such trade names as "Mycalex," "Mykroy," and "Kolonite," but because comparatively little is known about its fabrication, the full possibilities of this material have not always been realized.

The standard is intended to correct this situation. The requirements for testing and inspection of the material by the Armed Forces and prime contractors have been established. In addition, because of the nature of the material, it has been found expedient to include an appendix based on the combined experiences of those most familiar with the material.

This data will help to insure the most desirable design of glass-bonded mica insulators, and to facilitate procurement at minimum cost and production time.

The design criteria are presented here for the benefit of engineers and draftsmen concerned with the design of insulating parts for radio equipment.

Preferred Shapes ★ To provide maximum production, reduce fabrication time, and reduce costs, it is recommended that rectangular parts be used where possible and that irregular or curved sections be avoided.

Tapped Holes ★ Although holes in glass-bonded mica insulation can be tapped, it is recommended that such holes be avoided if possible. If tapped holes are required, they should be slightly countersunk to prevent chipping.

Bottoming of tapped or blind holes should be avoided.

Threads in tapped holes should conform to Class 1 fit.

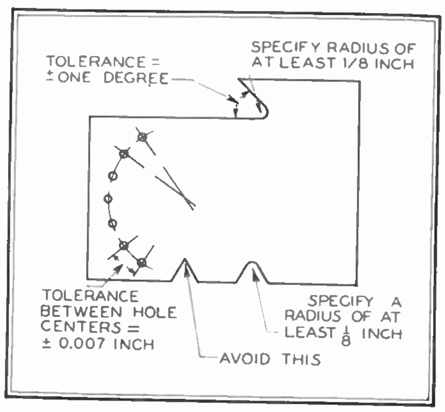


FIG. 2. HOLE TOLERANCES AND FILLETS

Counterboring ★ Although it is possible to counterbore glass-bonded mica, it is not always possible to secure sharp edges around the counterbore.

Thickness of Flat Parts ★ Flat plates or sheets from which most parts are fabricated are available in standard thicknesses of 1/8, 3/16, 1/4, 3/8, 1/2, 5/8, 3/4, 7/8, and 1 in. In the design of flat parts, standard thicknesses should be specified wherever possible. It should be noted that the nominal minimum thickness of flat parts is 1/8 in. Although thicknesses less than 1/8 in. can be produced, special grinding operations involving high cost and increase in production time are required. In any case, the thickness should be not less than 3/32 in. where the maximum dimension (length or width) of the part is 3 ins. For dimensions above 3 ins., the minimum thickness should be 1/8 in.

Round Rods ★ Round rods are available in

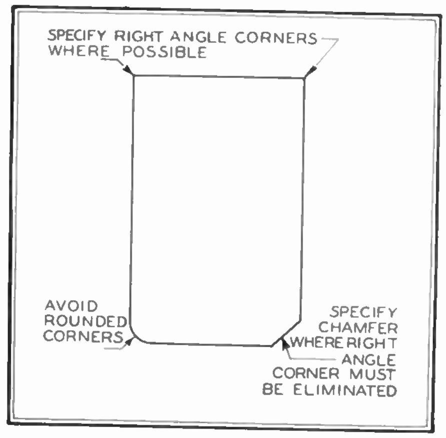


FIG. 3. RECOMMENDATIONS AS TO CORNERS

standard dimensions of 1/4, 3/8, 1/2, 5/8, 3/4, 7/8, and 1 in. In the design of parts to be machined from rod stock, such as bushings, washers, or spacers, standard diameters should be specified wherever possible.

Corners ★ On flat plate designs, right-angle outside corners should be specified where possible to avoid additional time-consuming machining operations. Where it is essential that sharp outside corners be eliminated, a chamfer should be used in place of a definite radius, as the latter requires the use of special jigs. (See Fig. 3.)

Angles ★ Where angles or V cuts are required in the edges of flat pieces, a radius of not less than 1/8 in. should be specified at the apex of the angle or V cut. (See Fig. 2.)

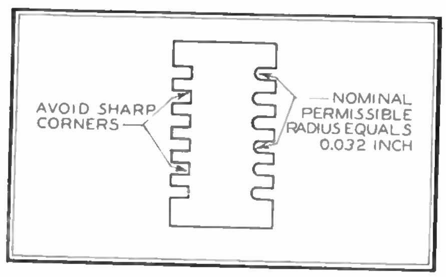


FIG. 4. AVOIDANCE OF CORNERS ON SLOTS

Holes ★ Round holes should be specified in preference to square, rectangular, or elongated holes as the latter involve costly,

(CONTINUED ON PAGE 53)

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AN EXPLANATION OF FREQUENCY MODULATION

A Clarification and Comparison of the Characteristics of Amplitude and Frequency Modulation, Part 2

BY W. L. EVERITT *

Frequency-Modulation Transmitters ★ Two important and quite different methods of obtaining frequency modulation are in use at the present time. A third method has also been announced.

The method proposed by Armstrong [3] makes use of the fact that for low values of m_p (m_p less than 0.5) the fundamental difference between amplitude and phase modulation lies in the phase relation between the carrier and side-band vectors. Balanced modulators have been extensively used [4] in carrier-current systems to obtain the two side bands of amplitude modulation and eliminate the carrier. In the Armstrong system the carrier output of the oscillator is shifted 90 degrees and then used in a balanced modulator to obtain side-band components corresponding to amplitude modulation with this carrier phase. The output is then added back to a carrier component with the phase of the oscillator to form a phase modulation system. The maximum allowable modulation factor m_p produced with these components is 0.5 since only one pair of side frequencies is available.

A block diagram showing the Armstrong system is shown in Fig. 11. The several components required will be discussed in turn.

This method is fundamentally a phase-modulation system, but it may be converted into a frequency-modulation system if an audio equalizer is used before the modulation. The required characteristic of this equalizer is that the output voltage must be inversely proportional to the audio frequency of the input voltage. With this equalizer in the audio system the phase modulation will be inversely proportional to the audio frequency of the original signal. It has been shown that this is the requirement for frequency modulation and so the combination produces true frequency modulation.

It has been explained that with this system m_p is limited to a maximum value of 0.5, in the original modulation. On account of the characteristic of FM which has been discussed, this maximum value of m_p can only be secured at the lowest audio frequency to be transmitted. The value of m_p at higher frequencies will be inversely proportional to the audio frequency. Then if a range from 40 to 15,000 cycles is to be transmitted the maximum value of m_p at 15,000 cycles will be $40/15{,}000 \times 0.5 = 0.0013$.

Such a method of obtaining frequency modulation, if used alone, would be entirely impractical since operation would be restricted to such low values of m_p and the advantages of frequency modulation lie in the use of large values.

If a radio-frequency amplifier has a large grid bias and relatively large radio-frequency voltage applied to its grid, the plate current will flow in pulses [5] containing harmonics of the grid exciting voltage. If the plate circuit is tuned to a harmonic of the grid voltage, the voltage across the tuned circuit will have a high value at this harmonic. For efficient operation this harmonic should be a low one, say the second or third. When tuned to a second harmonic the combination is called a frequency doubler.

It has been found that a frequency doubler also doubles the phase or frequency shift if an angular-modulated wave is applied to the grid, and therefore doubles the value of m_p and also m_f for such a wave. A series of n doublers would multiply m_p by 2^n.

If the method of obtaining frequency modulation now being discussed is operated with a relatively low carrier frequency and the output is passed through a sequence of doublers or triplers, the value of m_p can be correspondingly increased. It has been shown that if a deviation of 75,000 cycles is desired, the value of m_p at an audio frequency of 15,000 cycles would be $75{,}000/15{,}000 = 5$. It has also been shown that for the wide audio range of 40/15,000 cycles the m_p which can be initially produced by the Armstrong method at an audio frequency of 15,000 cycles is 0.0013. Therefore the amount of multiplication of m_p required is approximately $5/.0013 = 3{,}750$. The number of doublers required is then obtained by the solution of the equation

$$2^n = 3{,}750$$

or

$$n = 12 \text{ nearly}$$

If a final carrier frequency of 41 mc. is to be used, and straight multiplication were to be employed, the carrier frequency at which the initial modulation should take place would be determined by the frequency multiplication required. In this case

$$\text{Initial carrier frequency} = \frac{\text{Final carrier frequency}}{\text{Multiplication of doublers}} = \frac{41{,}000{,}000}{2^{12}} = 10{,}000 \text{ cycles per second}$$

It is not possible to modulate a 10,000-cycle carrier by an audio frequency of 15,000 cycles, since the audio frequency must be less than the carrier frequency. Therefore some modification of the system must be made. The modification adopted is to perform the modulation at an initial carrier frequency of the order of 200 kc. and pass it through a first group of say six doublers. The carrier frequency has then been multiplied 2^6 times and has reached a value of 12.8 mc. If now a final carrier frequency of 41 mc. is desired, the 12.8 mc. signal is combined with the output of a second crystal oscillator whose frequency is selected so that a beat note of $41/2^6$ or 0.6406 mc. is obtained. This does not affect m_p. The 640.6 kc. wave is then passed through a second group of six doublers to obtain the final 41-megacycle output. Since the initial frequency-modulated wave has now passed through 12 doublers, the multiplication of 2^{12} or 4,096 has been obtained.

The output of the second group of doublers is then amplified up to the final power required.

CONSIDERABLE engineering effort has been expended on speculation as to the shortcomings of Major Armstrong's method of using Frequency Modulation to provide an improved system for radio broadcasting and communications.

Most of the questions raised can be answered readily by those who have had practical experience with the use of FM. Answers to questions of theory are also available to those who seek them.

Professor Everitt covered the theory of FM very clearly and concisely when he prepared this paper nearly four years ago. Subsequent investigation has confirmed his mathematical analysis and his conclusions.

In his only statement based on speculation, however, time has shown him to have been mistaken. He stated that "the reactance tube method (of modulation) is simpler and would seem particularly applicable to low powers and portable equipment." In practice, the phase-shift method is being used exclusively for mobile equipment.

* Professor of electrical engineering at Ohio State University, Columbus.

[3] "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation," E. H. Armstrong, IRE *Proceedings*, volume 24, May 1936, page 689.

While this circuit seems complicated, it should be remembered that these operations can be performed at low power and with receiving-type tubes. The cost is not prohibitive for a transmitter station, since the investment in other equipment would be much greater.

The second method of frequency modulation operates in a distinctly different manner. If the capacity of a capacitor could be varied at an audio rate, and if this capacitor were included in the tuned circuit of an oscillator, it is apparent that the output would be frequency modulated.

The fundamental characteristic of a reactance is that the current flowing into the two terminals is 90 degrees out of phase with the voltage applied across these terminals. This same effect can be secured with a tube circuit. The method is illustrated in Fig. 12. The resistance R_1 is made small in comparison with the reactance of C_1. Then the alternating voltage between the control grid and cathode is substantially 90 degrees out of phase with the voltage impressed across the terminals *a-b*. But the plate current which flows in the tube is determined largely by the grid voltage. The choke L_3 provides a large impedance to alternating current so that the AC component of the plate current will flow in the terminals *a*, *b*. The current which flows into the terminals *a*, *b* will be 90 degrees out of phase with the voltage across it because of the grid control, and the circuit appears like a reactance at these terminals.

The magnitude of the reactance is a function of the amplification constant of the tube. In a variable-mu tube the amplification constant may be controlled by the voltage on the grid. Therefore if an audio voltage is also impressed on the control grid of the tube the effective reactance may be varied at an audio rate.

The terminals *a*, *b* are connected in parallel with the tuned circuit L_2, C_2 of a conventional oscillator whose output frequency is determined by the resonance of that circuit. With this combination a variation in the audio voltage on the grid of the reactance tube will produce a frequency-modulated wave in the output circuit of the oscillator L_4, C_4.

The circuit of Fig. 12 does not have the inherent stability of the system of Fig. 11 because the carrier frequency or frequency for zero modulation is not crystal controlled. Stability equivalent to crystal control is necessary in modern radio operation. In order to secure crystal control a more elaborate system is necessary. This is illustrated by the block diagram of Fig. 13.

The oscillator and reactance circuit are similar to those of Fig. 12. The oscillator usually operates at some submultiple of the desired frequency, say one-fourth or one-sixth. A frequency multiplier is used before the operation of the final power amplifier, as is standard practice at ultra-high frequencies. A sample of the output is brought back into a frequency converter where it is mixed with the output of a crystal oscillator for comparison purposes. The resultant beat note is then passed through a frequency discriminator of the same general type as used in receivers and illustrated in Fig. 10. If the final output changes frequency, the beat frequency passing into the discriminator will change. This change is used to produce a direct voltage in the discriminator which in turn is applied to the reactance tube to provide a correction on the frequency drift which has occurred.

This method of increasing stability has a marked similarity to the use of inverse feedback in audio amplifiers.

A delay or filter must be introduced in the frequency feedback circuit so that it is unresponsive to the variations in frequency produced by the audio modulation, but will make corrections for the long period drifts associated with oscillators which are not crystal controlled.

The two methods of frequency modulation transmitters each have their proponents. The Armstrong method is claimed to be more stable because the carrier frequency is directly controlled by the two crystals. The reactance tube method is simpler and would seem particularly applicable to low powers and portable equipment. It is too soon in terms of practical operation to be sure which will find the more general application.

The operation of the final amplifiers in both systems is essentially simpler than is the case in amplitude modulation, since attention need not be paid to the linearity of input-output amplitude curves.

In amplitude modulation the final high-power stage presents certain difficulties in operation. A transmitter normally requires [5] either a high-power audio amplifier with an output about 75 per cent of the rated carrier power to perform the modulation, or else the final stage must be operated at half its maximum efficiency. This is because in amplitude modulation the power output must be increased during modulation by an amount equal to the side-band power (50 per cent of the carrier power for $m = 1.0$). The increase in power must be supplied by either an audio amplifier or by an increase in the efficiency of the output stage during the audio cycle. An increase in efficiency can only be obtained if the efficiency in the absence of modulation is limited to half its maximum possible value. Both of these

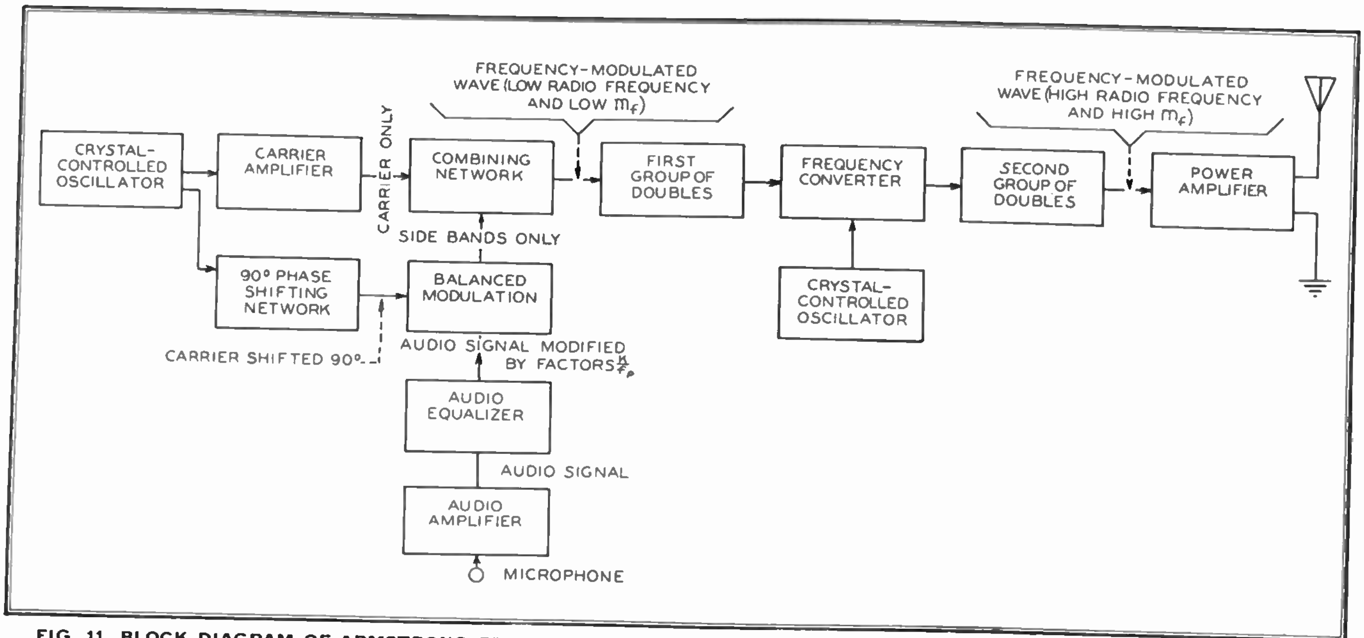

FIG. 11. BLOCK DIAGRAM OF ARMSTRONG FREQUENCY MODULATION TRANSMITTER WITH CRYSTAL FREQUENCY CONTROL

[5] "Communication Engineering" (a book), W. L. Everitt, McGraw-Hill Book Company, 1937.

expedients increase the cost of high-power stations materially. Since the amplitude and power output of an FM transmitter are constant during modulation, the final stage can operate at its maximum efficiency at all times even though the original modulation is performed at a low power level where only receiving-type tubes are required.

The question is frequently raised whether the wide band which must be transmitted for FM does not introduce difficulties in the tuned circuits. However, it should be remembered that the selectivity of any tuned circuits is given in terms of frequency ratio rather than absolute band width. A 200-kc. band width at 40 mc. is only one-half of one per cent of the carrier frequency, while the 10-kc. band width used in standard broadcasting at 1,000 kc. is one per cent of the carrier frequency. Therefore no difficulties are introduced in the transmitter by the required absolute width of the band when the carrier frequency is high.

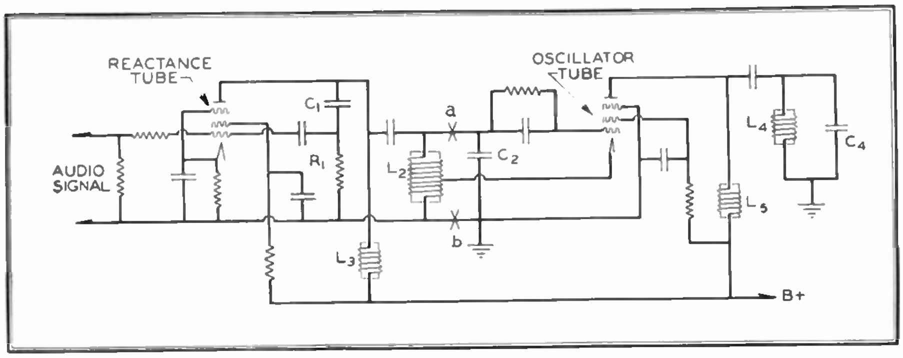

FIG. 12. CIRCUIT OF OSCILLATOR FREQUENCY-MODULATED BY REACTANCE TUBE

Application of FM to Services Other Than Broadcasting ★ Frequency modulation seems to have inherent advantages for other services than broadcasting. Important among these are its application to police and airway communication. The sharp limitation of the range obtained with FM is an advantage and it would appear that many more police transmitters covering specific areas could be used without interference. In airway service some of the most important contacts are needed during severe electrical storms and FM could make an important contribution in this field.

FM would also appear to have advantages for military purposes where limited ranges are desired and interference is a particularly severe problem.

In police, airway, and military communication, high-quality reproduction is not necessary and so a more limited band would serve the purpose.

FM has also been proposed for longer-distance communication by the use of relay or repeater stations spaced at intervals determined by the range of the transmitters. By the use of directional antennas this range can be increased. Previous proposals to use amplitude-modulated relay stations for broadcast-station interconnection have not met with favor because of the limited range and additional interference which they would cause, but it appears that a large part of this objection is eliminated when FM is used.

It is also possible to multiplex other services on FM transmission, such as facsimile, transmitting this service along with a sound signal, but with a reduction in the signal-to-noise ratio. Another suggestion has been to transmit two sound signals to obtain binaural reproduction. The possibilities of these uses have been only partially explored.

Conclusion ★ It would appear that frequency modulation is capable of producing a marked change* in broadcasting within the next few years. It is very doubtful if it will eliminate the use of the standard broadcast frequencies, as they are still capable of covering larger distances when (and only when) a transmitter is given exclusive use of a channel. It seems probable that many local stations designed to cover a limited area will be transferred to FM operation, and the number of cleared channels increased so as to take better advantage of the limited band of standard broadcast frequencies available. The development in these lines must eventually respond to the laws of economics and engineering.

* Note that this prediction was made by the author early in 1940. Editor's Note.

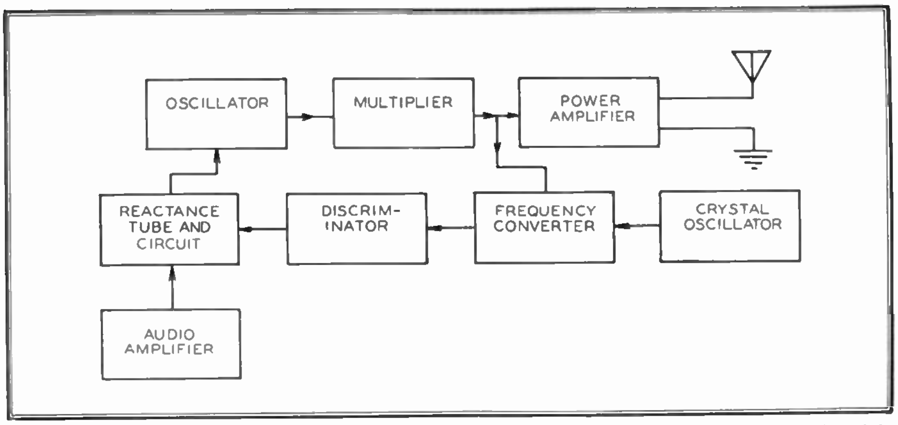

FIG. 13. BLOCK DIAGRAM OF REACTANCE-TUBE-CONTROLLED FREQUENCY MODULATION TRANSMITTER WITH CRYSTAL STABILIZATION AND DISCRIMINATOR

CHAIRMAN FLY CALLS PLANNING CONFERENCE FOR NOVEMBER 17TH

CHAIRMAN FLY of the FCC has called a conference of Government officials and the Radio Technical Planning Board to be held at Washington on November 17th. This is a preliminary step to post-war allocations of radio frequencies, but only organization and procedure will be discussed with RTPB members and panel chairmen. Policies of frequency allocations and systems standards will not be taken up at this time. Plans for this meeting were announced by Mr. Fly at his recent press conference with FCC Chief Engineer E. K. Jett.

On the 18th, W. R. G. Baker, Chairman of RTPB, has arranged for a meeting of the Administrative Committee to complete organization of panel chairmen, and to initiate important technical studies.

Mr. Fly announced that his conference would make plans for studies and organization of committees to survey future allocation requirements of the future. Thus industry and the Government groups will be enabled "to get their bearings and dig in for some hard technical work and study."

Thus certain questions of procedure among Government agencies and the RTPB can be resolved before the industry's engineering studies proceed too far. Mr. Fly expressed his satisfaction with the organization of the RTPB, and commended the leadership of the RMA and IRE in its establishment.

Plans for governmental radio needs will be made by IRAC, of which FCC Commissioner T. A. M. Craven is chairman, with recommendations from the Board of War Communications. IRAC includes representatives of the Army, Navy, Coast Guard, Departments of Agriculture and Commerce, and other Government agencies.

Mr. Fly discussed the possible transfer of television to higher parts of the radio spectrum, above the 56-mc. point where picture frequencies now begin.

SPOT NEWS NOTES

Items and comments, personal and otherwise, about manufacturing, broadcasting, communications, and television activities

New FM Applications: It is highly significant that new applications for FM broadcasting stations are being filed now, in preparation for the time when station construction can be resumed. Latest to file are:

Miami Valley Broadcasting Corporation (WHIO) Dayton, Ohio, 46.1 mc., to cover 7,750 square miles. This is a radius of more than 50 miles.

Matheson Radio Corporation (WHDH) Boston, Mass., 46.1 mc., to cover 3,600 square miles. This is a radius of 35 miles.

Stations WKBZ, Muskegon, Michigan, 45.7 mc., to cover 2,290 square miles. This is a radius of over 25 miles.

These will be held on file for the present, of course, but early action can be expected when the time comes to consider pending FM applications, since they will be handled in rotation. It is understood that many more are being prepared for filing, so that the FCC will have a fairly complete picture of channel needs and the band width necessary to accommodate them before they start to make any new frequency assignments.

I.R.E. President, 1944: Will be Hubert M. Turner, Associate Professor of Electrical Engineering at Yale University. He succeeds Dr. Lynde P. Wheeler, of the FCC. Prof. Turner is particularly noted for his methods of experimental and laboratory techniques in teaching radio engineering.

During the first World War, Prof. Turner organized the technical instruction for the Signal Corps at the University of Minnesota, and later at the Signal Corps School for Officer Candidates at Yale. He is the 32nd president of the I.R.E.

Vice President for the coming year will be Ralph A. Hackbusch, who is vice president in charge of radio at Research Enterprises, Ltd., Leaside, Ontario.

Directors elected for 3-year terms were: Raymond F. Guy, radio facilities engineer for NBC, New York; Lawrence C. F. Horle, consulting engineer, New York; and William C. White, engineer at G.E. electronics laboratory, Schenectady.

Arithmetic Department: A new Gallup Poll report is being offered as evidence that not more than 500,000 home radios are in need of tubes or servicing, thereby refuting statements from the industry that sets are going out of commission at a very much higher rate.

If the question asked by Gallup pollers had been, "Is your radio set in operating condition?" the results could be taken as indicating the true state of affairs. However, the question actually asked was: "Aside from food, what things that you need very much right now for your home or family would you buy if you could get them?"

According to the Gallup report, this question put radio sets into competition with tires, refrigerators, automobiles, washing machines, shoes, bobby pins, stoves, garters, and girdles.

If the Gallup figure of 500,000 defective sets is correct, radio sets are lasting too long. The Bureau of the Census found that there were 60,000,000 sets in use in 1940. If only 500,000 of these have gone wrong in the last 12 months, that would indicate that the life expectancy of the average radio is 120 years.

On the other hand, if the industry's estimate of 5 years is correct, 12,000,000 sets must go out of service every 12 months. Possibly this figure is high. Certainly the Gallup question did not elicit direct answers on this subject.

F. C. BEST, PRESIDENT, CHICAGO TELEPHONE SUPPLY, SPEAKING AT ARMY-NAVY "E" AWARD CEREMONIES

Ben Reiss: Yawning over some two months-old trade papers, after a tough day at the Seabees' Camp Perry: "I gather that most of our technicians have a pretty good case of indigestion from all the emotional advertisements that preach to them from the advertising sections of the industrial press. And if some industrial advertisers who are continuing heart-throb copy could hear the boys read their copy aloud with intonations, gestures, etc., they might come to appreciate the fact that it is never safe to underrate one's advertising audience, particularly in the technical field." This from a man who, in civilian life, was an old timer in radio advertising.

SGT. JOHN BASILONE, WHO WON CONGRESSIONAL MEDAL OF HONOR FOR KILLING 38 JAPS, GREETED BY ARTHUR FREED AT A FREED RADIO "SPEED PRODUCTION" RALLY

AFM Controversy: Concerning the situation between RCA Victor and Petrillo's American Federation of Musicians, J. W. Murray, general manager of the RCA Victor Record Division has this to say: "It had been hoped that before this time we would have been able to settle the differences with the American Federation of Musicians, but the Union has remained adamant in demands which we cannot accept.

"The RCA Victor Division of the Radio Corporation of America has for a long time been a party to negotiations with the American Federation of Musicians in an endeavor to end the strike which started on August 1, 1942. We have not yet been able to reach a satisfactory solution. Therefore, in order to avoid further delay, we are presenting our case to the appointed panel of the War Labor Board at formal hearings that will start Wednesday, November 3rd.

"From the very beginning it has been RCA Victor's position that we are willing to negotiate

(CONTINUED ON PAGE 55)

FM STATIONS IN THE UNITED STATES

This list of FM broadcasting stations shows new call letters which are effective November 1, 1943. Many of these stations chose the call letters of the affiliated AM station, with the suffix -FM. Experimental stations will continue to use their old calls until they change to commercial status.

CALIFORNIA

—LOS ANGELES—

Don Lee Broadcasting System . . . . 44.5 mc. KHJ-FM

—SAN FRANCISCO—

Board of Education . . . . KLAW

CONNECTICUT

—HARTFORD—

Travelers Broadcasting Service . . . . 45.3 mc. WTIC-FM
WDRC, Inc. . . . . 46.5 mc. WDRC-FM

DISTRICT OF COLUMBIA

—WASHINGTON—

Jansky & Bailey (Experimental) W3XO

ILLINOIS

—CHICAGO—

Zenith Radio Corp. . . . . 45.1 mc. WWZR
WGN, Inc. . . . . 45.9 mc. WGNB
Columbia Broadcasting System . . . . 46.7 mc. WBBM-FM
Moody Bible Institute . . . . 47.5 mc. WDLM
Board of Education . . . . WBEZ

—URBANA—

Board of Education . . . . WIUC

INDIANA

—EVANSVILLE—

Evansville on the Air . . . . 44.5 mc. WMLL

—FORT WAYNE—

Westinghouse Radio Stations, Inc. . . . . 44.9 mc. WOWO-FM

—SOUTH BEND—

South Bend Tribune . . . . 47.1 mc. WSBF

KENTUCKY

—BEATTYVILLE—

University of Kentucky . . . . WBKY

LOUISIANA

—BATON ROUGE—

Baton Rouge Broadcasting Co. . . . . 44.5 mc. WBRL

MASSACHUSETTS

—BOSTON—

Yankee Network . . . . 44.3 mc. WGTR
Westinghouse Radio Stations, Inc. . . . . 46.7 mc. WBZ-FM

—SPRINGFIELD—

Westinghouse Radio Stations, Inc. . . . . 48.1 mc. WBZA-FM

—WORCESTER—

Worcester Telegram Pub. Co. (Exp.) W1XTG

MICHIGAN

—DETROIT—

Evening News Association . . . . 44.5 mc. WENA
John Lord Booth . . . . 44.9 mc. WLOU

MISSOURI

—KANSAS CITY—

Commercial Radio Equip. Co. . . . . 44.9 mc. KOZY
Midland Broadcasting Company W9XER

NEW HAMPSHIRE

—MT. WASHINGTON—

Yankee Network . . . . 43.9 mc. WMTW

NEW YORK

—BINGHAMTON—

Wylie B. Jones Advt. Agency . . . . 44.9 mc. WNBF-FM

—NEW YORK CITY—

Edwin H. Armstrong . . . . 43.1 mc. WFMN
Municipal Broadcasting System . . . . 43.9 mc. WNYC-FM
Muzak Corporation . . . . 44.7 mc. WGYN
National Broadcasting Co. (Exp.) . . . . 45.1 mc. W2XWG
Interstate Broadcasting Co. . . . . 45.9 mc. WQWQ
Marcus Loew Booking Agency . . . . 46.3 mc. WHNF
Columbia Broadcasting System . . . . 46.7 mc. WABC-FM
Bamberger Broadcasting Service . . . . 47.1 mc. WOR-FM
Metropolitan Television, Inc. . . . . 47.5 mc. WABF
Board of Education . . . . WNYE

—ROCHESTER—

WHEC, Inc. . . . . 44.7 mc. WHEF
Stromberg-Carlson Tel. Co. . . . . 45.1 mc. WHFM

—SCHENECTADY—

Capitol Broadcasting Co. . . . . 44.7 mc. WBCA
General Electric Co. . . . . 48.5 mc. WGFM

NORTH CAROLINA

—WINSTON-SALEM—

Gordon Gray . . . . 44.1 mc. WMIT

OHIO

—CINCINNATI—

Crosley Corporation (Experimental) W8XFM

—CLEVELAND—

Board of Education . . . . WBOE

—COLUMBUS—

WBNS, Inc. . . . . 44.5 mc. WELD

PENNSYLVANIA

—PHILADELPHIA—

Pennsylvania Broadcasting Co. . . . . 44.9 mc. WIP-FM
WFIL Broadcasting Co. . . . . 45.3 mc. WFIL-FM
Westinghouse Radio Stations, Inc. . . . . 45.7 mc. KYW-FM
WCAU Broadcasting Co. . . . . 46.9 mc. WCAU-FM
William Penn Broadcasting Co. . . . . 47.3 mc. WPEN-FM

—PITTSBURGH—

Walker-Downing Corp. . . . . 44.7 mc. WTNT
Westinghouse Radio Stations, Inc. . . . . 47.5 mc. KDKA-FM

TENNESSEE

—NASHVILLE—

National Life & Accident Ins. Co. . . . . 44.7 mc. WSM-FM

WISCONSIN

—MILWAUKEE—

The Journal Co. . . . . 45.5 mc. WMFM

—SUPERIOR—

Head of the Lakes Bcstg. Co. (Exp.) W9XYH

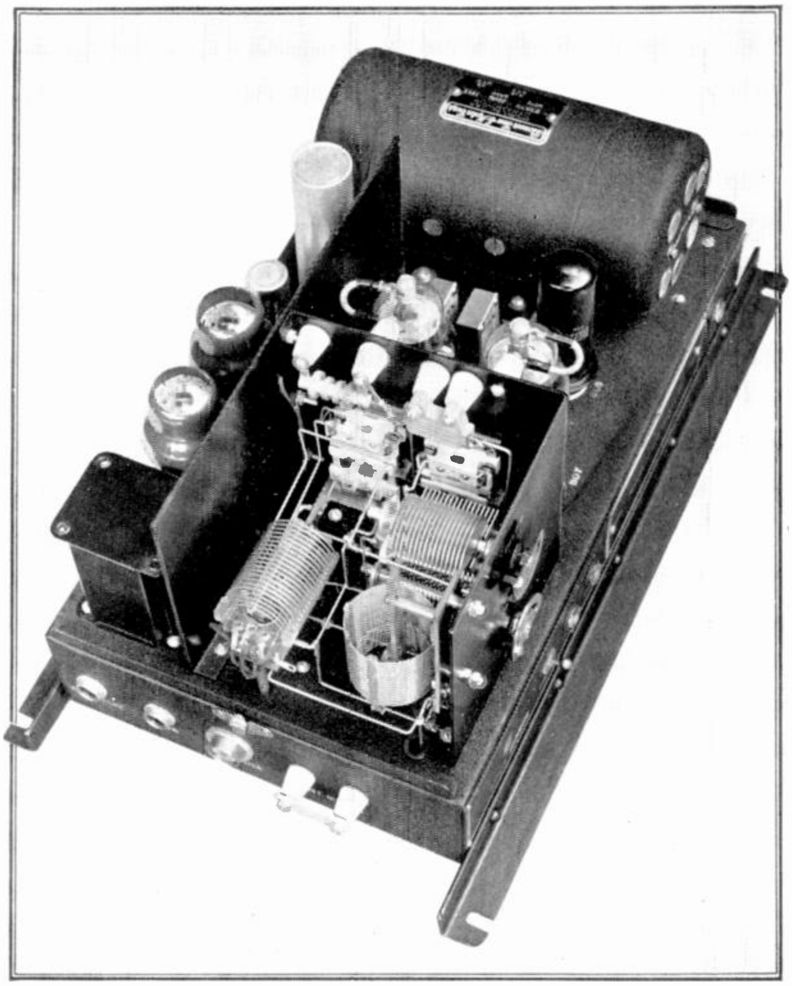

FIG. 1. CHASSIS OF THE TWO-FREQUENCY PHONE-CW TRANSMITTER UNIT

MOBILE AM EQUIPMENT FOR DX

Most Mobile Installations Are for Relatively Short-Range Use, but This Temco Phone-CW Equipment Can Cover Upward of 1,000 Miles

BY S. L. SACK*

UNDER ordinary circumstances, mobile installations are required to operate over relatively short distances from headquarters stations and from each other. Special services, however, call for the maintenance of communication over distances up to 1,000 miles or more, either by radiotelephone or, when atmospheric conditions blank out speech, by CW telegraph. It was for the latter service that the Temco equipment, shown in the accompanying illustrations, was designed.

General Description ★ The transmitter is designed to operate on any two predetermined frequencies between 2 mc. and 10 mc. With this broad band available, operating frequencies can be chosen for medium or long-range transmission, in accordance with prevailing day and night skip-distance conditions. In practice, the choice of frequencies is not left to the discretion of the operators. They follow instructions issued from their respective headquarters.

Power output of the transmitter is not less than 25 watts at 100% modulation, or 50 watts on CW telegraph. The outward appearance is shown in Figs. 3 and 5, while Figs. 1, 9, and 10 illustrate the construction of the chassis.

Two views of the receiver are given in Fig. 7, while Fig. 4 shows how it is installed under the dashboard. This is a conventional design, employing a superheterodyne circuit with one stage of RF amplification. Five crystal-controlled tuning frequencies are available. These can be changed by substituting other crystals, and by making corresponding adjustments.

Both units operate from a 6-volt car battery. The receiver draws approximately 55 watts, and the transmitter, when in use, draws a maximum of 264 watts.

Transmitter Details ★ The transmitter is designed to operate into a whip or telescopic antenna with a two-frequency loading coil of the type shown in Figs. 2 and 3. AF and RF characteristics are as follows:

1. Audio distortion from microphone input terminals to rectified antenna current is less than 3 db from 200 to 3,000 cycles.

2. Harmonic audio distortion or total RMS value of all audio harmonics is equal to 10% of RMS value of rectified antenna current.

3. The frequency-determining circuits

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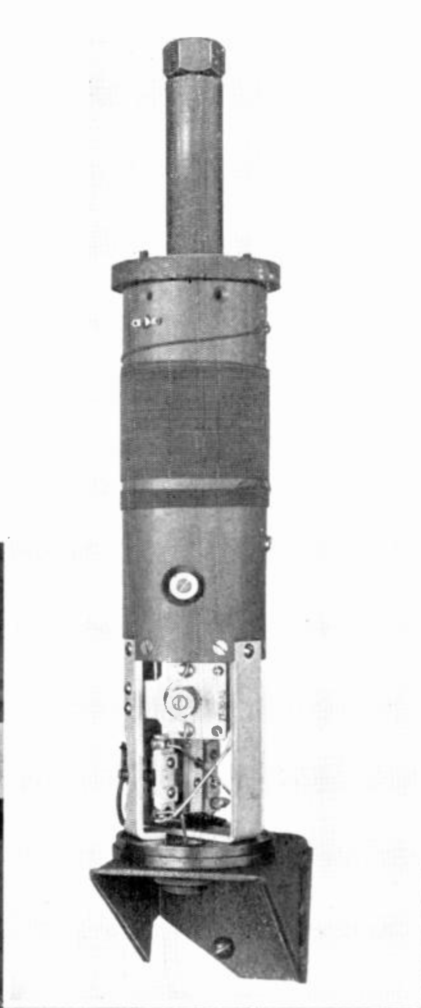
are sufficiently isolated from the power amplifier to prevent appreciable reaction on the carrier frequency when any RF control is detuned.

4. The frequency deviation of the carrier does not exceed .02%.

The transmitter chassis is reinforced by angle iron mounting strips 1 in. by 1 in. by 1/8 in. because, in the service for which these units were intended, they were mounted directly on the automobile deck, as shown in Fig. 3, using wooden brackets and carriage bolts. The chassis is of 16-gauge steel. All tuning adjustments have locking devices which can be tightened securely without changing the settings.

FIG. 2. RIGHT, ANTENNA LOADING COIL WITH THE BAKELITE COVER REMOVED



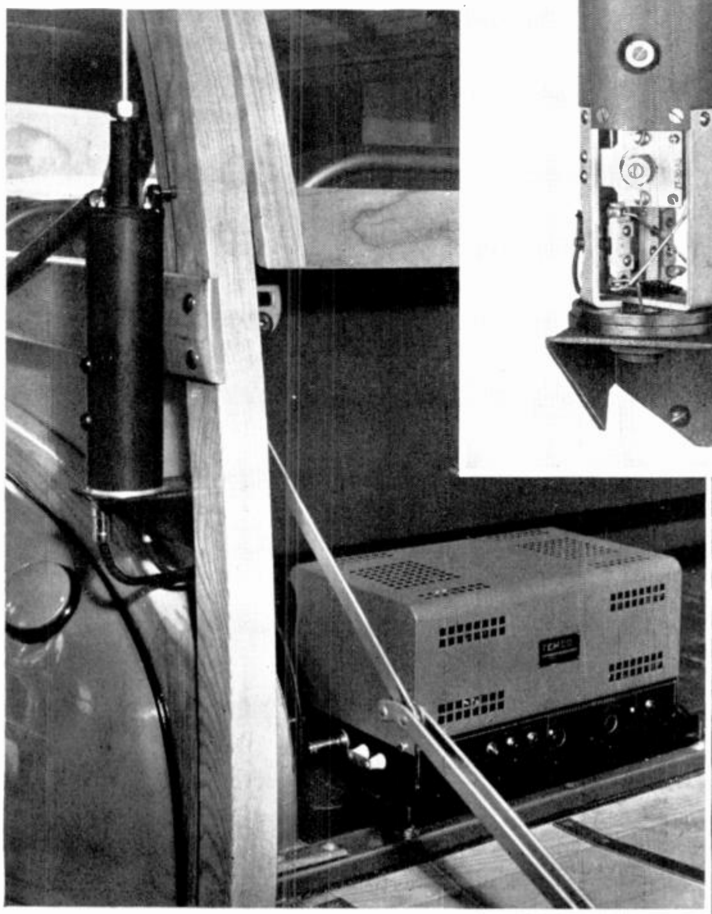
operating frequencies. Final control of the plate voltage is afforded by the push-to-talk switch on the microphone. The telegraph jack is normally closed when the key plug is removed. This plug must be removed during phone operation.

By means of a portable test set, Fig. 5, furnished with the equipment, control of the transmitter can be transferred to the rear of the car. The 12-point connector of the control-box cable is removed, and a similar connector from the test set is substituted. The meters are terminated with test plugs, to be inserted in jacks located on the transmitter chassis. Thus, while adjustments are being checked with the meters, duplicate dashboard controls are available at the transmitter location.

A TUNE-OPERATE switch, Fig. 6, inserts an extra resistance in the cathode circuit of the final amplifier stage, in order to reduce the plate voltage during tune-up procedure. When adjustments have been made, the switch is set at the OPERATE position.

Transmitter Circuit ★ Seven tubes are employed in the transmitter. These are:

1–6L6	Crystal-controlled oscillator
2–807	Parallel-connected final amplifier.
1–6C5	Speech input amplifier
1–6N7	Phase inverter driver
2–6L6G	Class AB2 modulators



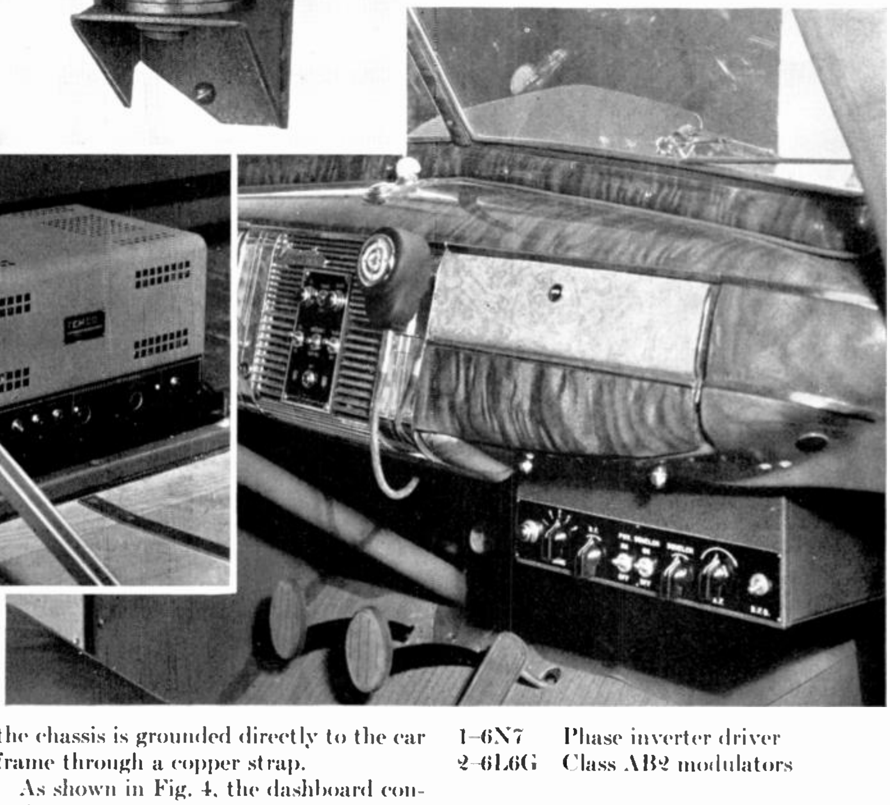


FIG. 3. ABOVE, TRANSMITTER AND ANTENNA INSTALLED IN A STATION WAGON. FIG. 4, RIGHT, CONTROL PANEL, MICROPHONE AND RECEIVER MOUNTED ON THE DASH BOARD

More than ordinary precautions were taken with respect to the permanence of electrical adjustments and rugged construction, in anticipation of more severe use than mobile equipment is ordinarily expected to withstand.

When the transmitter is in operation, it draws 44 amperes maximum from a 6-volt storage battery. Accordingly, No. 2 rubber-covered cable is used for the battery leads, and a fuse inserted in the negative side, separate from the transmitter. Then the chassis is grounded directly to the car frame through a copper strap.

As shown in Fig. 4, the dashboard control panel is mounted on what was intended as a loudspeaker grille. The control has four toggle switches, filament and plate pilot lights, key jack, microphone connector, and the cable connector. The switches control the application of filament power, application of plate power, selection of telephone or telegraph operation, and the selection of either of the two

The RF oscillator employs a beam power tube in a crystal controlled circuit. Crystals of low temperature-coefficient are used in the grid circuit to assure the maintenance of frequency within the required limits under all conditions of ambient temperature.

Screen voltage for the 6L6 oscillator tube is obtained by means of a series re-

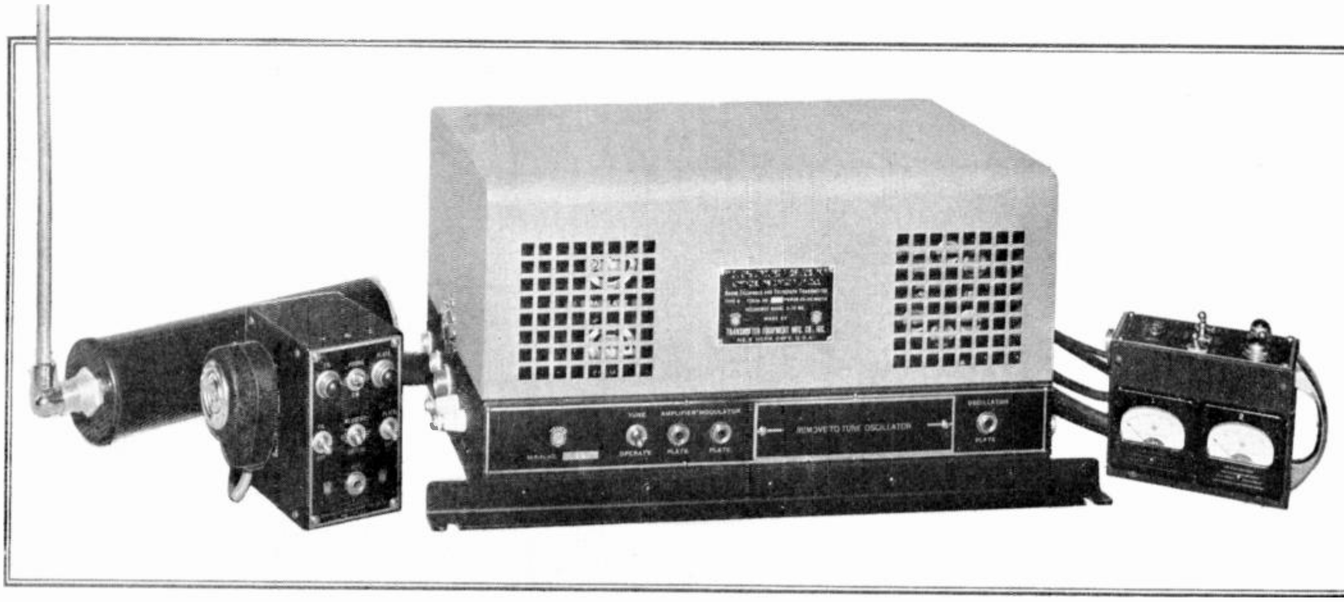


FIG. 5. THE ANTENNA AND LOADING COIL, CONTROL BOX AND MICROPHONE, 2-FREQUENCY TRANSMITTER, AND TEST SET

sistor of 12,500 ohms connected between the screen and a point of the oscillator plate supply at low RF potential. A second resistor, of 50,000 ohms, is connected between the screen and ground. This acts as a voltage-stabilizing bleeder. The screen is then bypassed directly to ground through a .002-mfd. condenser, providing an RF return for the screen circuit.

The plate circuit of the oscillator consists of two separately tuned plate circuits, selection of which is controlled by relay 3, a portion of which selects the corresponding crystal, X1 of X2. Plate operating voltage is applied to the oscillator tube through an RF choke.

Two 807 beam power tubes, operated in parallel, are used for the final power amplifier. The grids of the final power amplifier tubes are coupled to the oscillator stage by a .0005 mfd. condenser. Return to ground from the grids is obtained through the 10,000-ohm grid resistor. Two cathode resistors are employed for biasing. These comprise the normal cathode bias resistor of 50 ohms in series with a second resistor of 750 ohms, shunted by the TUNE-OPERATE switch.

Parallel feed is employed in the plate circuit of the final amplifier. An RF choke coil feeds voltage directly to both plates through parasitic suppressors. The .002 mfd. plate blocking condenser prevents

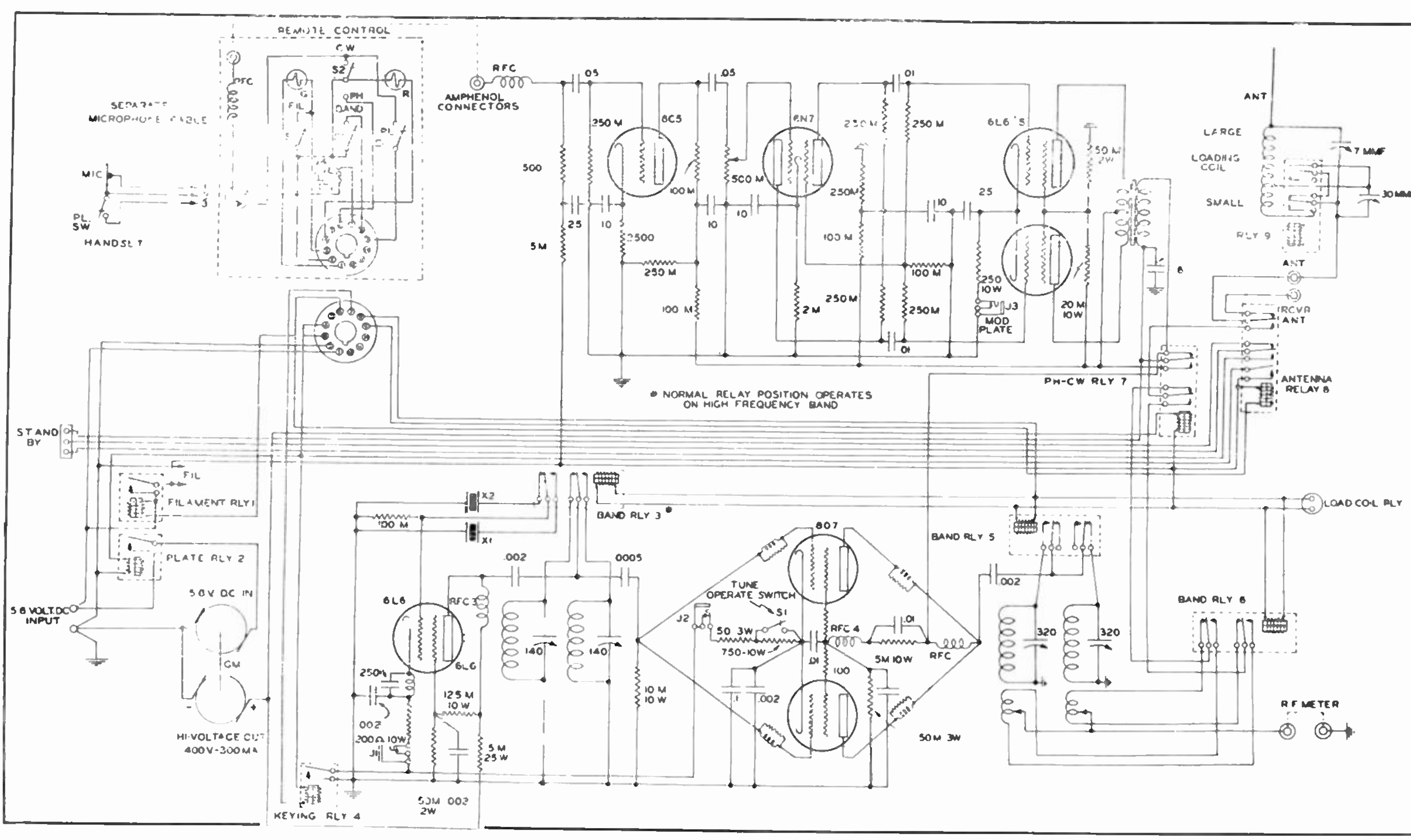


FIG. 6. WIRING DIAGRAM OF THE TRANSMITTER, CONTROL BOX, ANTENNA, AND FREQUENCY-SELECTING RELAY SYSTEM

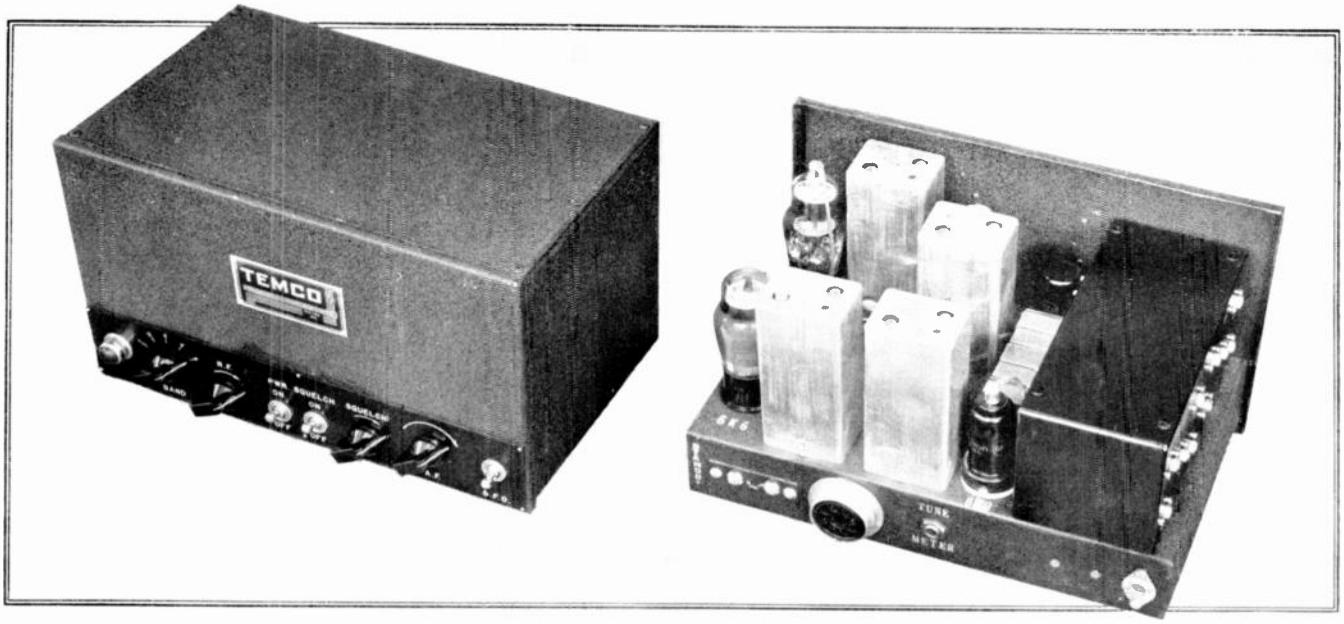


FIG. 7. THIS RECEIVER, FOR PHONE OR CW, IS TUNED TO FIVE FREQUENCIES, EACH CONTROLLED BY A PLUG-IN CRYSTAL

the plate voltage from entering the plate output circuit, while providing a low-impedance path between the plates of the tubes and the tuned plate output circuit.

The final amplifier plate circuit consists of two pre-tuned tank circuits, with their respective inductances and tuning condensers. Both tank inductances are provided with adjustable link coils which feed directly to the antenna loading coil unit. Relay 5 selects the final amplifier tank circuit, operating simultaneously with the other frequency-selecting relays.

A speech input circuit is provided in this transmitter, using a resistance network designed to operate in conjunction with a single-button carbon microphone. The AF circuits employ a 6C5 triode, operated as an AF amplifier, resistance-coupled to a 6N7 phase inverter. This, in turn, drives push-pull 6L6G tubes in class AB2. The modulator stage, transformer coupled to the plate circuit of the final amplifier, develops sufficient power to give 100% modulation of the carrier over the voice frequency range.

Antenna Loading Circuit ★ Construction of the antenna loading circuit is shown in Fig. 2, with the diagram in Fig. 6. It comprises an adjustable inductance, two small variable condensers which provide vernier tuning for each of two frequencies, and a

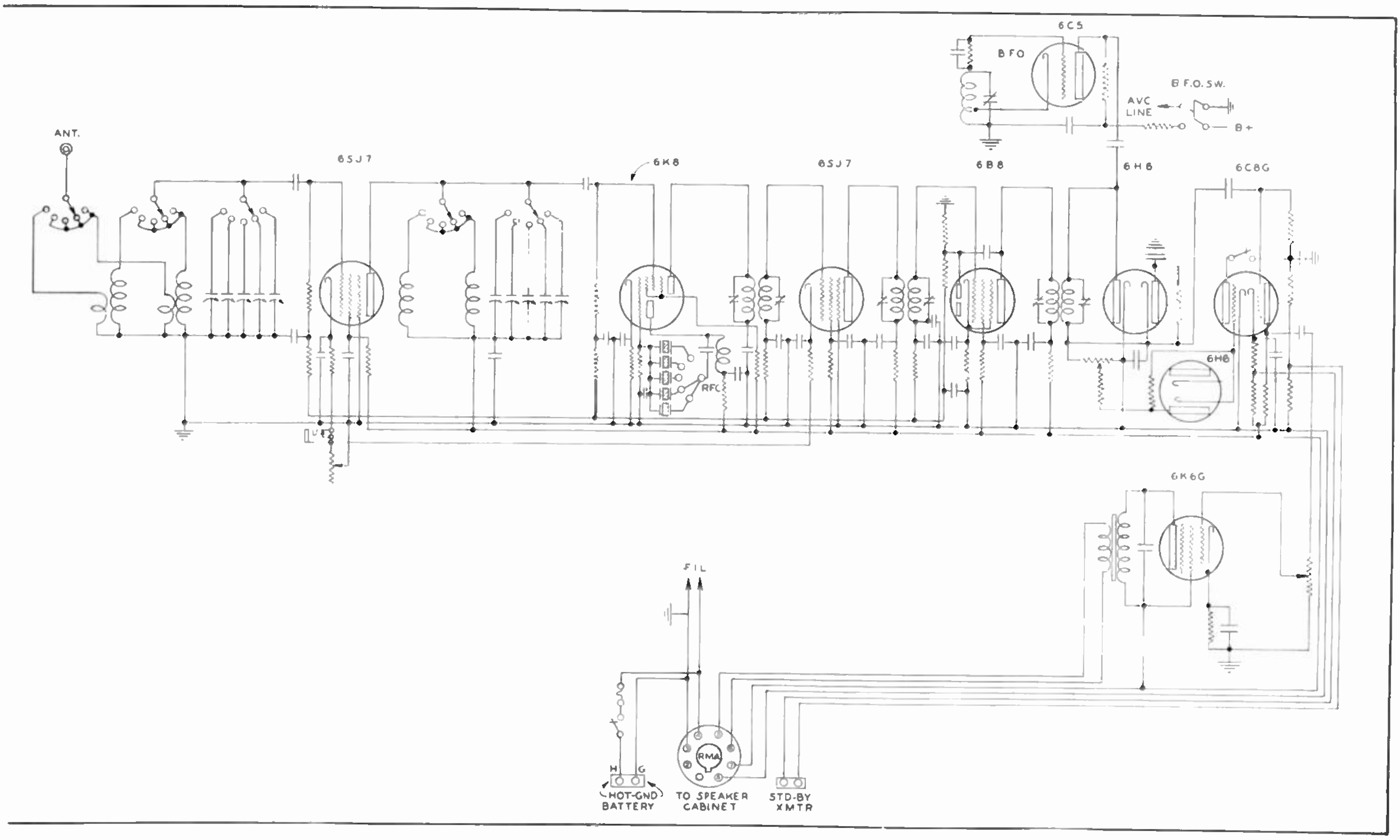


FIG. 8. WIRING DIAGRAM OF THE RECEIVER UNIT. THE INDIVIDUAL TUNING CONDENSERS ARE MOUNTED IN A SHIELD ON THE CHASSIS

two-way switching relay. There are also connections for inserting a thermo-coupled ammeter, to measure RF current flowing in the transmission line. These connections, visible at the end of the chassis in Fig. 1, are made up of terminals insulated by ceramic pillars, and carry a shorting strap for use when the circuit is not being metered.

The transmitter antenna terminal is an Amphenol fitting. Provision is also made for a receiving antenna, connected to relay 8, Fig. 6.

The loading coil, Fig. 2, is wound with more than sufficient turns of double silk covered wire to tune the shorter of the two antennas furnished to resonate within the frequency range. Two types of antennas are supplied: one is an 8-ft. whip, and the other, a 12-ft. telescopic antenna. Either one can be inserted at the top of the fitting, and clamped with the lock nut. Extra support for the antenna is afforded by two adjustable, insulated braces which are secured to the top plate over the loading coil.

The antenna is series-tuned on both frequencies. The upper section is for use with the No. 2, or higher, frequency, while the lower section is connected in series with the upper one, to tune the No. 1, or lower, frequency. Usually, the inductance of the upper coil must be adjusted for the higher frequency by removing turns from the top. In practice, it has been found that the adjustment of the lower coil has considerable reaction on the high-frequency adjustment, and a special procedure, explained below, must be followed.

Two variable condensers, built into the loading coil, are for fine tuning and for compensation of the capacity effect from the Bakelite tube. The screwdriver adjustments for these can be seen in Fig. 2. Both condensers should be set at approximately one-half capacity when the circuits are adjusted to resonance. For the benefit of those who are not acquainted with the procedure, it will be explained here.

Remove the Bakelite cover from the antenna coil and set both trimmer condensers at minimum capacity. Adjust the transmitter amplifier tank to resonance on frequency No. 2 with the coupling link inserted about half-way. Connect a 0–2.5 amp. RF ammeter across the terminals provided, after removing the shorting link.

Remove one turn at a time from the top of the upper loading coil, until a reading of about .75 amp. is obtained with the transmitter tank at resonance.

Adjust frequency No. 1 in the same manner. Return to frequency No. 2 and check the reading. The antenna should be somewhat closer to resonance. Rotate the upper trimmer condenser and observe the antenna current. If adding capacity throws the circuit further out of resonance, put the trimmer back to minimum capacity and remove one-half turn at a time until an antenna current of approximately 1.2 amps. flows with the transmitter tank at resonance.

Go back to frequency No. 1, and remove turns from the bottom of the lower coil until the antenna current reads approximately 1.5 amps. Switch to frequency No. 2, and recheck resonance by rotating the upper trimmer. The antenna should be still most nearly at resonance with the condenser at minimum.

Remove one-third of a turn at a time from the top of the upper coil until resonance is reached, and the antenna current begins to fall off again.

With the lower trimmer condenser about one-fourth enmeshed, resonate frequency No. 1 exactly, by removing turns from the bottom of the lower coil. Then, in a similar manner, adjust for resonance on frequency No. 2 with the upper trimmer condenser one-half enmeshed.

Finally, replace the Bakelite cover tube, and retune to exact resonance on each frequency by means of the trimmers. The ends of the wires must be soldered permanently to their respective connecting lugs.

When the adjustments have been completed in this particular case, the plate current on CW should be about 240 milliamperes, or 145 milliamperes in the phone position, representing power out-

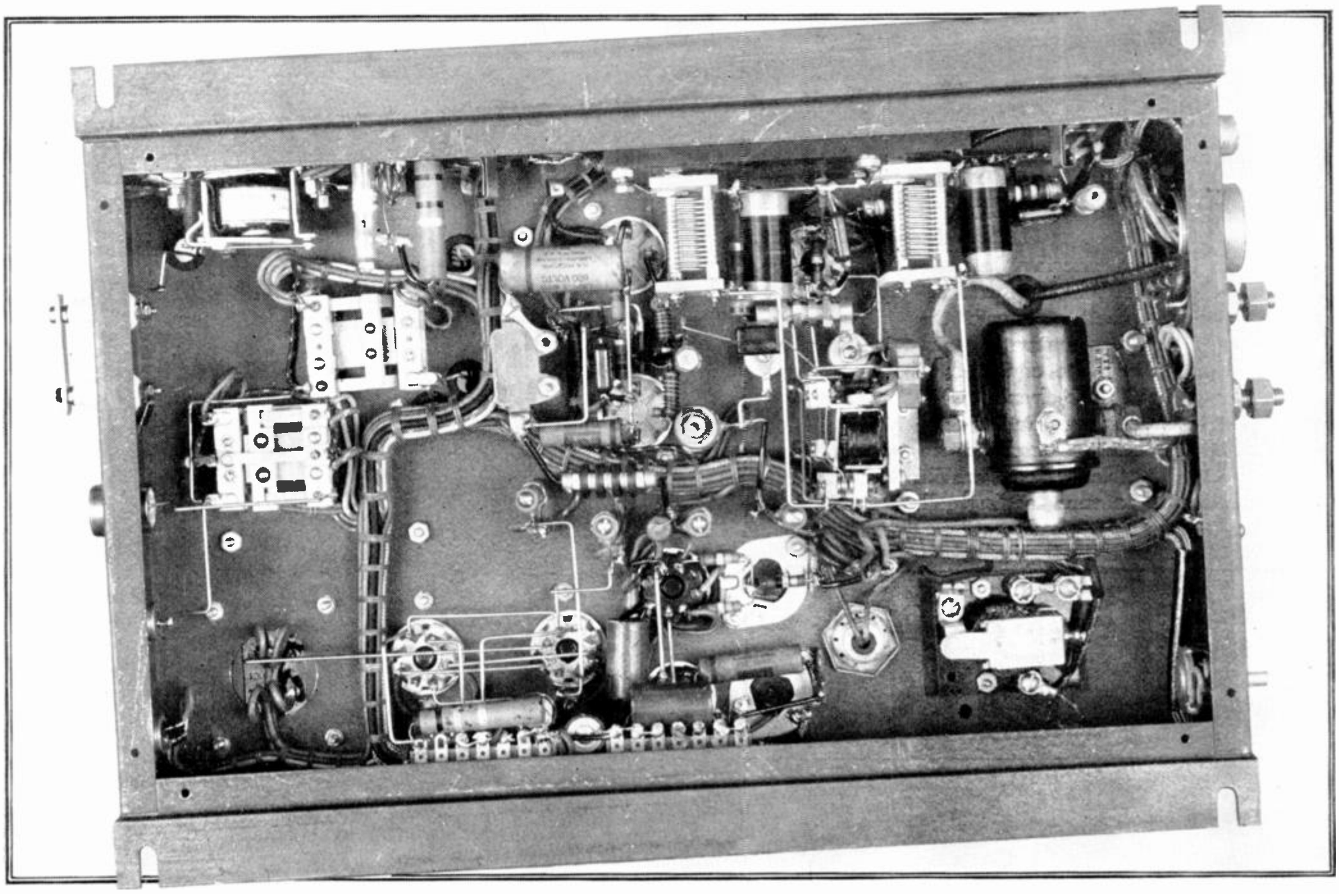


FIG. 9. UNDERSIDE OF THE TRANSMITTER CHASSIS. THE DESIGN IS VERY SIMPLE, WITH RELAYS MOST IN EVIDENCE

puts of 50 and 25 watts respectively. Dial locks must be tightened securely against vibration when the car is in motion.

Receiver Circuit ★ The receiver, Figs. 7 and 8, has one stage of RF amplification, a mixer oscillator stage, two IF stages, and a diode detector followed by two AF stages. Controls across the panel strip are: pilot light, 5-point frequency selector switch, an RF gain control, power and squelch switches, squelch control, volume control, and beat frequency oscillator switch.

The 6K8 mixer-oscillator tube uses a Pierce, or untuned, crystal-controlled oscillator. The 6B8 IF amplifier tube is arranged to operate also as an automatic volume control voltage source.

A type 6H6 duo-diode rectifier tube serves as a second detector and peak noise suppressor, while a 6C8G dual triode is used as the first audio amplifier and squelch tube. A second 6H6 rectifier, in conjunction with the squelch section of the 6C8G tube reduces the tendency for noise peaks to open the squelch. Final audio power amplifier is a 6K6G.

The operation of the squelch circuit is as follows: Under no-signal conditions, one triode of the 6C8G, operating without grid bias, draws plate current through a portion of the audio triode grid resistor, thus applying cut-off bias to the audio amplifier. When a signal is received, a negative voltage from the diode detector is applied to the squelch section of the 6C8G. This causes plate current to cease and removes the excessive grid bias from the audio amplifier. The action of this circuit is controlled by a switch and a potentiometer. The switch removes the squelch circuit entirely for CW operation of the receiver. The potentiometer controls the amount of signal input required to produce an audible signal in the output. This control should be set for the least value which will make the audio system inoperative with no signal received.

A 6C5 or a 6J5 triode is used as beat oscillator and is controlled by a switch which also shorts out the AVC circuit for CW reception. A radio frequency volume control is provided for CW reception. During phone reception, this control is left at maximum. A pair of terminals at the rear of receiver cabinet, and marked STANDBY cause the audio amplifier to become inoperative unless they are shorted. This feature allows the transmitter to be operated from a point adjacent to the speaker without danger of mechanical feed back to the microphone or the reception of undesirable dynamotor noises.

Fig. 7 shows the rear of the chassis, with a black shield box at the right. It contains the two sets of five condensers required for tuning the five different frequencies. Just at the left of this box are the five frequency-control crystals.

Both the receiver and transmitter were designed for greatest mechanical simplicity and electrical stability to assure continued performance under more severe conditions of use than are ordinarily encountered in mobile services. In these respects, and in ability to operate over very long distance, it has proved highly successful.

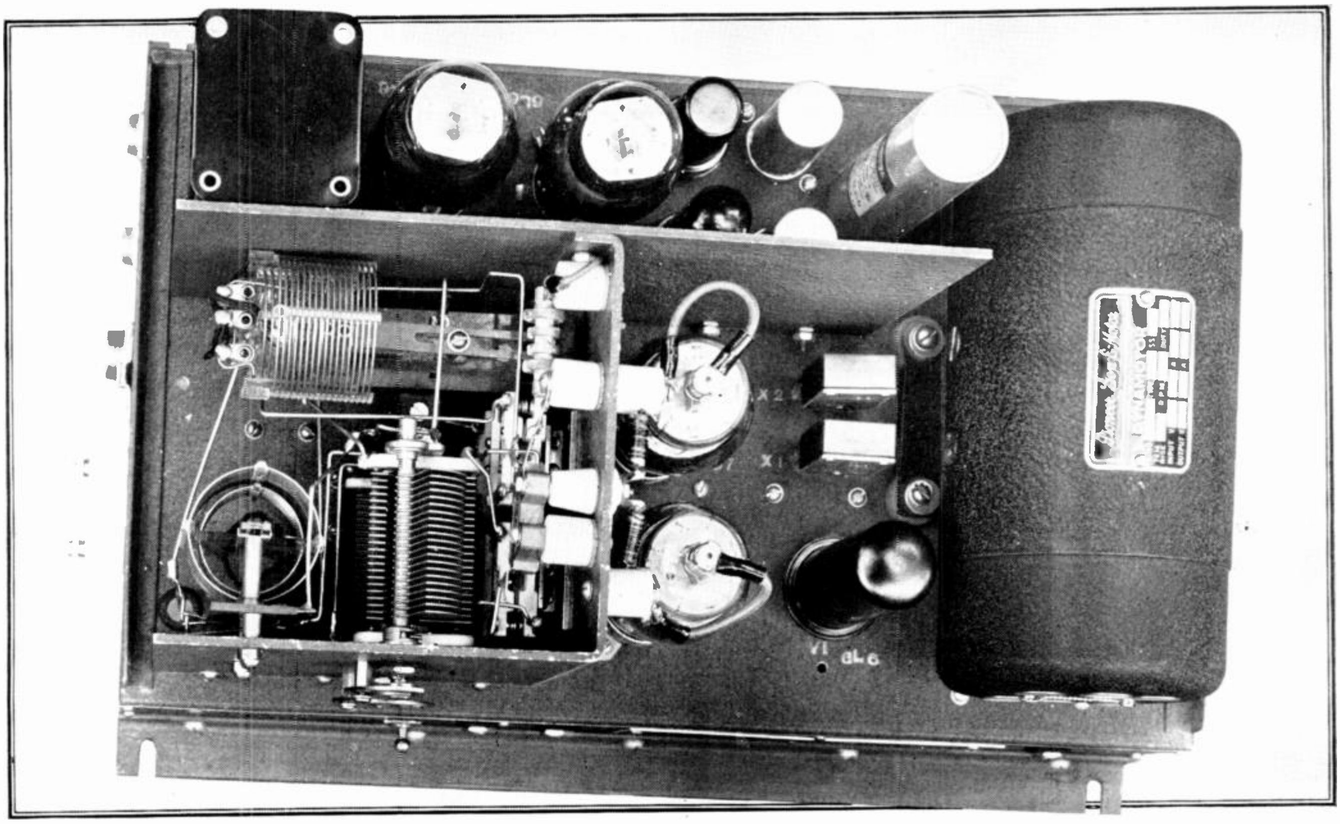


FIG. 10. HEAVY SHIELDING DIVIDES THE TRANSMITTER CHASSIS INTO THREE SECTIONS. NOTE THE HEAVY CONSTRUCTION

FM BROADCASTERS MEETING

A general meeting of FM Broadcasters, Inc. has been called for November 17th at the Drake Hotel in Chicago. Purpose of the meeting is to discuss the practicability of the present FCC method of assigning FM station coverage on the basis of square-mile trading areas. The matter of FM booster stations to supplement coverage will be taken up also.

Everett Dillard of Kansas City, Mo. is Chairman of the FMBI engineering committee.

A CORRECTION

In the review of REFERENCE DATA FOR RADIO ENGINEERS which appeared in our September issue, the price was given as $2.00. The publishers, Federal Telephone and Radio Corporation, have called our attention to the fact that the correct price is $1.00.

This error may have resulted from the impression in this office that, because of the value of the data presented in this volume, it is well worth the higher price to radio-electronics engineers.

PROPERTIES OF CELLULOSIC PLASTICS

Data on Cellulose Thermoplastic Compounds, and Comparisons with Thermoplastic and Thermosetting Resins

BY RALPH H. BALL*

IN DEALING with the development of new plastic applications for war production, there is a serious need for reliable information on the behavior of plastics. Part of this is due to the pioneering of new uses for plastics, but a substantial part is also due to the great number of new people who have had to deal with plastics and their properties for the first time — people who believe erroneously that they can use plastic physical property tables in the same way as tables of metal alloy properties — people who pore over charts and graphs and plastics comparators without the background of experience to interpret them — in short, people who need help.

It seemed to us that we could render a service at this time by discussing, in a simple and practical way, the properties of the cellulosic family of plastics in relation to each other and to other types of plastics.

The ramifications of the plastic industry have become so broad and complex that it is impossible to consider even a limited section of the industry, such as the cellulosic plastics, without circumscribing the scope of the discussion. The word *plastics* today is used very loosely to cover both elastomers and rigid plastics, and may even refer to surface coatings, and insulation binders. In the cellulosic family we are dealing only with rigid plastics, since none of the cellulose derivatives so far developed make satisfactory elastomers. Therefore, in evaluating the properties of the cellulosics among themselves, and their position competitively among other types of plastics, it is logical and necessary to limit ourselves to a discussion of rigid plastics.

From the viewpoint of both compounding and use there is quite a sharp line of demarcation between rigid plastics and elastomers. In terms of physical properties, we might define *rigid plastics* as those which require substantial force to deform them, and which show only a moderate deformation under the stress of usage. This would probably mean an elongation in tension of less than 100% and possession of an appreciable flexural strength. This is the type of plastic which the molder or fabricator must consider in deciding whether to use a cellulosic or some other plastic for his product, and it is, therefore, within this field that we will review the position and the properties of the cellulosic plastics.

Position of the Cellulosic Group ★ Production figures published on plastics usually lump together all their uses. They include not only the quantities used for plastic parts, but also such uses as surface coatings, impregnating compounds, binders for grinding wheels and brake blocks, plywood adhesives, and insulation varnishes. For this reason, the importance of the cellulosic family in the rigid plastic field is not generally appreciated. If these production figures are adjusted to cover only the field in which cellulosic plastics compete, namely, rigid plastics, we get an entirely different picture of the place occupied by the cellulosics.

The figures used to illustrate this point are based on the writer's personal estimate, made after checking available statistics. For the year 1943, it is believed that the production of cellulosic plastics will reach 75 to 80 million pounds. For the same period the production of all other rigid thermoplastics is expected to total 40 to 45 million pounds. The cellulosics, therefore, account for between 60 to 65% of the volume of rigid thermoplastics. If we extend this picture to include thermosetting plastics, the total of all rigid plastics this year will probably reach between 255 and 280 million pounds. The cellulosic plastics comprise approximately 30% of this total, being exceeded in volume only by the phenolics. Among the thermoplastics, therefore, the cellulosics are the largest by a wide margin, and they constitute an impressive percentage of the total rigid plastic production.

In proceeding to consider the properties of plastics, either within the cellulosic family, or between it and other types of plastics, general comparisons are not adequate. This is one of the major defects of plastics comparators, or tables of physical properties. For example, they do not show the reasons why cellulose acetate butyrate makes an excellent tube but has indifferent properties in the form of sheets, or why cellulose acetate propionate makes good film but has no particular value as a molding material. To make our comparison technically sound, we must go beyond the general properties of the plastics as they may appear in a table of physical properties, and consider factors not yet adequately described by precise test data. There are a number of ways in which the subject can be broken down to accomplish this purpose. One of the most practical, because it has some relation to use, is to consider separately each of the forms in which rigid plastics are supplied to the molder or fabricator, namely: sheets, rods and tubes, film, foil, and molding material.

Molding Material ★ Molding material presents a more complex picture than any of the other forms because of the variety of plastic products available. In the cellulosic field we have cellulose acetate, cellulose acetate butyrate and ethyl cellulose, each in a large series of compounds of varying properties. In the thermoplastic resin family we are dealing with methyl methacrylate, polystyrene, vinyl copolymer and vinylidene chloride. In the thermosetting resin group there are phenol formaldehyde, urea formaldehyde and melamine formaldehyde. Because of the breadth of this field, only the major points of similarity and difference will be dealt with in the discussion which follows.

It can be truly said that the cellulosics are the backbone of the injection and extrusion molding industry in this country. The technical reasons which account for this position are summarized in the following paragraphs.

In the first place, the cellulosics are the toughest of all plastics. This permits the molding of parts with sections much thinner than can be tolerated in other types of plastics. It is because of their toughness that cellulosic parts will stand a great deal of abuse without failure. In comparing the toughness of cellulosics with other plastics, we are handicapped by the lack of a good measuring stick. Neither tensile nor impact tests provide adequate figures for estimating the toughness of a plastic. It is a property which depends to some extent on the ability of the material to elongate and flex without permanent deformation, but other factors are also involved, and the problem of a test method has not been solved. Since we are without figures for expressing toughness, comparisons between the different materials will have to depend on practical experience based on use. Vinyl copolymer probably comes nearest to equalling the cellulosics in toughness. Vinylidene chloride is in the same range as vinyl copolymer at normal temperature, but its brittleness at reduced temperatures must be kept in mind in its toughness rating. Methyl methacry-

*Assistant Technical Director, Plastics Division, Celanese Corporation of America, Newark, N. J. From a paper delivered at the fall meeting of the Society of the Plastics Industry.

late is still lower down the toughness scale, and polystyrene and the thermosetting moldings are at the bottom.

A second factor responsible for the wide use of cellulosic molding compounds is the great variety of formulations available. Special requirements in physical properties, special problems in mold design, and peculiar machine conditions can usually be met by proper selection of compound. This simplifies the problem of adapting the molding compound to the job and results in a molding operation that runs smoothly and rapidly. None of the resinous plastics offers such a variety of compounds. A comparatively wide selection is available in the phenolics, but most of the other resins are produced only in two or three variations. This frequently leads to difficulties in designing the job for the plastics, since the plastic cannot be changed to adapt it to the job.

A third factor in the popularity of cellulosic molded parts is the range of colors available. Clear and colored transparents, mottles, translucents, pastels and opaque colors are all available in a complete range. Only two of the resinous plastics, methyl methacrylate and polystyrene, have a better basic clarity and freedom from color than the cellulose derivatives. This permits more delicately colored transparents, translucents, and pastels in these two plastics. However, none of the resinous plastics can be produced with the range of color effects available in cellulosic moldings. This is a particularly serious handicap in the case of the phenolic moldings, where the color range is limited and dull. Color has always been, and will probably continue to be, a very important factor in the use of plastics.

It should always be remembered that none of our present plastics is perfect. In selecting a material for a part, both the strong points and limitations must be examined in the light of the requirements for the job. Cellulosic plastics, like all others, have their limitations.

The most important limitation to consider is the fact that the cellulosics are thermoplastics. This is an important advantage, since by virtue of it they can be injection and extrusion molded and, thus, compete in cost per part with lower priced compounds which must be compression molded. However, their thermoplasticity means that cellulosic molded parts cannot be used at temperatures above their softening point. The same limitation, of course, applies to the resinous thermoplastics. Maximum temperatures permissable for the use of cellulosic molded parts vary in general from 150 to 215 deg. F., and follow the flow temperature of the molding compound rather closely. The same limits in general hold for the resinous thermoplastics, with the exception of vinylidene chloride, which has somewhat better heat resistance than the average cellulosic compound, and vinyl copolymer, which has lower heat resistance than most cellulosics. Where high temperature resistance is required, thermosetting plastics must be used, the phenol formaldehyde plastics being outstanding in this respect, with melamine formaldehyde a good second.

A second limitation which must be kept in mind in using cellulosic moldings is susceptibility to moisture. Although this varies in degree among the three cellulosic molding materials, as will be pointed out later, it is a characteristic of all of them. This manifests itself in two ways. In the softer flowing compounds it results in warpage of the molded part under humid conditions. In all cellulosic compounds it results in some change in the dimensions of the part with variations in humidity. Warpage can usually be overcome by proper selection of compound, and can also be minimized by care in the design of the part. Modern molding equipment can handle the harder flowing compounds with ease, and the use of such compounds will usually overcome warpage. Expansion and contraction with humidity change in cellulosic parts is normally small enough to present no obstacle in the majority of uses. It can usually be accommodated by making proper allowance in the design of the part. Where this cannot be done, the only recourse is to use one of the resinous plastics. All of them, with the exception of urea formaldehyde, are less sensitive to moisture than the cellulosics.

RADIO engineers and designers are coming more and more into contact with cellulosic plastics under the names of Lumarith (cellulose acetate), Celluloid (celluloid nitrate), Lumarith CAP (cellulose acetate propianate), Lumarith Ten (high acetyl cellulose acetate), and Lumarith E.C. (ethyl cellulose). These trade names apply to products of the Celanese Celluloid Corporation.

Some applications of these relatively new materials are as substitutes for those with more familiar names. Others are new applications peculiar to the new materials.

In this paper, Dr. Ball sorts out chemical names that are strange to the radio industry, and assigns them to their proper places in the scheme of molded parts, sheets, rods, and tubes for structural and insulating purposes.

His presentation of the subject is excellent for both study and reference purposes.

A third weakness in cellulosic plastics is lack of resistance to inorganic acids and alkalies. Of the cellulosic molding materials, ethyl cellulose is much more resistant than cellulose acetate or acetate butyrate. None of them compare with the resinous plastics in this respect. It should be pointed out, however, that all of the cellulosics are satisfactorily resistant to the milder organic acids.

An additional point which merits discussion, and which frequently is of more importance than resistance to acids and alkalies, is resistance to solvents. Although it is impossible to generalize on such a subject, some rough comparisons may be of value. Of the cellulosic plastics, cellulose acetate is the most solvent-resistant. It is not attached by aliphatic hydrocarbons such as oils and gasoline, and its resistance to aromatics and chlorinated hydrocarbons varies from good to fair, depending on the solubility of the plasticizer. Attack by chlorinated hydrocarbons and aromatics increases as we proceed through cellulose acetate propionate and cellulose acetate butyrate to ethyl cellulose. The latter has a broad range of solubility, but is still not attacked by straight chain hydrocarbons. Among the resinous plastics, the thermosets are unaffected by most solvents, being superior to all other plastics in this respect. Vinylidene chloride and vinyl copolymer are generally more resistant to solvents than the cellulose esters. Methyl methacrylate is somewhat similar to the cellulose esters, while polystyrene is more widely soluble and resembles ethyl cellulose in this respect.

While the comparisons made above between the cellulosics and the resins are valid for the cellulosic molding materials as a group, there are, nevertheless, individual differences in properties within the group which will influence the selection of compound for a particular job. A discussion of these differences may very well follow the listing of advantages and limitations used above.

With respect to toughness, ethyl cellulose is outstanding among the cellulosic molding materials. This holds at normal temperatures, and is particularly evident at reduced temperatures. Cellulose acetate and acetate butyrate are pretty much equal in toughness if proper adjustment is made in flow temperature. In general, the flow temperature of a cellulose acetate butyrate compound must be two to three steps softer than cellulose acetate to have the same toughness. For example, to equal the toughness of a H flow cellulose acetate, an MS cellulose acetate butyrate would need to be used. While this permits of lower molding temperatures, it will usually result in a lower heat distortion point for the cellulose acetate butyrate molding.

With regard to the variety of formulations which may be provided, all three of these cellulosics may be considered equal. Ethyl cellulose, being the newest, is not yet available in as complete a series of compounds as the other two, but it is capable of an even wider range of formulations.

On the subject of colors, there are some differences between these three cellulosics which may be noted. All are capable of the same types of color variation. However, cellulose acetate has the best basic color and clarity, and can, therefore, be converted into more delicate and brilliant colors. Cellulose acetate butyrate is a close second in this respect. Ethyl cellulose, because it is new, has the poorest color and clarity of the three, by a considerable margin. Nevertheless, we already have assurance from developments now in progress, that the color and clarity of ethyl cellulose will be greatly improved, and have every expectation that before long its color will be as good as the other cellulose derivatives.

Cellulose acetate and acetate butyrate are approximately equal in the maximum service temperatures which they will withstand. It is too soon yet to say that ethyl cellulose will excel them in this respect, but it can be said that, in a compound of equal flow, ethyl cellulose will stand a higher temperature without distortion.

There are also differences between these three cellulosics in moisture sensitivity. It is important to note that these differences cannot be predicted from water absorption data, especially where humidity warpage is involved. It is not the amount of water absorbed that matters, but the effect of this water on the molded part.

The comparison in warpage between cellulose acetate and acetate butyrate in the harder flow ranges has approximately the same relation to flow as indicated in discussing toughness. To give the same resistance to warpage, a cellulose acetate molding compound must be two or three steps harder in flow than the corresponding cellulose acetate butyrate. For example, an H_3 flow in acetate will equal an H flow in butyrate, or an H_5 will equal an H_2. Below MH flow in cellulose acetate, or MS flow in cellulose acetate butyrate, neither product has good resistance to humidity warpage. In this respect ethyl cellulose moldings are superior to both these cellulose esters by a considerable margin. For example, ethyl cellulose parts in MS flow have successfully withstood wet heat exposures of 100% humidity at 175 deg. F., which will distort either H_2 acetate butyrate or H_5 cellulose acetate.

The other manifestation of moisture sensitivity, namely, humidity expansion, also shows differences between these three cellulosics. The smallest dimensional change is found with ethyl cellulose, with cellulose acetate butyrate a close second. Cellulose acetate parts have considerably more expansion and contraction with humidity change. If these factors are appreciated by the designer of the plastic part, they can usually be allowed for, and are no obstacle to the use of any of these plastics for most applications.

In acid and alkali resistance cellulose acetate and acetate butyrate are similar. Neither has satisfactory resistance to alkalies or mineral acids, although cellulose acetate butyrate will stand considerably longer exposure than cellulose acetate. Both will perform satisfactorily in contact with organic acids such as fruit acids. Ethyl cellulose, on the other hand, is a substantial improvement in this respect. Its alkali resistance is good, and it has better acid resistance than is generally credited to it.

There are many other properties of lesser importance which might be brought out in comparing these three cellulosic molding materials among themselves, and with the resinous molding compounds. However, the above are believed to be the principal factors which should be considered in selecting the proper type of plastic for a molding job.

Sheets ★ In turning to the consideration of sheets, it is found that the general physical property requirements differ sufficiently from those of molding materials to call for a different selection of plastics. Because sheet uses demand thinner sections than moldings, freedom from brittleness is of great importance, and stiffness becomes a major factor. The high thermal decomposition point necessitated by the molding process is also reduced. For these reasons we find the selection of plastics materials for sheets confined to cellulose nitrate, cellulose acetate, cellulose acetate propionate, vinyl copolymer, methyl methacrylate and phenolic.

For years cellulose nitrate was the outstanding sheet material, and it is still a very important one. It provides a combination of stiffness and freedom from brittleness which no plastic material, cellulosic or otherwise, has ever equaled. Its ability to remain flat with age, its resistance to moisture and acids, and the ease with which it can be fabricated, are all strong points in its favor as a sheet material. Its limitations are well known, namely: inflammability, low heat distortion point, and discoloration on outdoor exposure. The way in which cellulose nitrate sheet production has been maintained, in spite of these serious limitations, is the best evidence of the value of its outstanding properties.

The sheet which combines the strong points of cellulose nitrate without its disadvantages is cellulose acetate. Burning rate and heat distortion point of cellulose acetate sheets are entirely satisfactory for most uses, and their light stability is excellent. Toughness and freedom from brittleness are outstanding properties, although cellulose acetate does not quite equal cellulose nitrate in its optimum combination of stiffness with freedom from brittleness. Cellulose acetate sheets have greater expansion and contraction with humidity change than cellulose nitrate, and this must be allowed for in mounting sheets of large area, such as those used in aircraft glazing. Except for greater sensitivity to humidity, and slightly less stiffness or snap, cellulose acetate sheets duplicate the major advantages of cellulose nitrate, without the disadvantages of the latter.

Cellulose acetate propionate sheets have been produced in small quantities, and represent a compromise in properties between cellulose acetate and cellulose nitrate. They are equal to the former in stability to light and heat, and in non-inflammability. They are equal to the latter in lack of moisture sensitivity. This has been accomplished, however, at the expense of stiffness, where cellulose acetate propionate sheets are not quite the equal of cellulose acetate. Cellulose acetate butyrate is still lower on the stiffness scale, to the point where it is not attractive as a general sheet material.

Ethyl cellulose sheet stock made by the block pressing method is not yet a commercial item. There is every indication, however, that there will be a demand for it, and that it will be produced. The outstanding properties expected in it are: toughness, especially at low temperatures, and lack of humidity sensitivity over a wide temperature range.

One point which should be emphasized in connection with the above review is the relation between processing method and colorability. Of all plastics, the cellulosics are the only ones which have been found amenable to the block pressing and slicing method of manufacture. This method permits infinitely greater color variation than any other processing technique. The great variety of exact configurations, the duplication of marbles and precious stones which have made cellulose acetate and cellulose nitrate sheet products synonymous with beauty in color, can be produced only by the block pressing method. This advantage, possessed only by the cellulosic family, should not be underestimated.

In the resinous plastic group there are two thermoplastics available in sheet form, namely, methyl methacrylate and vinyl copolymer. In their properties they differ widely from one another and from the cellulosic plastics. They are both stiffer than any cellulosic sheet. They are also both more brittle than any cellulosic sheet, a limitation which is especially true of methyl methacrylate. Moreover, because of the methods used in their manufacture, their colorability is practically limited to plain colors.

Methyl methacrylate, because of brittleness, cannot be produced or handled economically in gauges below 40 mils, and serious breakage results even with 60 mil sheets. In heavier gauges, however, methyl methacrylate sheet has several virtues which offset this weakness, and account for its use on a large scale, especially in aircraft glazing. Its major advantages are color, clarity, moisture resistance, and good weathering characteristics. Its heat distortion point is quite good for a thermoplastic. Its abrasion resistance is fair, being poorer than that of cellulosic sheets. A decision regarding its use would be determined largely by balancing the color, clarity and weather resistance required against the brittleness which could be tolerated in the particular application.

Vinyl copolymer sheets, although substantially more brittle than cellulosics, are less brittle than methacrylate, and are still

(CONTINUED ON PAGE 35)

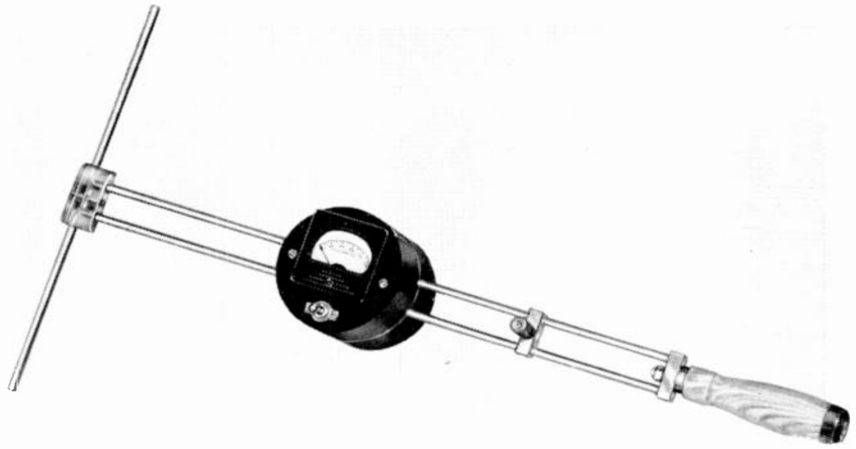


FIG. 1. ERCO RESONANCE METER DESIGN IS SUITED TO LABORATORY AND FIELD USE

RADIO DESIGNERS' ITEMS

Notes on Methods and Products of Importance to Design Engineers

Resonance Indicator: A very convenient piece of measuring equipment is the Erco type MW-60 resonance meter, Fig. 1. This is designed to meet the need of determining resonance accurately in oscillators and transmitters, for standing-wave ratios, transmission lines, antenna systems, tank circuits, coupling devices, and modulation indication.

Because of its rugged construction, it is also suited to use in the field where resonance measurements must be made on absolute altimeters, blind landing markers, glide path markers, airport traffic control transmitters, and also for broadcast relay equipment.

Fixed Resistance Standards: The American Standards Association has completed a new war standard for fixed composition resistors, identified as C75.7 — 1943.

The data presented represents the first agreement that has been reached between users and manufacturers of resistors as to what the performance characteristics of general-purpose fixed resistors should be.

Standard specifications now set forth the performance requirements, test methods, standard dimensions, standard resistance values, and ratings for fixed composition resistors for non-specialized applications.

This data is of value to designers of radio-electronics equipment both because its use will facilitate procurement and service in the field as well. The standard has been approved by the Army and Navy for equipment for the Signal Corps and the Bureau of Ships.

Copies of the standard can be obtained at a price of 60c from the American Standards Association, 29 West 39th Street, New York City 18.

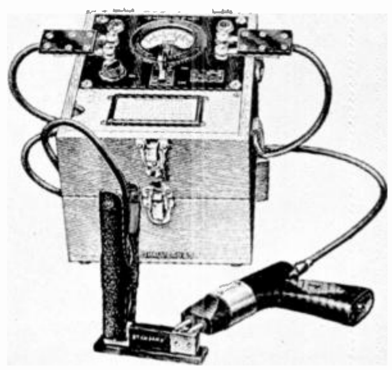


FIG. 2. SHALLCROSS RESISTANCE METER

Low-Resistance Measurements: Low-resistance test sets, type 645 (Army range) and type 653 (Navy range), featuring complete portability and greater ease and speed of operation, have been brought out by Shallcross Mfg. Company, Collingdale, Pa.

Bond or contact resistance measurements as low as .0001 ohm can be made by attaching the fixed clamp to one side of the bonded surface and touching the hardened points of the pistol grip exploring probe to the other side.

In addition to their widespread use in testing aircraft bonding, these test sets are used to test railroad bonds, radio equipment, contact resistance of relays, circuit breakers, and switches.

Range of the Army type is 0.005 and 0.5 ohm full scale, and of the Navy type, 0.003 and 0.3 ohm full scale. A descriptive catalog is available on request.

Name Plates: Name plates for military equipment are, in most cases, specified to be made of phenolic material. However, there is a catch to this which has caused some contractors much trouble and loss of time.

If specifications call for a fabric-base material, there are only certain approved sources from which such material can be obtained. In one recent case, a manufacturer of phenolic name plates accepted an order for plates to be made from drawings which called for fabric base material.

Subsequently, when it was found that fabric-base material had not been used, the supplier countered with the claim that the material had been approved by the Signal Corps. The answer to that, of course, is that the Signal Corps does not issue any blanket approvals. Moreover, it happens frequently that Ft. Monmouth may approve something, but the Aircraft Radio Laboratory may reject it. This works the other way, too. And they may both be in disagreement with the Naval Research Laboratory.

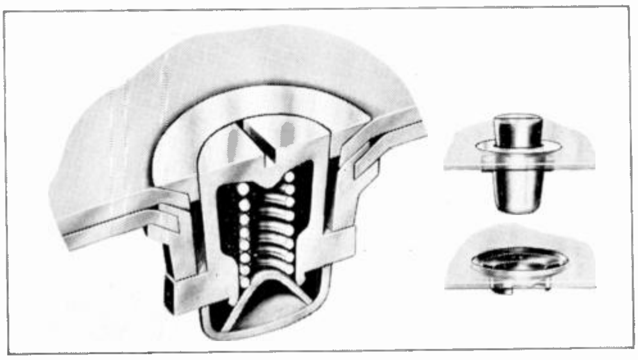


FIG. 3. SIMLOCK FASTENER, FOR SECURING REMOVABLE PANELS, PRESENTS A SMOOTH AND ATTRACTIVE APPEARANCE ON RADIO EQUIPMENT

Panel Fasteners: The new Simlok fastener for panels and plates on radio equipment is illustrated in Fig. 3. The special feature of this device is that when it is tightened the load is not carried by the spring, but by hardened steel lugs. Thus the spring is only required to hold the two parts of the fastener in a locked position.

Since the stud is self-ejecting, it serves as a signal that it is unlocked. This is sometimes important, for covers on mobile equipment are sometimes put in place but left unfastened because there is nothing to indicate that they are loose. The stud is held by the outer sheet, and cannot be lost.

ORGANIZATION OF THE THIRTEEN RTPB PANELS

ORGANIZATION of the thirteen panels of the Radio Technical Planning Board which will study the various problems of postwar radio has been nearly completed at this time of writing. The chairmen and vice chairmen are:

SPECTRUM UTILIZATION: Chairman, Dr. Alfred N. Goldsmith, 580 Fifth Avenue, New York City; vice chairman, Dr. R. H. Manson, Stromberg-Carlson Telephone Company, Rochester.

FREQUENCY ALLOCATION: Chairman, Dr. C. B. Jolliffe, RCA-Victor Division, Camden, N. J.; vice chairman, F. M. Ryan, American Telephone & Telegraph Company, 195 Broadway, New York City.

HIGH FREQUENCY GENERATION: Chairman, Roger M. Wise, Sylvania Electric Products, Inc., 500 Fifth Avenue, New York City; vice chairman, H. F. Argento, Raytheon Production Company, Waltham, Mass.

STANDARD BROADCASTING: Chairman, H. S. Frazier, National Association of Broadcasters, 1760 N Street, N.W., Washington, D. C.; vice chairman, Burgess Dempster, Crosley Corporation, Cincinnati, O.

VHF BROADCASTING: Chairman, G. E. Gustafson, Zenith Radio Corp., 6001 Dickens Ave., Chicago; C. M. Jansky, Jr., Jansky & Bailey, National Press Building, Washington, D. C.

TELEVISION: Chairman, D. B. Smith, Philco Corporation, Philadelphia; vice chairman, I. J. Karr, General Electric Company, Bridgeport, Conn.

FACSIMILE: Chairman, John V. L. Hogan, 730 Fifth Avenue, New York City; vice chairman, C. J. Young, RCA-Victor Division, Camden, N. J.

RADIO COMMUNICATION: Chairman, Haraden Pratt, Mackay Radio & Telegraph Company, 67 Broad Street, New York City.

RELAY SYSTEMS: Chairman, E. W. Engstrom, RCA Laboratories, Princeton, N. J.; vice chairman, Dr. Ralph Bown, Bell Telephone Laboratories, 463 West Street, New York City.

RADIO RANGE, DIRECTION, AND RECOGNITION: Chairman, W. P. Hilliard, Bendix Radio Corporation, Baltimore, Md.; vice chairman, C. G. Frick, General Electric Company, Schenectady, N. Y.

AERONAUTICAL RADIO: Chairman, J. C. Franklin, Director of Communications, Transcontinental Western Airlines, Kansas City, Mo.

INDUSTRIAL, SCIENTIFIC AND MEDICAL EQUIPMENT: Chairman, C. V. Aggers, Westinghouse Electric & Manufacturing Company, Baltimore, Md.; vice chairman, H. B. Marvin, General Electric Company, Schenectady, N. Y.

POLICE, EMERGENCY SERVICES: Chairman, Prof. D. E. Noble, Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago; vice chairman, Frank Walker, Intl. Assn. of Chiefs of Police, c/o Michigan State Police, Detroit.

PROPERTIES OF CELLULOSIC PLASTICS

(CONTINUED FROM PAGE 32)

tough enough for a good many uses. Their combination of stiffness with reasonable freedom from brittleness is one of their principal assets. Excellent water and chemical resistance are also strong points of vinyl copolymer sheets. Their major weaknesses are low heat distortion point and discoloration on exposure to ultra violet light.

In addition to these thermoplastic sheets, there is one important thermoset sheet, namely, laminated phenolic. This sheet is much more brittle than any cellulosic sheet. It cannot be heat formed and fabricated by the easy means adaptable to thermoplastics. Nevertheless, it has widespread and important use, especially in industrial equipment, because of its form stability, its resistance to moisture and chemicals, and its ability to withstand high temperatures.

Rods and Tubes ★ In considering rods and tubes in the same way as we have sheets, the first point to note is that we have a wider selection of resinous plastics and a different selection of cellulosics.

In the cellulosic rods and tubes, there is production in cellulose nitrate, acetate, and acetate butyrate, and in ethyl cellulose. No cellulose acetate propionate rods are being made, their place having been taken by cellulose acetate butyrate. The lack of stiffness of cellulose acetate butyrate is not as important a factor in rods and tubes as in sheets, because the heavier cross-sections provide more rigidity.

With the above exception, the same basic points of comparison discussed under sheets hold for rods and tubes. For combined toughness and rigidity cellulose nitrate has no equal. Its hold on the tool handle business is a good example of this. Next to cellulose nitrate in combining toughness with stiffness is cellulose acetate. Cellulose acetate butyrate is less stiff than cellulose acetate, but is less affected by variation in humidity. For freedom from brittleness at low temperature, ethyl cellulose is again outstanding.

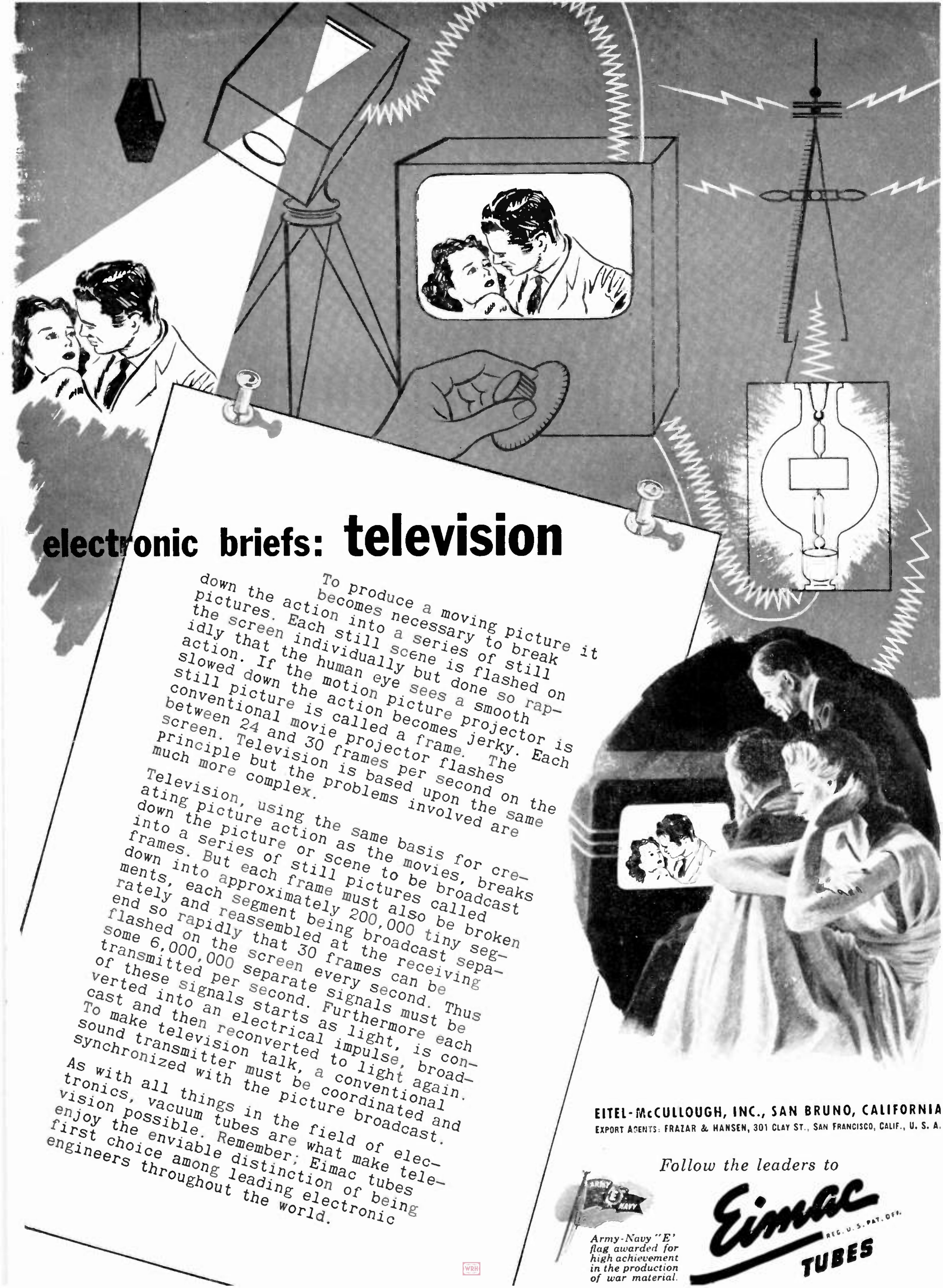
There are three general processes for the production of cellulosic rod and tube, which affect the color combinations which can be attained. The block pressing method, similar to that used for sheets, permits great variety and exact configuration of color. Only cellulose nitrate and cellulose acetate rods and tubes are now made by this method. The dry extrusion process gives solid colors. Cellulose acetate, cellulose acetate butyrate and ethyl cellulose rods and tubes are made by dry extrusion. Therefore, if color is a factor, these processing variations must be kept in mind in selecting rod and tube material.

Resinous plastic rods and tubes may be obtained in methyl methacrylate, polystyrene, vinyl copolymer, vinylidene chloride and phenolic. Of these the phenolics are made by laminating, and the others by extrusion. In dealing with sheets, a comparison has already been made between the cellulosic plastics and methyl methacrylate, vinyl copolymer and phenolics. The same comparisons hold for rods and tubes.

Neither polystyrene nor vinylidene chloride were covered in the discussion on sheets. Both appear to be specialty materials when it comes to rods and tubes. Polystyrene rod has been produced in small quantity, principally for special uses in the electrical field. Among the rigid plastics, it is outstanding in its low power factor at high frequency. It also has high clarity and good color, and excellent resistance to water, acids and alkalies. Its principal limitation is brittleness. The chemical and water resistance of vinylidene chloride tubing has led to its use as industrial pipe, where its color limitations and brittleness at low temperatures are not serious handicaps. The necessity for using special alloys in extruding it has also retarded its general application.

Before concluding this discussion, it may be well to point out that in making the comparisons and drawing the conclusions at least as much weight has been given to practical experience and performance in the field as to physical test data. This has been done for two reasons. In the first place, we must admit that the interpretation of physical data has fallen away behind practical information on the utilization of plastics. A great deal of fundamental study on the physics and engineering of plastics remains to be done before theory catches up to practice. In the second place, considering all the various plastic forms, and the different problems and requirements of each, the picture grows so complex that it is impossible to condense the information into any concise set of charts or tables which will properly summarize even the data presented in this paper. When it is considered that this data is in itself only a review, and leaves much detail untouched, the complexity of the problem becomes apparent.

From the comparisons drawn in this discussion, we have seen that the cellulosic plastics occupy a large and important place in the field of rigid plastics. Their two chief limitations of temperature and humidity sensitivity are more than offset, in many applications, by their advantages. Their position of importance is merited by their toughness, by the variety of formulations in which they are supplied, by the ease with which they can be manufactured into finished articles, and by the range of color effects which can be produced.


electronic briefs: television
To produce a moving picture it becomes necessary to break down the action into a series of still pictures. Each still scene is flashed on the screen individually but done so rapidly that the human eye sees a smooth action. If the motion picture projector is slowed down the action becomes jerky. Each still picture is called a frame. The conventional movie projector flashes between 24 and 30 frames per second on the screen. Television is based upon the same principle but the problems involved are much more complex.
Television, using the same basis for creating picture action as the movies, breaks down the picture or scene to be broadcast into a series of still pictures called frames. But each frame must also be broken down into approximately 200,000 tiny segments, each segment being broadcast separately and reassembled at the receiving end so rapidly that 30 frames can be flashed on the screen every second. Thus some 6,000,000 separate signals must be transmitted per second. Furthermore each of these signals starts as light, is converted into an electrical impulse, broadcast and then reconverted to light again. To make television talk, a conventional sound transmitter must be coordinated and synchronized with the picture broadcast.
As with all things in the field of electronics, vacuum tubes are what make television possible. Remember; Eimac tubes enjoy the enviable distinction of being first choice among leading electronic engineers throughout the world.
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DIRECTORY OF MANUFACTURERS & ENGINEERS

Companies and Engineers Engaged in the Manufacture of Radio and Associated Equipment, Laboratory Apparatus, Components, Materials, Supplies, Molded Parts, and Production Machines

THIS is the most complete Directory of Manufacturers and Engineers ever published. Names of Engineers are omitted only because they were not furnished after two requests. This Directory will be published again in April, 1944, with revisions and additions, to keep it up-to-date. We expect that the listings of Engineers will be more complete at that time.

Following are the abbreviations used to indicate the official titles of the Engineers:

CAF—Chief Engineer in Charge of Transformers
CAN—Chief Engineer, Aerial Navigation
CC—Carrier Current Engineer
CCP—Chief Engineer, Communications Products
CDF—Chief Engineer, Direction Finders
CE—Chief Engineer
CEA—Chief Acoustical Engineer
CED—Chief Development Engineer
CEE—Chief Electrical Engineer
CEL—Chief Electronics Engineer
CEM—Chief Mechanical Engineer
CEP—Chief Products Engineer
CER—Chief Radio Engineer
CES—Chief Design Engineer
CEX—Chief Experimental Engineer
CQ—Chief Engineer in Charge of Quartz Crystals
CR—Chief Engineer, Receivers
CRE—Chief Research Engineer
CRF—Chief Engineer, RF Division
CT—Chief Engineer, Transmitters
DE—Director of Engineering
EC—Condenser Engineer
EE—Engineer in Charge of Electrolytic Condensers
IE—Microwave Engineer
ME—Engineer in Charge of Mica Condensers
PE—Engineer in Charge of Paper Condensers
RA—Radio Engineer
RD—In Charge of Research and Development
RE—Receiver Engineer
RES—Research Engineer
SE—Senior Electrical Engineer
SP—In Charge of Special Products
TD—Technical Director
TE—Transmitter Engineer
TO—In Charge of Towers
VE—Engineer in Charge of High-Voltage Condensers
XE—Experimental Engineer

MANUFACTURERS

— A —

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Ace Mfg. Corp., 1255 E. Erie Ave., Philadelphia 24, Pa.
Acme Elec. & Mfg. Co., Cuba, N. Y.
Acme Elec. Heating Co., Boston, Mass.
Acme Wire Co., New Haven, Conn.
Advance Elec. Co., 1260-A W. Second St., Los Angeles, Calif.
Advance Recording Prods. Co., Long Island City, N. Y.
Aero Electric Corp., Los Angeles, Calif.
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Allied Radio Corp., 833 W. Jackson Blvd., Chicago, Ill. L. M. Dezettel (CE)
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Aluminum Co. of America, Pittsburgh, Pa.
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American Brass Co., Waterbury, Conn.
American Coils Co., 26 Lexington St., Newark, N. Y.
American Communications Corp., 306 Broadway, N. Y. C.
American Condenser Corp., 2508 S. Michigan Ave., Chicago, Ill.
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Amer. Elec. Heater Co., 6110 Cass Ave., Detroit, Mich.
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Amer. Hardware Co., 476 Broadway, N. Y. C.
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American Steel & Wire Co., Rockefeller Bldg., Cleveland, O.
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Amplifier Co. of America, 398 Broadway, New York 13, N. Y. N. M. Haynes (CE)
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Atlas Condenser Products Co., 548 Westchester Ave., N. Y. C.
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Audio Devices, Inc., 1600 Broadway, N. Y. C.
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Auto-Engraver Co., 1776 Broadway, N. Y. C.
Automatic Electric Co., 1033 Van Buren St., Chicago, Ill. K. W. Graybill (CE)
Automatic Winding Co., Inc., Harrison, N. J. J. R. Mazzola (CE)
Avery Adhesives, 451 Third St., Los Angeles, Calif.
Avia Prods. Co., 737 N. Highland Ave., Los Angeles, Calif.

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Bausch & Lomb Optical Co., Rochester, N. Y.
Bakelite Corp., 30 E. 42nd St., N. Y. C.
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Belden Mfg. Co., 4673 W. Van Buren St., Chicago, Ill.
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Benwood Linze Co., 1815 Locust St., St. Louis, Mo. Carl E. Peters (CE)
The Thomas & Betts Co., 36 Butler St., Elizabeth, N. J. C. A. Badeau (CE)
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Bird, Richard H., Waltham, Mass.
Birnback Radio Co., 145 Hudson St., N. Y. C.
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Black & Decker Mfg. Co., Towson, Md.
Blaw-Knox Company, Pittsburgh, Pa.
Bliley Electric Co., Union Sta. Bldg., Erie, Pa. J. M. Wolfskill (CE)
Blum & Co., Inc., Julius, 532 W. 22nd St., N. Y. C.
Bodine Elec. Co., 2254 W. Ohio St., Chicago, Ill. C. A. Rall (CE)
Boonton Radio Corp., Boonton, N. J.
Boots Aircraft Nut Corp., New Canaan, Conn.
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Boston Insulated Wire & Cable Co., Boston, Mass.
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Brach Mfg. Corp., Newark, N. J.
Brainin Co., 233 Spring St., New York 13, N. Y. C. S. Brainin (CE)
Brand & Co., Wm., 276 Fourth Ave., N. Y. C.
Brandywine Fibre Prods. Co., Wilmington, Del.
Breeze Mfg. Corp., Newark, N. J.
Brilhart Co., Arnold, Great Neck, N. Y.
The Bristol Co., Waterbury, Conn. L. G. Bean (CE), J. W. Peckham (RD), J. R. Waidelich (SP)
Arthur Brown & Bro., 67 W. 44th St., N. Y. C.
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Bud Radio, Cleveland, O.
J. H. Bunnell & Co., 81 Prospect St., Brooklyn 1, N. Y. Devereaux Martin (CE)
Bunting Brass & Bronze Co., Toledo, O.
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Burstein-Applebee Co., Kansas City, Mo.
Burton-Rogers Co., 857 Boylston St., Boston, Mass. V. S. Church (CE)

— C —

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Cambridge Thermionic Corp., Concord Ave., Cambridge, Mass.
Camburn Products Co., 490 Broome St., N. Y. C. Robert Lahn (CE)
Camfield Mfg. Co., 718 N. Seventh St., Grand Haven, Mich. Robert Harry Lilyblad (CE)
Camloc Fastener Co., 420 Lexington Ave., N. Y. C.
Cannon Co., C. F., Springwater, N. Y.
Cannon Elec. Devel. Co., 3209 Humboldt, Los Angeles, Calif.
Carbide & Carbon Chemicals Corp., 30 E. 42nd St., N. Y. C.
The Carborundum Co., Globar Div., Niagara Falls, N. Y. Ben A. Bovee (CE)
Cardwell Mfg. Corp., Allen D., Brooklyn, N. Y.
Carnegie-Illinois Steel Corp., Pittsburgh, Pa.
Carrier Microphone Co., Inglewood, Calif.
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Centralab Div. of Globe-Union, Inc., 900 E. Keefe Ave., Milwaukee, Wis. H. W. Rubinstein (CE)
Central Screw Co., 3519 Shields Ave., Chicago, Ill.
W. M. Chace Co., 1600 Beard Ave., Detroit, Mich. Stanely R. Hood (CE)
Champion Radio Works, Danvers, Mass.
Chandler Prods. Corp., Cleveland, O.
Chicago Molded Prods. Corp., 1025 N. Kolmar, Chicago, Ill.
Chicago Telephone Supply Co., W. Beardsley Ave., Elkhart, Ind. N. C. Schellenger (CE)
Chicago Transformer Corp., 3501 Addison St., Chicago, Ill.
Cinaudagraph Speakers, Inc., 3911 S. Michigan Ave, Chicago, Ill.
Cinch Mfg. Co., 2335 W. Van Buren St., Chicago, Ill.
Cinema Eng. Co., Burbank, Calif.
Clare & Co., C. P., 4719 W. Sunnyside Ave., Chicago, Ill.
Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn, N. Y. George J. Mucher (CE)
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Colonial Kolonite Co., 2212 W. Armitage Ave., Chicago, Ill.
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Communication Products Co., Jersey City, N. J.
Communications Equip. Corp., 134 W. Colorado St., Pasadena, Calif. Mattson (CER)
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Continental Elec. Co., Geneva, Ill. J. H. Hutchings (CE), H. C. Myers (CER), Dr. G. Lewin (CED)
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Cornell-Dubilier Elec. Corp., 1000 Hamilton Blvd., S. Plainfield, N. J. William M. Bailey (CE)
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General Electronics, Inc., Paterson, N. J.
The General Industries Co., Olive and Taylor Sts., Elyria, O. D. L. Boyd (CE)
General Inst. Corp., 829 Newark Ave., Elizabeth, N. J. Harold M. Detrick (CE)
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General Radio Co., 30 State St., Cambridge, Mass. Melville Eastham (CE)

General Scientific Corp., 4829 S. Kedzie Ave., Chicago, Ill.
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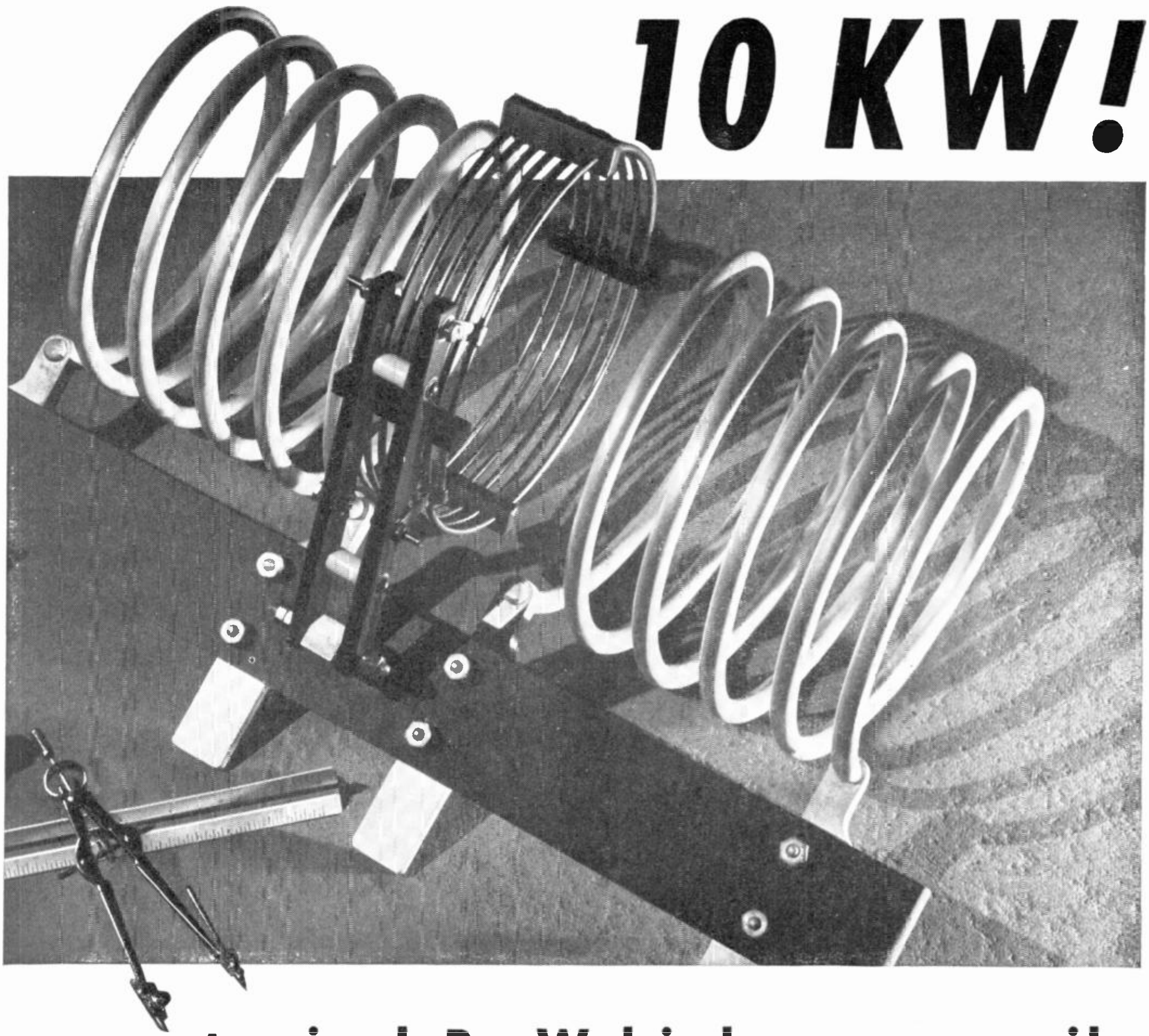

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Magner Mfg. Co., Inc., 444 Madison Ave., New York 22, N. Y.
Magnetic Windings Co., 16 and Butler Sts., Easton, Pa. Alvah Rittenhouse (CE)
Majestic Radio & Television Corp., 2600 W. 50th St., Chicago, Ill. D. E. Foster (CE)
P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind. Glenn W. Carpenter (CE)
Mall Tool Co., 7708 S. Chicago Ave., Chicago, Ill.
Mangold Radio Parts & Stamping Co., 6300 Shelbourne St., Philadelphia, Pa.
Marken Machine Co., Keene, N. H.
McGraw-Hill Book Co., 330 W. 42nd St., N. Y. C.
Measurements Corp., Boonton, N. J. Jerry B. Minter (CE)
John Meck Industries, Liberty at Penn., Plymouth, Ind. E. W. Applebaum (CE)
Meissner Mfg. Co., Mt. Carmel, Ill.
Mercold Corp., 4217 Belmont, Chicago, Ill.
Metals & Controls Corp., Attleboro, Mass.
Metaplast Corp., 205 W. 19th St., N. Y. C. Harold Weller (CEL)
Merit Coil & Transformer, 311 N. Desplaines St., Chicago, Ill. H. Jones (CE)
Mica Insulator Co., 196 Varick St., N. Y. C.
Micamold Radio Corp., 1087 Flushing Ave., N. Y. C. Aniello DiGiacomo (CE)
Micarta Fabricators, Inc., 4619 Ravenswood Ave., Chicago, Ill.
Micro Switch Corp., Freeport, Ill.
Millen Mfg. Co., Malden, Mass.
J. W. Miller Co., 5917 S. Main St., Los Angeles, Calif. Paul O'Connor (CE)
Minneapolis-Honeywell Regulator, Minneapolis, Minn.
Minn. Mining Co., 155 Sixth Ave., N. Y. C.
Mobile Refrigeration, Inc., 38–32 54th St., Woodside, L. I., N. Y.
Molded Insulation Co., 335 E. Price St., Philadelphia, Pa. Arno Zillger (CE)
Monitor Piezo Prod. Co., Pasadena, Calif.
Monsanto Chemical Co., Springfield, Mass.
Donald P. Mossman, Inc., 6133 N. Northwest Highway, Chicago, Ill.
Muehlhausen Spring Corp., Logansport, Ind. J. R. Gustofson (CE)
Mueller Electric Co., 1583 E. 31st St., Cleveland, O. E. H. DeConingh (CE)
Murdock Mfg. Co., Chelsea, Mass.
Muter Co., 1255 S. Michigan Ave., Chicago, Ill. K. E. Rollefson (CED)
Mycalex Corp. of Amer., Clifton, N. J.

— N —

National Co., Inc., 61 Sherman St., Malden, Mass. Dana H. Bacon (CEE), Wm. J. Larkin (CEM)
National Electronic Mfg. Co., 22–78 Steinway St., Long Island City, N. Y. John R. Carpenter (CE)
Nat'l Fabricated Prods., W. Belden Ave., Chicago, Ill.
National Screw & Mfg. Co., Cleveland, O.
National Union Radio Corp., Newark, N. J.
Ntl. Varnished Prod. Corp., Woodbridge, N. J.
National Vulcanized Fibre Co., Wilmington, Del.
New England Mica Co., Waltham, Mass.
New England Screw Co., Keene, N. H.
Newport Rolling Mill Co., Newport, Ky.
Newark Transformer Co., 17 Frelinghuysen Ave., Newark, N. J.
New Wrinkle, Inc., Dayton, O.
New York Transformer Co., 26 Waverly Pl., N. Y. C. Z. Burzyoki (CE)
Noma Elec. Corp., 55 W. 13th St., N. Y. C. J. E. Funk (CE)
No. American Philips Co., 145 Palisade St., Dobbs Ferry, N. Y. H. G. Boyle (CE)
Northern Engineering Labs., 50 Church St., N. Y. C. John Zaleski (CE)
Northern Industrial Chemical Co., Boston, Mass.
Northam Warren Corp., Stamford, Conn.
Nothelfer Winding Labs., Trenton, N. J.
Norwalk Transformer Corp., South Norwalk, Conn.

— O —

Oak Mfg. Co., 1267 Clybourn Ave., Chicago, Ill.
Ohio Carbon Co., Cleveland, O.
Ohio Electric Co., 74 Trinity Pl., N. Y. C.
The Ohio Nut & Bolt Co., 600 Front St., Berea, O. Robert A. Reich, Jr. (CE)
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago, Ill. Herbert Levy (CE)
D. W. Onan & Sons, 43 Royalston Ave., Minneapolis, Minn. J. C. Holby (CE)
Operadio Mfg. Co., St. Charles, Ill. J. F. McCraigh (CE)
Owens-Corning Fiberglas Corp., Toledo, O.
Oxford-Tartak Radio Corp., 3911 S. Michigan Ave., Chicago, Ill. George Rusher (CE)

— P —

Pacific Metals Co., Ltd., San Francisco, Calif.
Palnut Co., Inc., Irvington, N. J.
Parisian Novelty Co., 3510 S. Western Ave., Chicago, Ill. Louis J. Komorous (CE)
Parker Co., Charles, Meriden, Conn.
Parker-Kalon Co., 198 Varick St., N. Y. C.
Par-Metal Prod. Corp., Long Island City, N. Y.
Patton MacGuyer Co., Providence, R. I.
Pawtucket Screw Co., Pawtucket, R. I.
Peck Spring Co., Plainville, Conn.
Peerless Electrical Prod. Co., 6920 McKinley Ave., Los Angeles, Calif. John Jauch (CE)
Perkins Machine & Gear Co., Springfield, Mass.
Permoflux Corp., 4916 W. Grand Ave., Chicago, Ill. W. E. Gilman (CE)
Peterson Radio, Council Bluffs, Iowa
Pheoll Mfg. Co., Chicago, Ill.
Philharmonic Radio Corp., 216 William St., N. Y. C. Victor Brociner (CE)
Philmore Mfg. Co., Inc., 113 University Pl., N. Y. C. Reginald Burke (CE)
Phosphor Bronze Smelting Co., Philadelphia, Pa.
Photobell Corp., 116 Nassau St., N. Y. C. A. Edelman (CE)
Pierce-Roberts Co., Trenton, N. J.
Pioneer Gen-E-Motor, 5841 W. Dickens Ave., Chicago, Ill.
Pitman Pub. Corp., 2 W. 45th St., N. Y. C.
Plax Corp., Hartford, Conn.
Polymet Condenser Co., 699 E. 139th St., N. Y. C.
Potter & Brumfield Co., Princeton, Ind.
Potter Co., 1950 Sheridan Rd., N. Chicago, Ill.
Powers Electronic & Communication Co., New St., Glen Cove, N. Y. A. J. Sanial (CE)
Precision Fabricators, Inc., Rochester, N. Y.
Premier Crystal Labs, 63 Park Row, N. Y. C.
Precision Piezo Serv., 427 Mayflower St., Baton Rouge, La. C. E. Pearce (CE)
Precision Tube Co., 3824–26–28 Terrace St., Philadelphia, Pa. Eugene Turney (CE)
Premax Products Division, Chisholm-Ryder Co., Inc., Niagara Falls, N. Y. G. O. Benson (CE)
Premier Metal Etching Co., 21–03 44th Ave., Long Island City, N. Y.
Presto Elec. Co., New York Ave., Union City, N. J.
Presto Recording Corp., 242 W. 55th St., N. Y. C.
Printloid Inc., 93 Mercer St., N. Y. C. Jerry Margolish (CE)
Pyroferric Co., 175 Varick St., N. Y. C.

— Q —

Quaker City Gear Works, Inc., N. Front St., Philadelphia, Pa.

— R —

Racon Electric Co., Inc., 52 E. 19th St., N. Y. C. A. I. Abrahams (CE)
Radell Corp., Guilford Ave., Indianapolis, Ind.
Radex Corp., 1308–22 N. Elston Ave., Chicago, Ill. G. E. Ditzler (CE)
Radiant Corp., W. 62nd St., Cleveland, O.
The Radiart Corp., 3571 W. 62nd St., Cleveland 2, O. W. Russell Allen, III (CE)
Radio City Products Co., 127 W. 26th St., N. Y. C. Morris Lieblich (CE)
Radio Condenser Co., Camden, N. J.
Radio Engineering Labs., Inc., Long Island City, N. Y. Frank A. Gunther (CE)
Radio Mfg. Engineers, Inc., 306 First Ave., Peoria, Ill. R. M. Planck (CE)
Radiomarine Corp. of America, 75 Varick St., N. Y. C. I. F. Byrnes (CE)
Radio Receptor Co., Inc., 251 W. 19th St., N. Y. C., Everett D. Gibbs (CE)
Radio Speakers, Inc., 221 E. Cullerton, Chicago, Ill.
Radio Tech. Pub. Co., 45 Aston Pl., N. Y. C.
Rauland Corp., 4245 N. Knox Ave., Chicago, Ill. J. J. O'Callaghan (CE)
Raymond Rosen Co., 32nd and Walnut Sts., Philadelphia, Pa. D. N. Lapp (CE)
Raytheon Mfg. Co., Waltham, Mass.
Raymond Mfg. Co., Corry, Pa.
RCA Victor Division, Radio Corp. of America, Camden, N. J. Dr. C. E. Jolliffe (CE)
Readrite Meter Works, Bluffton, O.
Rea Magnet Wire Co., E. Pontiac St., Extd., Ft. Wayne, Ind. Edward I. Snyder (CE)
Rec Mfg. Co., Holliston, Mass.
Redmond Co., A. G., Owosso, Mich.
Reeves Sound Labs., 62 W. 47th St., N. Y. C. Hazard E. Reeves (CE)
Rehtron Corp., 2159 Magnolia Ave., Chicago, Ill.
Reliance Die & St'p'ng Co., 1260 Clybourn Ave., Chicago, Ill.
Reliance Instr. Co., 1135 W. Van Buren St., Chicago, Ill.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif. H. A. Greene, Jr. (CE)
Republic Steel Corp., Cleveland, O.
Revere Copper & Brass, 230 Park Ave., N. Y. C.
Richardson Allen Corp., 15 W. 20th St., N. Y. C. F. F. Sylvester (CE)
Richardson Company, Melrose Park, Ill.
John F. Rider Laboratories, 404 Fourth Ave., N. Y. C. John M. Borst (CE)
Rockbestos Products Corp., New Haven, Conn. Harold S. Moore (CE)
Roebling's Sons Co., John, Trenton, N. J.
Rogan Bros., 2001 S. Michigan Ave., Chicago, Ill.
Rohm & Haas Co., Washington Sq., Philadelphia, Pa.
The Rola Company, Inc., 2530 Superior Ave., Cleveland, O. J. Q. Tiedje (CE)
Roller-Smith Co., 1766 W. Market St., Bethlehem, Pa. R. M. Smith (CE)
Ronald Press Co., 15 E. 26th St., N. Y. C.
Rothard Mfg. Co., N. 9th Ave., Springfield, Ill.
Rowe Industries, Inc., Toledo, O.
Royal Engineering Co., Whippany Post Office, East Hanover, N. J. C. Kenneth Rose (CE)
The Ruby Chemical Co., 68–70 McDowell St., Columbus, O. G. C. Baker (CE)
Runzel Cord & Wire Co., 4723 Montrose Ave., Chicago, Ill.
Russel, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Russell Co., Chicago, Ill.
Ryerson & Son, Inc., Jos. T., Chicago, Ill.

— S —

Sanborn Co., 39 Osborne St., Cambridge, Mass. Maurice Rappaport (CEA), Arthur Miller (CE)
Sangamo Elec. Co., Springfield, Ill.
Schott Co., W. L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Scientific Radio Products Co., 738 West Broadway, Council Bluffs, Ia. E. M. Shideler (CE)
Scientific Radio Service, 4301 Sheridan, University Park, Md. H. D. Eisenhauer (CE)
Scovill Mfg. Co., 99 Mill St., Waterbury, Conn. N. A. Cornell (CE)
Security Steel Equipment Corp., Avenel, N. J. Oscar A. Wilkerson, Jr. (RE)
J. P. Seeburg Corp., 1510 N. Dayton St., Chicago, Ill. M. W. Kenney (CE)
Selectar Mfg. Co., Long Island City, N. Y.
Selenium Corp. of America, 1800 W. Pico Blvd., Los Angeles, Calif. Eric Lidow (CE)
Sensitive Research Instr. Co., 9 Elm Ave., Mt. Vernon, N. Y. Vincent P. Cronin (CE)
Seymour Mfg. Co., Seymour, Conn.
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago 39, Ill. W. M. Hanneman (CE)
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa. Frederic D. V. Mitchell (CE)
Sherman Mfg. Co., H. B., Battle Creek, Mich.
Sherron Metallic Corp., Flushing Ave., Brooklyn, N. Y.
Shure Bros., 225 W. Huron, Chicago, Ill.
Sickles Co., F. W., 165 Front St., Chicopee, Mass. Howard J. Benner (CE)
Sigma Instruments, Inc., 76 Freeport St., Boston, Mass.
Signal Electric Mfg. Co., Menominee, Mich.
Signal Indicator Corp., 140 Cedar St., N. Y. C.
Simplex Wire & Cable Co., 79 Sidney St., Cambridge, Mass. E. W. Davis (CEE)
Simpson Elec. Co., 5218 W. Kinzie, Chicago, Ill.
Slater Electric & Mfg., Co., Brooklyn, N. Y.
Small Motors, Inc., 1308–22 N. Elston Ave., Chicago, Ill. J. A. Snow (CE)
Snyder Mfg. Co., Noble and Darien Sts., Philadelphia, Pa.
Sola Elec. Co., 2525 Clybourn Ave., Chicago, Ill.
Solar Mfg. Corp., 23 St. and Ave. A, Bayonne, N. J. James I. Cornell (CE)
Southington Hardware Mfg. Co., Southington, Conn.
Sparks Withington Co., Radio Div., Jackson, Mich. Harold V. Nielsen (CE)
Spaulding Fibre Co., Inc., 233 Broadway, N. Y. C.
Spencer Thermostat, 34 Forest St., Attleboro, Mass. John D. Bolesky (CE)
Sperry Gyroscope Co., Inc., Garden City, N. Y. Dr. Carl A. Frische (CER)
Sperry Gyroscope Co., Inc., Manhattan Bridge Plaza, Brooklyn, N. Y. E. C. Sparling (CE)
Sprague Specialties Co., North Adams, Mass.
Stackpole Carbon Co., St. Marys, Pa.
Standard Piezo Co., Carlisle, Pa.
Standard Pressed Steel Co., Jenkintown, Pa.
Standard Spring & Mfg. Co., 236 42nd St., Brooklyn, N. Y.
Std. Transformer Corp., 1500 N. Halsted St., Chicago, Ill. H. H. Krefft (CE)
Standard Winding Co., 44–62 Johns St., Newburgh, N. Y. Frank A. Catanzariti (CE)
Stanley Tool Div. of Stanley Works, New Britain, Conn.
Star Porcelain Co., Trenton, N. J.
Steel Sales Corp., 129 S. Jefferson St., Chicago, Ill.
Steward Mfg. Co., Chattanooga, Tenn.
Steward Mfg. Corp., 4311 Ravenswood Ave., Chicago, Ill.
Stewart Stamping Co., 621 E. 216th St., Bronx, N. Y.
Sticht Co., Inc., HH., 27 Park Pl., N. Y. C.
Stille-Young Corp., 2300 N. Ashland Ave., Chicago, Ill.
Stokes Machine Co., F. J., Philadelphia, Pa.
Stokes Rubber Co., Joseph, Trenton, N. J.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y. Frederic C. Young (CE), Wm. F. Cotter (CER)
Sullivan Varnish Co., 410 N. Hart St., Chicago, Ill. Mortimer Sullivan (CE)
Sun Radio Co., 212 Fulton St., N. Y. C.
Superior Elec. Co., Bristol, Conn.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J. Simon Goldberg (CRE), Lionel Lorant (CAF)
Superior Tube Co., P. O. Drawer 191, Norristown, Pa. R. H. Gabel (CE)
Suprenant Elec. Ins. Co., Boston, Mass.
Sylvania Electric Products, Inc., 500 Fifth Ave., N. Y. C. Roger M. Wise (CE)
Synthane Corp., Oaks, Pa.

— T —

Tablet & Ticket Co., 1021 W. Adams St., Chicago, Ill.
Taylor Fibre Co., Norristown, Pa.
Taylor Tubes, Inc., 2341 Wabansia, Chicago, Ill.
Technical Appliance Corp., 516 W. 34th St., N. Y. C. Donald Malpass (CE)
Tech-Art Plastics, 41–01 36th Ave., Long Island City, N. Y.
Tech. Laboratories, 7 Lincoln St., Jersey City, N. J. Magnus Bjorndal (CE), M. H. Loughnane (RA)
Telephonics Corp., 350 W. 31st St., N. Y. C.
Teleradio Eng. Corp., 484 Broome St., N. Y. C.
Tenney Engineering, Inc., Montclair, N. J.
Thermador Elec. Mfg. Co., 5119 S. Riverside Dr., Los Angeles 22, Calif. John W. Wardell (CAF)
Thomas & Skinner Steel Prod. Co., Indianapolis, Ind.
Thompson Clock Co., H. C., Bristol, Conn.
Thomas & Betts Co., Elizabeth, N. J.
Thordarson Elec. Mfg. Co., 500 W. Huron, Chicago, Ill.
Tillotson Furniture Co., Jamestown, N. Y.
Trade-Wind Motorfans, Inc., 5725 S. Main St., Los Angeles, Calif.
Transmitter Equipment Mfg. Corp., 345 Hudson St., New York, N. Y. S. L. Sack (CE)
Trav-Ler Karenola Radio & Telev. Corp., 1036 W. Van Buren St., Chicago, Ill. Richard J. O'Brien (CE)
Treitel-Gratz Co., Inc., 142 E. 32nd St., N. Y. C. Frank W. Gratz (CE)
Trent Company, Harold E., Philadelphia, Pa.
Trimm Radio Mfg. Co., 1770 W. Berteau, Chicago, Ill.
Triplett Electrical Inst. Co., Bluffton, O. Fred J. Lingel (CE), John Maxon (RE)
Triumph Mfg. Co., 4017 W. Lake St., Chicago, Ill.
Truscon Steel Co., Youngstown, O.
Tull Metal & Supply Co., Atlanta, Ga.
Tungsol Lamp Works, Inc., 95 Eighth Ave., Newark, N. J. A. K. Wright (CE), R. H. Fidler (DE)
Turner Co., 909 Seventeenth St., N. E., Cedar Rapids, Ia. Rollins H. Mayer (CE)

— U —

Ucinite Co., Newtonville, Mass.
United Cinephone Corp., Torrington, Conn.
United Electronics Co., 42 Spring St., Newark, N. J. B. F. Steiger (CE)
United Transformer Co., 150 Varick St., N. Y. C.
Universal Microphone Co., 424 Warren Ave., Inglewood, Calif. Les Willyard (CE)
Universal Plastics Corp., New Brunswick, N. J.
University Labs., 225 Varick St., N. Y. C. Arthur Blumenfeld (CE)
United Screw & Bolt Corp., 71 Murray St., N. Y. C.
U. S. Rubber Co., 1230 Sixth Ave., N. Y. C.
Utah Radio Prod., 320 W. Ohio St., Chicago 10, Ill. W. Austin Ellmore (CE)

— V —

Valpey Crystal Corp., 1244 Highland St., Holliston, Mass. Donald MacDougall (CE)
D. Van Nostrand Co., 250 Fourth Ave., N. Y. C.
Varflex Corp., 305 N. Jay St., Rome, N. Y. G. L. Wolfe (SP)
Victor Insulators, Inc., Victor, N. Y. Edwin M. Meyer (CE)
Vasco Elec. Mfg. Co., 4116 Avalon Blvd., Los Angeles, Calif.
Vibration Specialty Co., 1536 Winter St., Philadelphia, Pa.
Vulcan Elec. Co., Lynn, Mass.

— W —

Walker-Turner Co., Inc., Plainfield, N. J.
Wallace Mfg. Co., Wm. T., Madison and Chili, Peru, Ind. Joseph R. Myers (CE)
Ward Leonard Elec. Co., Mt. Vernon, N. Y.
Ward Products Corp., 1523 E. 45th St., Cleveland, O.
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill. Howard A. Gates (DE)
Webster Products, 3825 W. Armitage Ave., Chicago, Ill. Norman L. Conrad (CE)
Western Elec. Co., 195 Broadway, N. Y. C.
Western Felt Works, 4031 Ogden Ave., Chicago, Ill.
Westinghouse Elec. & Mfg. Co., 2519 Wilkins Ave., Baltimore, Md. R. N. Harmon (CER)
Westinghouse Elec. Mfg. Co., Lima, O.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Westinghouse Lamp Div., Bloomfield, N. J.
Weston Elec. Instr. Corp., 614 Frelinghuysen Ave., Newark, N. J. W. N. Goodwin, Jr. (CER)
Wheeler Insulated Wire Co., Bridgeport, Conn.
Wheelco Instruments Co., 847 Harrison St., Chicago, Ill. Theodore A. Cohen (CE)
White Dental Mfg. Co., 10 E. 40th St., N. Y. C.
Whitehead Metal Prods. Co., 303 W. 10th St., N. Y. C.
Whitney Blake Co., New Haven, Conn.
Whitney Screw Corp., Nashua, N. H.
Wick Organ Co., Highland, Ill.
Wiley & Sons, John, 440 Fourth Ave., N. Y. C.
Williams & Company, Inc., Pittsburgh, Pa.
Willor Mfg. Corp., 794 E. 140th St., New York 54, N. Y.
Wilmington Fibre Specialty Co., Wilmington, Del.
Wilson Co., H. A., 105 Chestnut, Newark, N. J.
Wincharger Corp., East 7th and Division, Sioux City, Ia. V. C. Miron (CE)
Winslow Co., Inc., Liberty St., Newark, N. J.
Wirt Co., Germantown, Pa.
Worner Prod. Corp., 1019 W. Lake St., Chicago, Ill.

— Z —

Zeiss, Inc., Carl, 485 Fifth Ave., N. Y. C.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill. G. E. Gustafson (CE)
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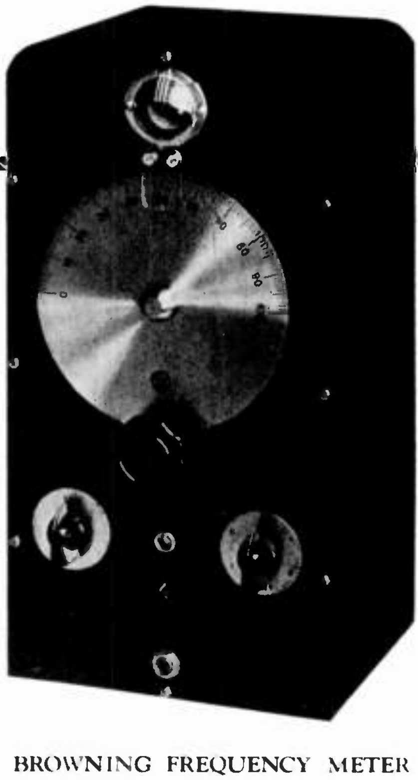
The Browning Crystal-Controlled Frequency Meter is standard equipment for all police, fire, public service, and other emergency radio systems . . . .



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— A —

Abel, A. E. (HE), Bendix Radio Div., Bendix Aviation Corp.
Abrahams, A. I. (CE), Racon Electric Co., Inc.
Allen, W. Russell, III (CE), The Radiart Corp.
Anderson, Donald E. (CE), J-B-T Instruments, Inc.
Angus, Wm. M. (CE), Gen. Elec. Co., Engineering, Receiver Div., Electronics Dept., Bridgeport, Conn.
Applebaum, E. W. (CE), John Meck Industries
Applegate, Ivan D. (CE), Ideal Commutator Dresser Co.
Armstrong, I. (CEE), Dinion Coil Co.

— B —

Babcock, Stuart K. (CE), Electronic Specialty Co.
Bacon, Dana H. (CEE), National Co., Inc.
Badeau, C. A. (CE), The Thomas & Betts Co.
Bailey, William M. (CE), Cornell-Dubilier Elect. Corp.
Baker, G. C. (CE), The Ruby Chemical Co.
Balint, John (RE), Link Radio Corp.
Barlow, William A. (CE), General Winding Co.
Bassett, Rex Earl, Jr. (RD), Rex Bassett, Inc.
Bauer, Brunton (CER), Hewlett-Packard Co.
Bean, L. G. (CE), The Bristol Co.
Benner, Howard J. (CE), F. W. Sickles Co.
Benson, G. O. (CE), Premax Products Div., Chisholm-Ryder Co., Inc.
Bergman, S. D. (LE), Burndy Engineering Co., Inc.
Bevington, K. A. (CE), American Molded Products Co.
Bjorndal, Magnus (CE), Tech. Laboratories
Blackburn, Richard K. (CE), Crystal Research Labs.
Blumenfeld, Arthur (CE), University Labs.
Blye, H. (CE), DeJur-Amsco Corp.
Bolesky, John D. (CE), Spencer Thermostat
Borst, John M. (CE), John F. Rider Laboratories
Bovee, Ben A. (CE), The Carborundum Co., Globar Div.
Boyd, D. ?. (CE), The General Industries Co.
Boyle, H. G. (CE), No. American Philips Co.
Bozak, R. T. (CER), Dinion Coil Co.
Brainin, C. S. (CL), C. S. Brainin Co.
Broeiner, Victor (CE), Philharmonic Radio Corp.
Brown, Harold J. (RE), Electronic Laboratories, Inc.
Brown, M. E. (CEL), Borg-Gibbs Lab., The Geo. W. Borg Corp.
Browning, Glenn H. (CE), Browning Labs., Inc.
Browning, S. D. (CDE), Federal Telephone & Radio Co.
Budelman, F. T. (CE), Link Radio Corp.
Burke, Reginald (CE), Philmore Mfg. Co., Inc.
Burroughs, Louis R. (CE), Electro-Voice Mfg. Co., Inc.
Burzycki, Z. (CE), New York Transformer Co.
Butler, H. R. (CCP), Federal Telephone & Radio Co.
Byrnes, I. F. (CE), Radiomarine Corp. of America

— C —

Carlson, V. E. (CEX), Aircraft-Marine Products, Inc.
Carpenter, Glenn W. (CEE), P. R. Mallory & Co., Inc.
Carpenter, John R. (CE), Insuline Corp. of America
Carpenter, John R. (CE), National Electronic Mfg. Co.
Carr, Albert H. (CE), Fada Radio & Elec. Co.
Carter, Robert W. (CE), Carter Motor Co.
Catanzariti, Frank A. (CE), Standard Winding Co.
Cezar, Albert (CE), Electronic Transformer Co.
Chalfin, N. L. (CRE), Crystal Research Labs.
Christaldi, Dr. P. S. (CE), Allen B. Du Mont Labs., Inc.
Church, V. S. (CE), Burton-Rogers Co.
Clark, R. A. Jr. (CE), Communication Equip. & Eng. Co.
Clement, Lewis M. (RD), The Crosley Corp.
Cohen, Harold (CE), Harco Steel Co.
Cohen, Theodore A. (CE), Wheelco Instruments Co.
Cohn, Maury (CE), The Electro-Motive Mfg. Co.
Coleman, H. Roger (SP), General Aniline Works
Collins, J. L. (EE), Aerovox Corp.
Comstock, J. A. (CE), Acme Electric & Mfg. Co. Clyde Plant
Conrad, Norman L. (CE), Webster Products
Cornell, James I. (CE), Solar Mfg. Corp.
Cornell, N. A. (CE), Scovill Mfg. Co.
Cotter, Wm. F. (CER), Stromberg-Carlson Co.
Cox, C. Russell (CE), Victor J. Andrew Co.
Craft, L. Morgan (CE), Collins Radio Co.
Cronin, Vincent P. (CE), Sensitive Research Instr. Co.
Cullin, J. F. (CE), General Armature Corp.
Curtiss, W. R. (CE), Conn. Tel. & Elec. Div., Great American Ind.

— D —

Dante, J. J. (CE), Dante Elec. Mfg. Co.
Daugherty, R. M. (CE), The Detrola Corp.
Davis, E. W. (CEE), Simplex Wire & Cable Co.
Davis, F. M. (RD), Collins Radio Co.
DeConingh, E. H. (CE), Mueller Electric Co.
Detrick, Harold M. (CE), General Inst. Corp.
Dezettel, L. M. (CE), Allied Radio Corp.
DiGiacomo, Aniello (CE), Micamold Radio Corp.
Ditzler, G. E. (CE), Radex Corp.
Donaldson, W. R. (CE), Celanese Corp.

— E —

Eastham, Melville (CE), General Radio Co.
Eckstein, E. A. (CE), Eckstein Radio & Television Co., Inc.
Edelman, A. (CE), Photobell Corp.
Eisenhauer, H. D. (CE), Scientific Radio Service
Ellmore, W. Austin (CE), Utah Radio Prod.

— F —

Faber, Leon A. (CE), The James Knights Co.
Ferguson, J. C. (CE), Farnsworth Telev. & Radio Co.
Fidler, R. H. (DE), Tungsol Lamp Works, Inc.
Fishberg, Sidney (CE), Cosmic Radio Corp.
Foster, D. E. (CE), Majestic Radio & Television Corp.
Foute, Ken (CE), Drake Mfg. Co.
Franklin, Wm. S. (CE), John E. Fast & Co.
French, Sherwood P. (CT), Kaar Engineering Co.
Frische, Dr. Carl A. (CER), Sperry Gyroscope Co., Inc., Garden City
Frye, Raul H. (CE), Electronic Laboratories, Inc.
Funk, J. E. (CE), Noma Elec. Corp.

— G —

Gabel, R. H. (CE), Superior Tube Co.
Gardner, B. G. (VE), Aerovox Corp.
Garlick, Walter, Jr. (TD), American Transformer Co.
Gates, Howard A. (DE), Warwick Mfg. Corp.
Gates, Parker (CE), Gates Radio Co.
Gibbs, Everett D. (CE), Radio Receptor Co., Inc.
Gillman, W. E. (CE), Permoflux Corp.
Girard, W. E. (CE), H-B Electric Co.
Glaser, Mark (CL), DeWald Radio Corp.
Goldberg, Simon (CRE), Super Electric Products Corp.
Goodwin, W. N., Jr. (CLR), Weston Elec. Instr. Corp.
Gratz, Frank W. (CE), Treitel-Gratz Co., Inc.
Gray, Dudley (CE), Doolittle Radio Inc.
Gray, F. E. (CE), Gray Radio Co.
Graybill, K. W. (CE), Automatic Electric Co.
Greene, H. A., Jr. (CE), Remler Co. Ltd.
Gunther, Frank A. (CE), Radio Engineering Labs., Inc.
Gustafson, G. E. (CE), Zenith Radio Corp.
Gustofson, J. R. (CE), Muehlhausen Spring Corp.

— H —

Hamond, George I. (CE), Eagle Electric Mfg. Co.
Hanneman, W. M. (CE), Shakeproof, Inc.
Harges, Michael T. (CE), Lear Avia
Harnett, Daniel E. (CE), Hazeltine Electronics Corp.
Harrison, R. N. (CER), Westinghouse Elec. & Mfg. Co., Baltimore, Md.
Harris, J. F. (SE), American Transformer Co.
Harvey, Clifford A. (CE), Harvey Wells Communications, Inc.
Hass, A. (CE), Hudson American Corp.
Haynes, N. M. (CE), Amplifier Co. of America
Helwig, Norman C. (CR), Kaar Engineering Co.
Heppner, E. A. (CE), Consolidated Radio Prod. Co.
Heyman, S. (ME), Aerovox Corp.
Hoiby, J. C. (CE), D. W. Onan & Sons
Hood, Stanley R. (CE), W. M. Chace Co.
Howes, G. T. (CE), Eitel-McCullough, Inc.
Hutchings, J. H. (CE), Continental Elec. Co.

— I —

Israel, Dorman D. (CE), Emerson Radio & Phonograph Corp.

— J —

Jauch, John (CE), Peerless Electrical Prod. Co.
Johnson, J. O. (CEP), Aircraft-Marine Products, Inc.
Jolliffe, Dr. C. B. (CE), RCA Victor Division, Radio Corp. of America, Camden, N. J.
Jones, Elmer T. (CT), Rex Bassett, Inc.
Jones, H. (CE), Merit Coil & Transformer

— K —

Kahn, Louis (CER), Aerovox Corp.
Kalstein, A. G. (PE), Aerovox Corp.
M. Kaplowitz (CE), Federal Mfg. & Eng. Corp.
Kaufman, Albert A. (CE), Industrial Synthetics Corp.
Kayner, Harry J. (CED), Doolittle Radio Inc.
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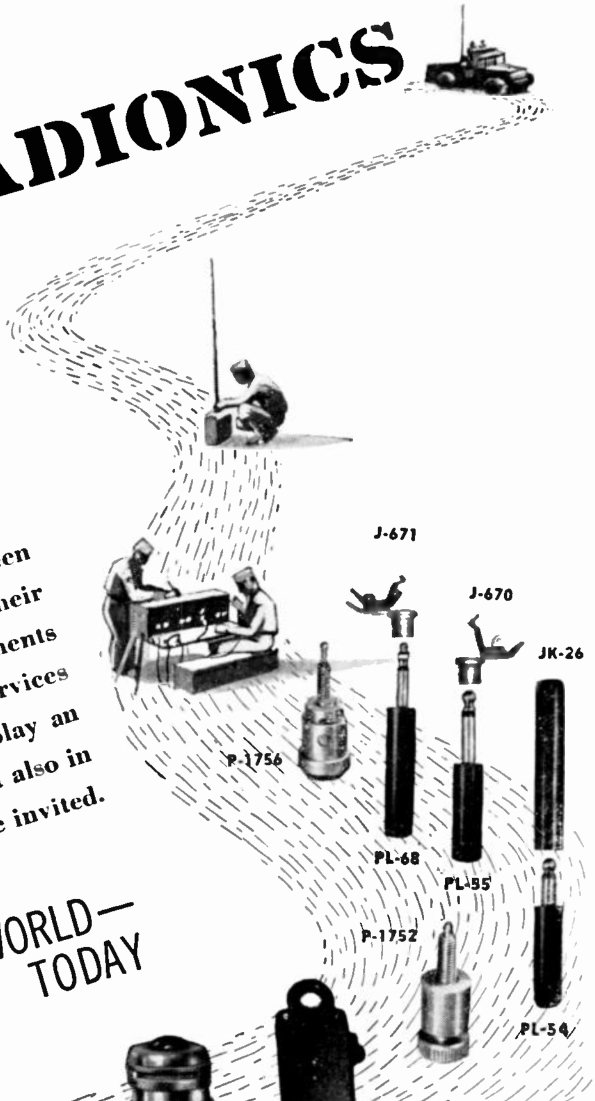

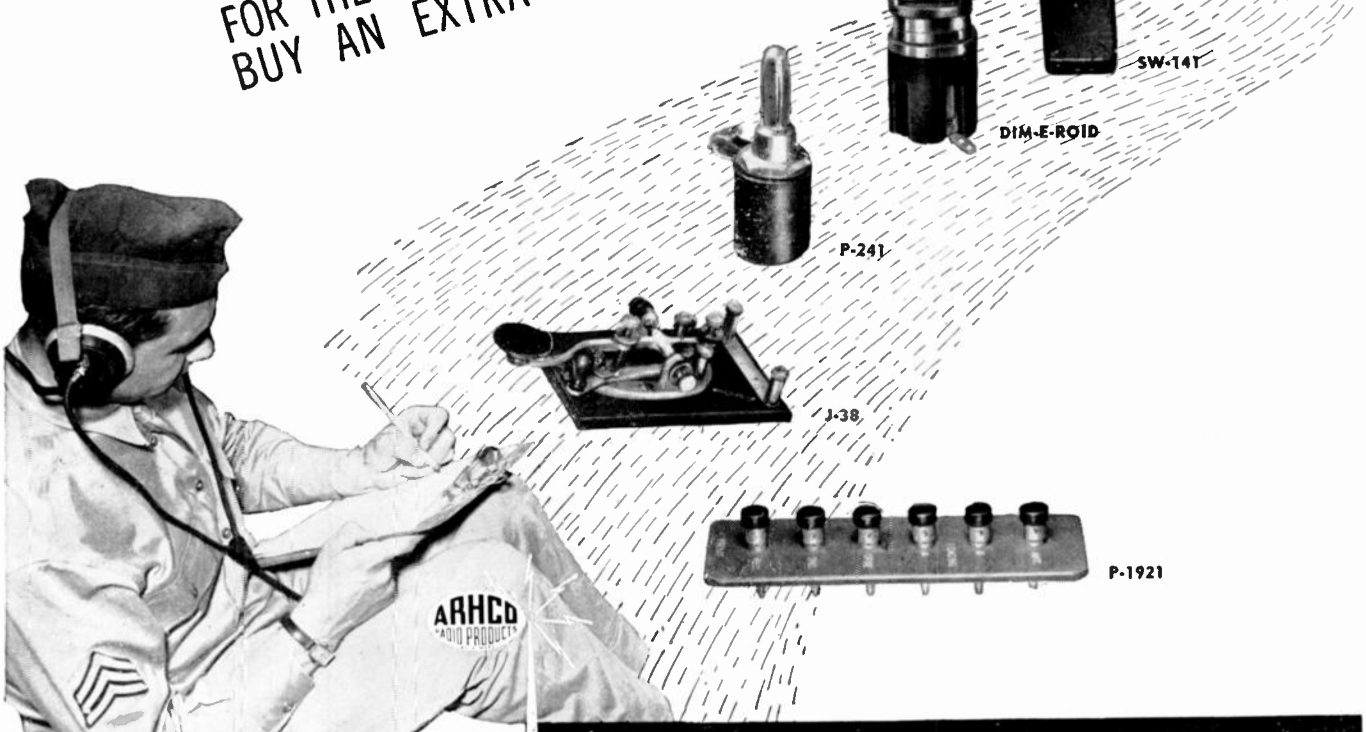

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Kunz, Warren (CE), Alden Products Co.
Kurland, Jerome J. (CE), Illinois Condenser Co.

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Lahn, Robert (CE), Camburn Products Co.
Lallone, A. R. (CAN), Federal Telephone & Radio Co.
Lapp, D. N. (CE), Raymond Rosen Co.
Larkin, Wm. J. (CEM), National Co., Inc.
Lasswell, Charles (CE), Girard-Hopkins
Lastovicka, L. J. (CE), Lectrohm, Inc.
Lawler, John (CE), Auburn Button Works
Lee, Marvin (CE), Burndy Engineering Co., Inc.
Levenberg, M. H. (CE), Condenser Products Co.
Levy, Herbert (CE), Ohmite Mfg. Co.
Levy, M. L. (SP), Emerson Radio & Phonograph Corp.
Lewin, Dr. G. (CED), Continental Elec. Co.
Lidow, Eric (CE), Selenium Corp. of America
Lieblich, Morris (CE), Radio City Products Co.
Lillyblad, Robert Harry (CE), Camfield Mfg. Co.
Lindberg, C. A. (CE), Air Way Elec. Appl. Corp.
Linell, C. S. (CE), Carron Mfg. Co.
Lingel, Fred J. (CE), The Triplett Electrical Instrument Co.
Litt, I. (CR), Lafayette Radio Corp.
Lorant, Lionel (CAF), Super Electric Products Corp.
Lord, Benjamin C. (CE), Halstead Traffic Communications Corp.
Loughnane, M. H. (RA), Tech. Laboratories
Lowit, Rudolf (CE), Callite Tungsten Corp.

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MacCoun, T. (CC), Link Radio Corp.
MacDougall, Donald (CE), Valpey Crystal Corp.
Mallard, M. T. (CE) Cornish Wire Co., Inc.
Malpass, Donald (CE), Technical Appliance Corp.
Margolish, Jerry (CE), Printloid, Inc.
Marsten, Jesse (CE), International Resistance Co.
Martin, Devereaux (CE), J. H. Bunnell & Co.
Matthey, L. H., Jr. (CE), Hartman Corp. of America
Mattson, Ebert (CER), Communications Equip. Corp.
Mayer, Rollins H. (CE), The Turner Co.
Maxon, John (RE), The Triplett Electrical Instrument Co.
Mazzola, J. R. (CE), Automatic Winding Co., Inc.
McCraigh, J. F. (CE), Operadio Mfg. Co.
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Miller, Arthur (CE), Sanborn Co.
Miller, E. A. (CE), Acme Electric & Mfg. Co., Cuba Plt.
Minnich, Edw. L. (CQ), Rex Bassett, Inc.
Minnium, Byron B. (EC), Erie Resistor Corp.
Minter, Jerry B. (CE), Measurements Corp., Boonton, N. J.
Miron, V. C. (CE), Wincharger Corp.
Mitchell, D. H. (CE), Galvin Mfg. Corp.
Mitchell, Frederic D. V. (CE), Shallcross Mfg. Co.
Moon, R. B. (RE), Bendix Radio Div., Bendix Aviation Corp.
Moore, Harold S. (CE), Rockbestos Products Corp.
Mucher, George J. (CE), Clarostat Mfg. Co., Inc.
Muir, D. (CT), Lafayette Radio Corp.
Myers, H. C. (CER), Continental Elec. Co.
Myers, Jos. R. (CE), Wm. T. Wallace Mfg. Co.

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Nader, J. (DE), Elcor, Inc.
Neary, John F. (TE), Lehigh Structural Steel Co.
Nielsen, Harold V. (CE), Sparks Withington Co., Radio Div.
Norton, L. D (RD), Dictaphone Corp.

— O —

O'Brien, Richard J. (CE), Trav-Ler Karenola Radio & Telev. Corp.
O'Callaghan, J. J. (CE), The Rauland Corp.
O'Connor, Paul (CE), J. W. Miller Co.
Olander, Lloyd W. (CE), E. F. Johnson Co.
Oram, D. K. (RE), Hammarlund Mfg. Co., Inc.
Osterland, Edmund (CE), Ballantine Labs.

— P —

Packard, David (CE), Hewlett-Packard Co.
Pearce, C. E. (CE), Precision Piezo Serv.
Pearce, R. M. (CE), Haydon Mfg. Co.
Peek, Walter E. (RA), Electronic Laboratories, Inc.
Peckham, J. W. (RD), The Bristol Co.
Peters, Carl E. (CE), The Benwood Linze Co.
Peterson, Henry (CE), Lepel Laboratories
Planck, R. M. (CE), Radio Mfg. Engineers, Inc.
Pray, G. E. (CE), Airplane & Marine Instruments, Inc.

— R —

Rall, C. A. (CE), Bodine Elec. Co.
Rappaport, Maurice (CEA), Sanborn Co.
Reeves, Hazard E. (CE), Reeves Sound Labs.
Reich, Robert A., Jr. (CE), The Ohio Nut & Bolt Co.
Reynolds, W. H. (CE), American Instrument Co.
Rhoads, John A., Jr. (CER), Air Associates, Inc.
Ricko, James (CE), General Television Co.
Ridley, P. G. (SP), Gavitt Mfg. Co.
Rittenhouse, Alvah (CE), Magnetic Windings Co.
Roemisch, Joseph L. (DE), Communication Measurements Lab.
Rollefson, K. E. (CED), The Muter Co.
Rose, Kenneth (CE), Royal Engineering Co.
Rosenbaum, Jack (CE), Espey Mfg. Co.
Rubinstein, H. W. (CE), Centralab Div. of Globe-Union, Inc.
Rudd, W. C. (CE), Induction Heating Corp.
Rusher, Geo. (CE), Oxford-Tartak Radio Corp.
Russell, Valoran (CE), Crescent Industries, Inc.
Ruth, Edward (CE), Erco Radio Labs., Inc.

— S —

Sack, S. L. (CE), Transmitter Equipment Mfg. Co., Inc.
Samuelson, R. E. (CE), The Hallicrafters Co.
Sanial, A. J. (CE), Powers Electronic & Comm. Co.
Schellenger, N. C. (CE), Chicago Telephone Supply Co.
Schnell, Wm. J. (CE), Electrical Research Labs., Inc.
Schnoll, Nathan (CE), Industrial Instruments, Inc.
Schum, W. R. (CER), Cover Dual Signal Systems, Inc.
Schutz, F. G. (CE), Ace Mfg. Corp.
Schwarz, B. A. (CE), Delco Radio Div., General Motors Corp.
Seble, A. D. (CE), Air King Products Co.
Shideler, E. M. (CE), Scientific Radio Products Co.
Shimer, Richard B. (CE), Kenyon Transformer Co., Inc.
Silver, McMurdo (CER), Grenby Mfg. Co.
Sims, W. H., Jr. (TE), Bendix Radio Div., Bendix Aviation Corp.
Small, John M. (CE), Detroit Power Screwdriver Co.
Smith, J. P., Jr. (CE), The Daven Co.
Smith, R. M. (CE), Roller-Smith Co.
Snow, J. A. (CE), Small Motors, Inc.
Snyder, Edward I. (CE), Rea Magnet Wire Co.
Soderquist, C. J. (CE), Fisher Research Lab.
Sorg, Harold E. (RD), Eitel-McCullough, Inc.
Sparling, E. C. (CE), Sperry Gyroscope Co., Inc., Brooklyn
Steiger, B. F. (CE), United Electronics Co.
Stickney, F. S. (CE), Instrument Specialties Co., Inc.
Sullivan, Mortimer (CE), Sullivan Varnish Co.
Sylvester, F. F. (CE), Richardson Allen Corp.

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Thompson, J. H. (CES), Aircraft-Marine Products, Inc.
Tieje, J. Q. (CE), The Rola Co., Inc.
Tiffany, W. M. (CE), Cover Dual Signal Systems, Inc.
Townsend, C. S. (CE), Bendix Radio, Div. of Bendix Aviation Corp.
Trickey, Philip H. (CE), Diehl Mfg. Co., Finderne Plant
Trott, Barnet S. (CE), Garod Radio Corp.
Turney, Eugene (CE), Precision Tube Co.
Tyler, A. W. (PH), Eastman Kodak Co.

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Wagener, Winfield G. (CE), Heintz & Kaufman, Ltd.
Waldelich, J. R. (SP) The Bristol Co.
Wardell, John W. (CAF), Thermador Elec. Mfg. Co.
Webb, Wilbur L. (CE), Bendix Radio Div., Bendix Aviation Corp.
Weller, Harold (CEL), Metaplast Corp.
Weinstien, Murray (CE), Freed Radio Corp.
Weise, R. C. (CE), Barker & Williamson
Weiss, Walter A. (CEL), Hickok Elec. Inst. Co.
Weltmann, Otto (XE), Lepel Laboratories
Whitaker, James (TE), Hammerlund Mfg. Co., Inc.
Whitney, Lewis H. (CEM), Grenby Mfg. Co.
Whittier, Carl H. (CE), General Communication Co.
Wilkerson, Oscar A., Jr. (RE), Security Steel Equip. Corp.
Willyard, Les (CE), Universal Microphone Co.
Wise, Roger M. (CE), Sylvania Electric Products, Inc.
Wolcott, C. Frederick (CE), Gilfillan Bros., Inc.
Wolcott, R. B. (CEM), Crystal Research Labs.
Wolfe, G. L. (SP), Varflex Corp.
Wolfskill, J. M. (CE), Bliley Electric Co.
Wright, A. K. (CE), Tungsol Lamp Works, Inc.

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Young, Frederic C. (CE), Stromberg-Carlson Co.

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Zaleski, John (CE), Northern Engineering Labs.
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Zmuda, Dan (CE), H.R.S. Products

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POSTWAR HOME RADIO DESIGN

(CONTINUED FROM PAGE 13)

first place. And in the second place, manufacturers for years have been urging the public to buy tomorrow's set today. It will be hard to sell yesterday's set tomorrow to that same public.

And it would be foolish to disregard the newcomers, the concerns who abandoned their pre-Pearl Harbor products to build military radio equipment. Having built up competent engineering staffs and well-equipped laboratories, and with skill and experience in the radio field, they are going to make a determined effort to stay in radio.

This new competition has the advantage of knowing only the latest and best in design and production practice, with none of the bad habits which have hampered some long-established radio plants in their peace-to-war conversion. Many will fall by the wayside, but those who stick will teach the oldtimers a few tricks.

The Rush for Jobbers ★ Frequently it is stated that the postwar rush to grab the best jobbers, and to deliver enough sets to hold them in line, will make it necessary for manufacturers to jump right into production of their prewar models. No doubt there will be competition to sign up good jobbers but they, in turn, will be in a position to choose the lines that will be preferred by the best dealers. And these dealers will want the best merchandise, which means the newest models.

Radio dealers have had a lot of time to think about their past mistakes. No doubt they are still rubbing scars they got from all the deals that cost them so much money. Some of them may not be too anxious to buy from jobbers, anyway. There are going to be several fine lines available on direct factory franchises, with prices protected by limiting the number of dealers in each city.

Planning Problems ★ Theoretically, it would be a bright idea to work on distribution in advance of the time when civilian production will start. Actually, it will be difficult for manufacturers to get even tentative commitments from distributors in advance. The attitude will be: "I want to have a look at the field before I make a decision." Radio jobbers have always played their cards close to the chest, and there is all the more reason for them to do so in this case.

The big mail-order houses, such as Sears Roebuck and Montgomery Ward, have a more accurate knowledge of what their customers want than probably any radio manufacturer. They will be the first to reach definite conclusions on new models. In the past, they have not generally been considered competitors of companies which produced the sets they marketed. However, they developed their sales to the

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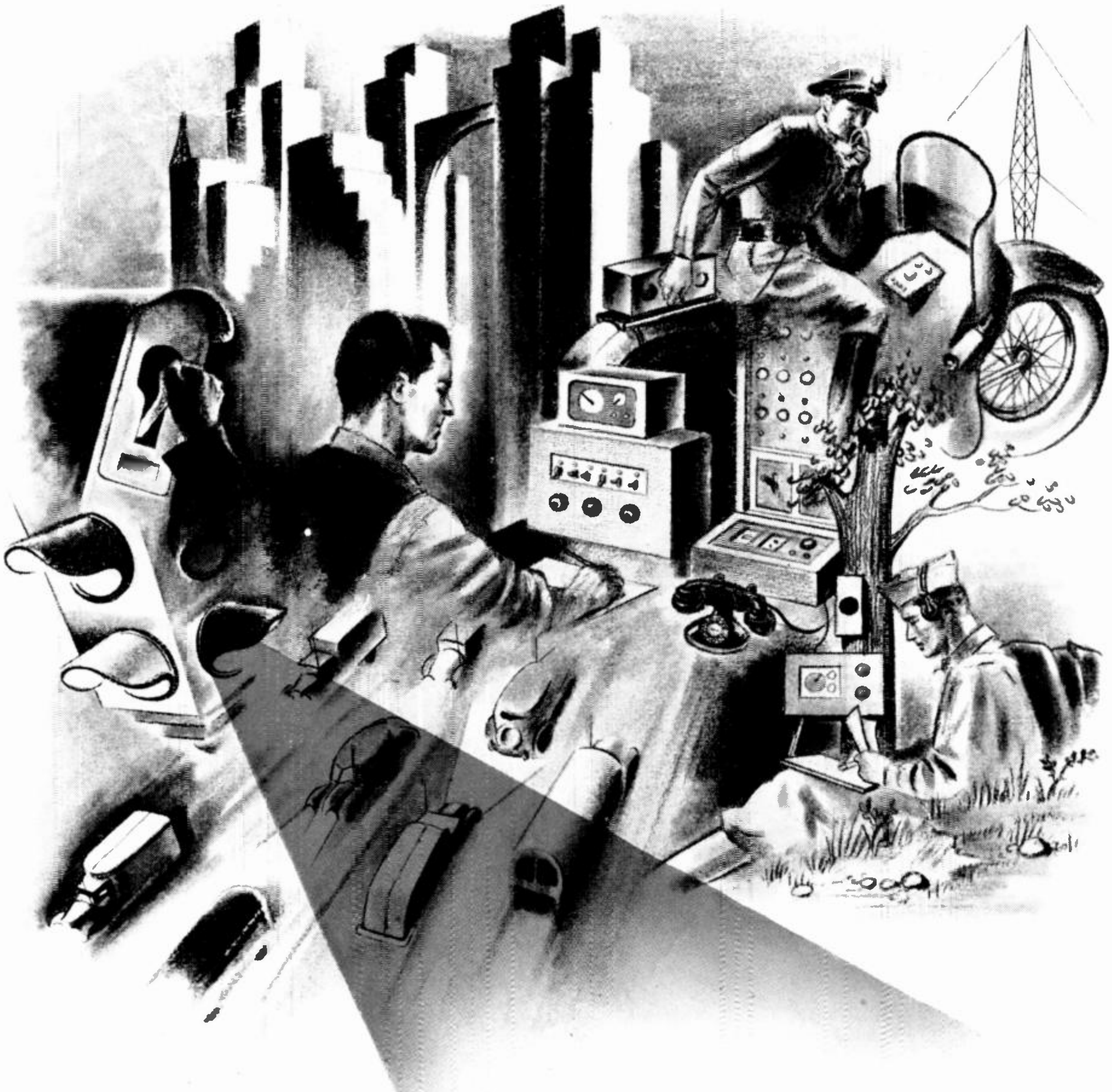

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BACK THE ATTACK! BUY *MORE* WAR BONDS!

POSTWAR HOME RADIO DESIGN

(CONTINUED FROM PAGE 47)

point where they were taking out a very substantial share of the retail volume. Furthermore, the ratio of quality to price in the sets they were selling was higher than that of some "standard" lines.

New Cabinets ★ Radio cabinets have always been a headache to manufacturers, the trade, and the public. From the point of view of the furniture designer and decorator, they have been horrors, for the most part. Good cabinets are so expensive that the resulting retail price could be held down only by cheapening the radio sets installed in them. Since radio manufacturers do not make cabinets, they must add their own profit to the cabinet manufacturer's profit. Thus, as the ratio of cabinet cost to chassis cost goes up, the relative value to the consumer goes down, for the percentage of double-profit goes up.

Postwar, when thousands upon thousands of people will finally discard sets that they should have replaced prior to 1940, they will be more particular and discriminating than ever before. New tastes, new ideas, new homes will multiply the cabinet headaches.

Metal Cases ★ One way in which this situation will be met is the use of plain metal or wood cases to house receivers only. The speakers will be mounted in separate cabinets, or disguised by building them into furniture pieces.

Such companies as National and Hallicrafters did this very successfully for amateur receivers. In fact, they had some very attractive metal cases that proved acceptable because their simplicity and functional design did not compete with furniture. There is no objection to having a radio set look like what it is.

This idea will be borrowed for broadcast receivers, and will prove popular not only for the reason stated above, but because such models can be fitted into furniture pieces to suit individual tastes. The cost of discarding metal boxes is so small that their use will open up new means of suiting customer's needs. From the manufacturers' angle, this is a solution to the problem of selling chassis to the public, a practice frowned upon by manufacturers in the past because it upset cabinet stocks, or because it concealed the identity of the manufacturer.

The same chassis will be far cheaper in a metal case than in a formal cabinet. However, this will not affect the dollar-sales, for if a customer has a definite amount to spend, he will end up with a better chassis, and better performance. Dealers who have competent servicemen will add to their sales by handling the work of installing such radios, and the accompanying speakers, in furniture pieces.

Metal-cased sets will have advantages

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to dealers. As a rule, the models they can't move have the same chassis as the popular numbers. The trouble lies in the cabinet designs, either because they are not acceptable or because they are dated by their appearance. Or it may be merely the color of the wood!

Chassis Designs ★ Nearly all military equipment is designed in units, hooked up by separable connectors. This is done to facilitate installation and service. We have all had ample opportunity to observe the advantages of such construction. Some of the more expensive home radios will be designed in that way. The idea is not new, but it has not been applied to civilian equipment in the most effective manner.

It is not enough to have the tuning circuits on one chassis and the audio end on a second chassis. Both should be mounted in a quick-detachable manner. To remove one or the other should not require the performance of a major operation. Particularly, the chassis should not be fastened with wood screws which, once removed, will not hold again.

In some cases, where two chassis were used, the interconnecting wires were soldered to terminals. In the struggle of unsoldering and replacing the leads, the connections were seldom secure and certain thereafter. Designers should borrow some ideas on this detail from their aircraft radio experience.

Mechanical Details ★ Today, many a set has become inoperative for no other reason than that dial-drive strings have broken, and there are no local servicemen to go through the manual gymnastics necessary to fix them. Of all bad mechanical design, of which there has been a great deal in home radios, the use of strings to drive dials and condensers was probably the outstanding example.

The use of variable inductances with trolley-wheel contacts, of the Ware tuner type, has proved so satisfactory on certain military equipment that some designers plan to substitute them for variable condensers. This will result in some very interesting design innovations.

Compared to the military equipment that the industry has been producing, the hodge-podge of wires and condensers, resistors, and chokes running around under civilian radio chassis looks like a wireman's nightmare. Adding cheap and flimsy hardware made the result thoroughly awful to look at, and so difficult to work on that the manufacturers, rather than the servicemen, should have been blamed for the expense of repairs and the difficulty in getting faults corrected properly when they developed.

Many manufacturers have acquired only a veneer of good design and production

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practices, and that under duress. Relieved from responsibility to Government inspectors, they will fall back into their old habits and methods. Others will hold to the improved practices they have learned. Some of the newcomers will do the same because they have not had experience in producing prewar junk.

There will be a large and highly profitable market for really good equipment, particularly in homes where ex-service radio men have learned how such apparatus is constructed. Furthermore, there will be a demand for new sets so great that price will not be a factor of competition in the beginning.

Crystal Control ★ Facilities for producing quartz crystals in enormous volume will be seeking peacetime markets. Plug-in crystals of sufficient accuracy for civilian radio use will be offered at retail prices low enough to permit their use on receivers selling above the $100 mark. Crystal control is the only method available to provide push-button tuning that is free from drift, particularly on FM tuning channels. With plug-in crystals, it will be easy to change the settings, particularly if the owner moves from one city to another.

Pushbutton-controlled tuning circuits or button-operated tuning mechanisms used in the past did not and could not give satisfaction. Many were of value only as point-of-sale features, and could not be used for their intended purpose even though they were often the deciding factor in making sales.

The real job of automatic tuning, however, will be done with plug-in crystals. Added convenience will be provided by a remote-control arrangement distinguished from prewar types by the use of a light 3- or 4-wire cable. This will control the volume and operate a stepping relay or a series of inter-dependent relays to select the desired crystal.

Built-in Systems ★ Radio wiring for built-in wall speakers and control-box receptacles will be a feature of new homes. No cabinet design can compete in acoustical efficiency with a speaker built into a wall, particularly when the rear of the speaker faces free air. This is not only the most satisfactory way to dispose of the speaker cabinet question, but is the least expensive mounting means. The volume control can be located on a wall-plate below or near the speaker, or at some distance away, depending upon the use and layout of the room. The cost of pulling in additional wires for automatic phonograph control is slight. Then the wall plate would carry an on-off switch and pilot light, volume control, station selector, radio-phonograph button, and a record-reject button. Wiring would terminate in a closet or

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POSTWAR HOME RADIO DESIGN

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compartment for a plain, metal-case radio receiver and an automatic phonograph turntable. The use of relays for the controls would simplify the wiring and assure dependable operation.

Such an installation would cost no more than the wooden console cabinet it would eliminate, the furniture problem would be disposed of in the most effective manner, and the acoustic performance of the installation would be far superior to anything that can be obtained from the most expensive cabinet radios of conventional design.

Properly presented to the public, this type of installation can be made a "must" in postwar homes, along with the new kitchen equipment.

FM Tuning ★ It is hardly necessary to mention that FM tuning will differentiate old sets from new ones. Whether the FM reception will do justice to Frequency Modulation broadcasting or not is another matter.

Back in the days when prospective purchasers asked, "Does it have short-wave tuning?" it was important to be able to say, "Yes, you can get short waves, but not here in the store because we have so much static." People accepted such answers. They asked the question mostly to show that they knew enough about radio to ask it. They didn't know what to expect of short waves, and so they weren't disappointed if they heard mostly squawks, squeaks, and shrieks.

It will be different when dealers demonstrate FM. The poor receiving conditions in the stores will tend to force the issue of FM performance. People will compare the static-eliminating characteristics of different sets. Furthermore, they will not compare the AM tone quality of one set against another. They will compare the difference between AM and FM quality of one set against another. In these factors there is demonstrable difference. The sets will speak for themselves in a manner more persuasive than salesmen's arguments.

Price Competition ★ The trade had begun to feel the influence of FM which made the months immediately following Pearl Harbor the most profitable it had known for years. There are always influences which tend to depress profits in any field. Radio has had more than its fair share in the past. It will not be without them in the future.

However, they will be offset to a substantial degree by the very significant effects of adding Frequency Modulation reception in modern radio set design. That is because FM is not a tricky way of doing the same old thing, but a brand-new means to greater enjoyment of radio entertainment.

NEW FCC POLICE RADIO REGULATIONS

A NEW regulation adopted by the FCC requires that any applicant who proposes to furnish coördinated police radio communication service to one or more municipalities, counties, or Governmental agencies *other than the applicant* must make specific formal request for authority to furnish such service. Complete description of the service to be rendered must be filed, including information as to the use of one-way or two-way communication with mobile units. Applications must be accompanied by duplicate copies, under oath, of all agreements relating to the service to be rendered. The agreement must set forth the nature of the service, and include a statement of the ownership, control and maintenance of the equipment, and what charges, if any, will be made for the service.

GLASS-BONDED MICA INSULATORS

(CONTINUED FROM PAGE 18)

time-consuming machine operations. The distance between edges of holes and between an edge of the insulator and the edge of a hole should be not less than 1/8 in. (See Fig. 1.)

Key Ways in Holes ★ The machining of key ways, slots, or notches in holes is costly and time-consuming since milling, grinding, or filing operations are required. Alternative methods of anchoring metal parts should be considered by the designer. A small hole close to the main mounting hole may be used to receive an anchoring or positioning pin. Such small holes are usually drilled partially through the insulator. If a key way is essential, a radius of 0.032 in. should be allowed on the inside corners. (See Fig. 1.)

Bushings ★ The wall thickness of bushings should be not less than as shown in the following Table:

WALL THICKNESS FOR BUSHINGS

Maximum Bushing Length (inch)	Outside Diameter (inch)	Minimum Permissible Wall Thickness (inch)
1/4	Up to 3/8	1/16
1	Up to 1/2	1/8
1	1/2 to 3/4	3/16
1	3/4 to 1	1/4

Slotted Bars ★ A radius of 0.032 in. should be allowed on the inside corners of slots cut in the edge of parts. (See Fig. 4.)

Tolerances ★ In general, and unless otherwise specified, the following tolerances should apply to all dimensions of insulators:

TOLERANCES FOR OVERALL DIMENSIONS

Length (inches)	Tolerances (± inch)		
	Length	Width	Thickness
Up to 16	1/64	1/64	1/64
16 or greater	1/64	0.020	1/64

GLASS-BONDED MICA INSULATORS

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Hole Spacing ★ A tolerance of ±0.007 in. should apply to dimensions for distances between hole centers and distances from hole centers to reference edges or reference lines. Although it is possible to fabricate to closer tolerances, such tolerances involve special fabricating tools and technique, and should therefore be avoided unless essential. (See Fig. 2.)

Hole Size ★ Standard tolerances for all hole diameters should be ±0.005 inch for all diameters up to 0.5 in., then ±1 per cent of hole diameter for all diameters 0.5 in. and greater.

Angular Dimensions ★ Where angles or V cuts are required in the edges of flat pieces, the tolerance on such angular dimensions should be ±1 degree. (See Fig. 2.)

Where angular dimensions are specified for the layout of holes, the tolerance on dimensions between hole centers should be ±0.007 inch. It is recommended that the chord distance between hole centers be indicated on drawings to assist in the layout of hole centers. (See Fig. 2.)

Flatness ★ Where flatness limits are not indicated on the drawing or specification, the limit of 0.0015 inch, per inch of length for any dimension has been adopted.

Diameter of Rods ★ A tolerance of ±0.005 inch will apply to the diameter of all round rods.

Tolerances ★ The data compiled represents that which is considered good design practice, and does not necessarily imply that closer tolerances on any important dimensions or special designs cannot be produced by special handling such as molding with or without metal inserts, hot punching, or hot forming.

The standard for glass-bonded mica was prepared at the request of the WPB by the following committee, under the chairmanship of L. J. Cavanaugh, General Electric Company; L. C. Athy, International Products Corporation (P. C. Stufft, alternate); B. R. Boymel, Navy Department, Bureau of Ships (J. R. O'Brien, alternate); T. M. Caven, Camp Evans Signal Laboratory; W. A. Evans, Bell Telephone Laboratories (K. G. Coutlee, alternate); H. E. Froberg, Colonial Kolonite Company; A. T. Krogh, Westinghouse Electric & Manufacturing Company (L. T. Mallette, alternate); Harold Miller, Aircraft Radio Laboratory; A. J. Monacks, Mycalex Corporation of America (S. D. Haberle, alternate); D. E. Replogle, Electronic Mechanics, Inc. (Robert Goldsmith, alternate); H. R. Terhune, Radio Corp. of America; and H. R. Wilsey, American Standards Association, Secretary.

SPOT NEWS NOTES

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an agreement which has to do with the welfare of the performing musicians employed by the Company to make records. The Union states that they have no dissatisfaction with either wages or working conditions which prevailed at the time of the strike.

"However, the Union has demanded that we pay money directly to them for the benefit of unemployed musicians. We are unwilling to pay money either direct to a union, or to persons not employed by us and who have never been employed by us. That is the principal point at issue, so far as we are concerned, that is holding up a settlement of the controversy.

"What complicates the situation seriously is that one record company, which was in full accord with RCA Victor and the other record companies on this important principle, dating back to the earliest conferences with the Union, has seen fit to abandon this principle, and has signed a contract which contains other provisions unacceptable to us."

Amazing: There have been cases where living persons have read their own obituaries in the newspapers, but here is a new one with a man-bites-dog twist to it — a case where the report of the expected birth of a new FM transmitter was read by the station's operating personnel.

The account was published in *Variety* where, under the caption "FCC OK's New FM-er", it was stated that the "License was granted to New York City to construct the station when material and manpower become available. Station may not be built until after the War."

Last month, on page 55, we discussed the quality of New York City's FM programs at some length. And we're sure we haven't been listening to a station that won't be built until after the War!

C. J. Burnside: Manager of Westinghouse radio division at Baltimore, received the honorary degree of Doctor of Engineering from his alma mater, South Dakota School of Mines. During almost 20 years at Westinghouse, he has served as radio engineer, designer of broadcast equipment, manager of radio engineering, and sales manager of the radio division, before he was advanced to his present post.

Television Development: An increase of 50% in the number of television stations that can operate in the television band is claimed by Scophony Corporation of America for a system using their Skiatron inventions. Laboratory experiments, according to Arthur Levey, SCA president, show that definitions of at least 1,000 lines can be obtained, which is a higher degree of sharpness than present motion picture standards require. This is due to cathode

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SPOT NEWS NOTES

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ray spot employed. If the SCA system proves commercially practical, it may result in the revision of the FCC's television standards for television transmitters and receivers. Scophony headquarters are at 527 Fifth Avenue, New York City.

Durham, N. C.: The Durham Radio Corporation has applied for construction permit to erect an FM broadcasting station.

More FM for Chicago: Moody Bible Institute station WDLM was officially dedicated on November 1st, has been operating for some time on an experimental basis. Now a regular schedule will be maintained on weekdays from 11:00 A.M. to 6:15 P.M. and from 8:00 A.M. to 10:00 P.M. Sunday programs will start at 8:00 A.M. Later, evening programs will be extended. Present power is 1 kw., to be increased to 50 kw. after the War.

Easthampton, Mass.: E. F. Russell and R. T. Pennoyer have been appointed manager and assistant manager, respectively, of General Electric's vacuum tube works at East Hampton.

War by Television: Soap-manufacturing Lever Brothers, through the advertising agency Ruthrauff & Ryan, Inc., inaugurated a new television show "The Face of the War" on November 3rd from the Dumont station in New York City. Programs will be supervised by Tom Hutchinson, director of television for R. & R. WZXWV has recently applied for commercial license, and for permission to make antenna changes.

Tube Substitution Chart: A pamphlet issued by Sylvania Electric Products, Inc., presents data on tube types for substitutions in home radios. The charts cover 150-milliampere tubes for AC-DC receivers, 300-milliampere tubes for AC-DC receivers, and various types for battery-operated sets. Reference notes indicate circuit modifications, where necessary, and show first and second choices for replacement types. The pamphlet fits standard loose-leaf binders. Copies can be obtained on requests addressed to Sylvania at Emporium, Pa.

Home Radio Questionnaire: The 227,000 stockholders of General Electric Company are being asked to indicate the features they hope to find in postwar radio sets. A booklet illustrating various styles of radios, together with a questionnaire postcard, have been sent with each third-quarter dividend check. Stockholders are also being asked when they plan to buy new receivers and if they want FM tuning. One question relates to wood finish and color, a matter which has always been a serious problem. No reference is made to television.

COST OF TELEVISION RECEIVERS

LATEST to promise low-priced television receivers is Klaus Lansberg, director of television at Paramount Pictures' station W6XYZ, stating that "Wartime mass production of similar equipment has shown the way for production of television receivers below $100."

Experience with television equipment built at the time of the New York World's Fair has shown that those sets were built too cheaply, if service over any considerable time is to be expected.

And if the same sets were built today, they would cost much more, for the average pay of radio factory workers has more than doubled. Comparisons with the cost of military equipment are dangerous, too, because selling prices under Government contracts do not allow for jobber and dealer discounts. The only specific reduction now in sight is in the prices of cathode ray tubes. There is a good reason why the price of cathode ray tubes should come down. Before the War, they were virtually hand made. Now production machines are used.

FROM A SIGNAL CORPS INSPECTOR

A RADIO ENGINEER is a person who passes as an exacting expert on the basis of being able to turn out with prolific fortitude infinite series of incomprehensible formulas calculated with micrometric precision from vague assumptions based on debatable figures taken from inconclusive experiments carried out with instruments of problematical accuracy by persons of dubious reliability and questionable mentality for the avowed purpose of annoying and confounding a hopelessly chimerical group of esoteric fanatics referred to all too frequently as Practical Radio men.

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

tion of the equipment is authorized by the Government, the reservation of equipment is not a purchase contract. It merely establishes a priority rating for delivery. The customer retains title to the Bonds, and receives the income while they are on deposit. The War Bond deposit can be withdrawn at any time, upon request, and without penalty.

The following table shows the Bond deposits required for FM transmitters and associated equipment:

FM BROADCAST STATIONS

	Maturity Value
¼-kw. transmitter	$250
1-kw. transmitter	400
3-kw. transmitter	700
10-kw. transmitter	1,200

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WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 57)

PAUL L. CHAMBERLAIN EXPLAINS THE G.E. EQUIPMENT RESERVATION PLAN

50-kw. transmitter	3,500
1-bay antenna, less mast	50
2-bay antenna	125
4-bay antenna	250
Station monitor	50
Speech input	125
S-T relay transmitter and receiver	300

AM BROADCAST STATIONS

	Maturity Value
5-kw. transmitter	$1,200
50-kw. transmitter	5,000
500-kw. transmitter	15,000

From this it will be seen that equipment for a complete 1-kw. FM transmitter, S-T relay, and 2-bay antenna, except for the mast, can be reserved by depositing only $1,000 in War Bonds. Here, then, is material for formulating definite plans by prospective broadcasting organizations, and for present AM broadcasters who expect to add or shift to FM when the time comes to go into action.

W. R. David, in charge of broadcast transmitter sales, made the startling statement that G. E. expects that "FM will eventually supplant all local, most regional, and some of the high-power AM stations now in operation." He further predicted that within five years the present 50-odd FM stations will be increased to 500, and the 900 AM stations now on the air will be reduced in number to 750.

This seems to be an overly-conservative estimate if any progress is to be made in eliminating heterodyne interference between AM stations. This would probably call for cutting down the number of AM broadcasters to 250, in which case the FM

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WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 58)

DR. W. R. G. BAKER, SPEAKING AT THE GENERAL ELECTRIC LUNCHEON

stations might very well total over 1,000.

Mr. David discussed the development of FM relay stations for network operation in some detail. These will be automatic, unattended receiver-transmitter installations working on very high frequencies with directional antennas to form radio program highways in the ether. Programs can be passed on from one station to another an indefinite number of times without loss of quality because of the high fidelity and freedom from static interference on FM. The input power required for FM transmitters is much lower than for AM transmitters of the same range.

Whether FM relay stations will be set up as a public utility, similar to the telephone system, or as an auxiliary operation of radio networks, only time and the FCC will determine.

As for the immediate postwar market for new home radios providing FM reception, figures were presented which showed that 50,000,000 people live within range of the FM stations now on the air. This indicates a market which can absorb 12,500,000 new receivers.

These statements represent the considered opinions of one company. Announcements from others will undoubtedly follow from RCA, REL, and Western Electric. These, with G.E. were the four prewar manufacturers of FM broadcasting equipment. There is no question but what their combined efforts will result in the sale and erection of a considerable number of new FM stations immediately following the thaw of the FCC's freeze order.

To manufacturers of home radios, each new station will mean a further increase in the demand for new sets — equipped with FM circuits. — *Milton B. Sleeper.*

Gene O'Haire illustrates and analyzes war news with maps. This Wednesday night feature has a rating of 2.37 out of 3.00.

Amateur boxing matches draw a large studio audience. This feature has a rating of 2.35 out of 3.00.

Light operas and operettas are presented by well-known college and other amateur groups. A recent hit showed a rating of 2.26 out of 3.00.

A "home" program of helpful hints for the housewife suggests housekeeping time savers. The program rates 2.23 out of 3.00.

COME TO SCHENECTADY . . . and See Your Future Television Station in Action

To you, the future telecaster, General Electric offers as an aid to your planning a wealth of television programming and manufacturing experience.

Station WRGB in Schenectady is General Electric's television workshop. It is one of the finest and most complete television studios in the world.

At WRGB programs are created, studied and analyzed. Live talent multiple-scene productions are staged at low cost. Audience reaction is constantly checked and a rating established for every show. Operettas, civic meetings, variety shows, drama, sports events, and educational features are but a few.

Enthusiastic responses and repeated requests from an interested studio and home receiver audience prove the success of WRGB's weekly features—reactions providing abundant information which G.E. will gladly share with those considering television for after the war.

WRGB workshop is another example of General Electric's service to the broadcasting industry.

Within the limitations imposed by 100% war production, General Electric is planning and developing post war television. Experiments are constantly in progress. As a result, programming refinements seen nowhere else often are to be seen at WRGB.

If you are in the broadcasting field, or interested in building a television station after the war, COME TO SCHENECTADY and inspect WRGB in operation. No other manufacturer of television broadcasting and receiving equipment offers so much knowledge and experience as General Electric. You are welcome at WRGB. Write . . . *Electronics Dept., General Electric, Schenectady, N. Y.*

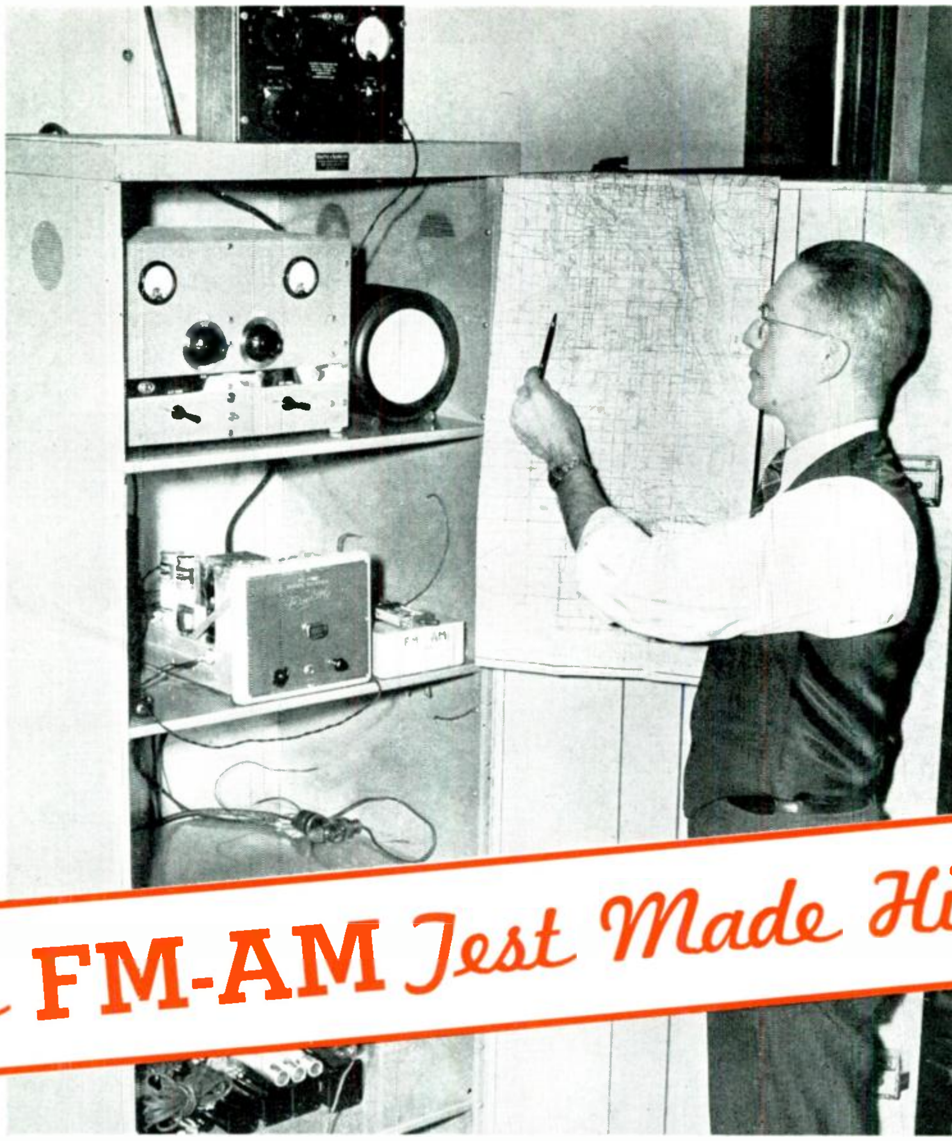
Tune in "THE WORLD TODAY" and hear the news direct from the men who see it happen, every evening except Sunday at 6:45 E.W.T. over CBS. On Sunday listen to "The Hour of Charm" at 10 P.M. E.W.T. over NBC.

GENERAL ELECTRIC FM · TELEVISION · AM

160-B9

COMPLETE STATION EQUIPMENT • STUDIO EQUIPMENT • TRANSMITTERS • ANTENNAS • ELECTRONIC TUBES • HOME RECEIVERS

1940



This FM-AM Test Made History

IN 1939, the Chicago Police Department decided to add talk-back transmitters to their patrol-car receivers. Various AM equipments were tested, but performance was not reassuring. It lacked the necessary degree of certainty.

A serious handicap was the high intensity of interference set up by great banks of elevator controls and relays, and by the ventilating machinery adjacent to the headquarters receiving station in the tower of the Field Building.

Then, in March, 1940, an REL Frequency Modulation transmitter was installed in one of the patrol cars, and an REL receiver was set up at headquarters.

Comparative talk-back tests were made from AM- and FM-equipped cars, under the direction of Fred H. Schnell, then radio engineer for the Chicago Police Department. The same antenna was used for both AM and FM reception as the cars cruised around the city.

On every count, the REL equipment, using Armstrong phase-shift modulation with crystal frequency control, proved superior to the best AM performance. As a result of this test, the City of Chicago purchased 200 REL Frequency Modulation transmitters for their police cars. This was the first police communications system to be modernized with FM equipment.

LOOK TO REL FOR PEACETIME LEADERSHIP

Engineering improved equipment for War today, REL is planning further improvements for Peace tomorrow. Among these will be REL "packaged" FM broadcast stations, low in cost and easy to erect, for communities which now lack adequate, enjoyable, static-free radio entertainment.

REL

RADIO ENGINEERING LABS., Inc.
Long Island City 1 New York

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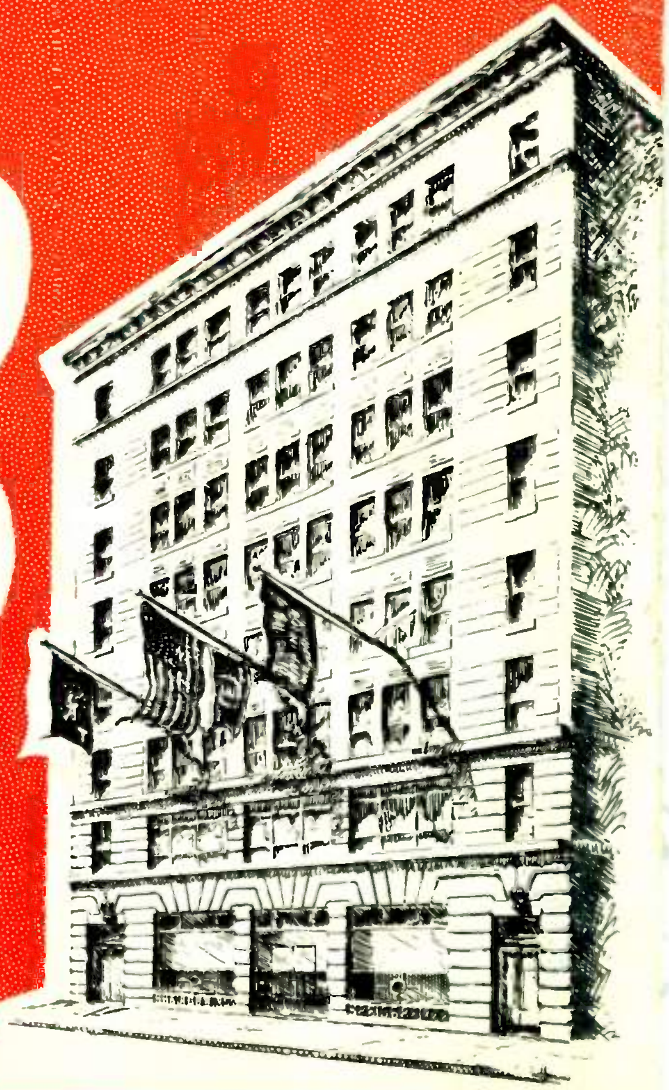

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