

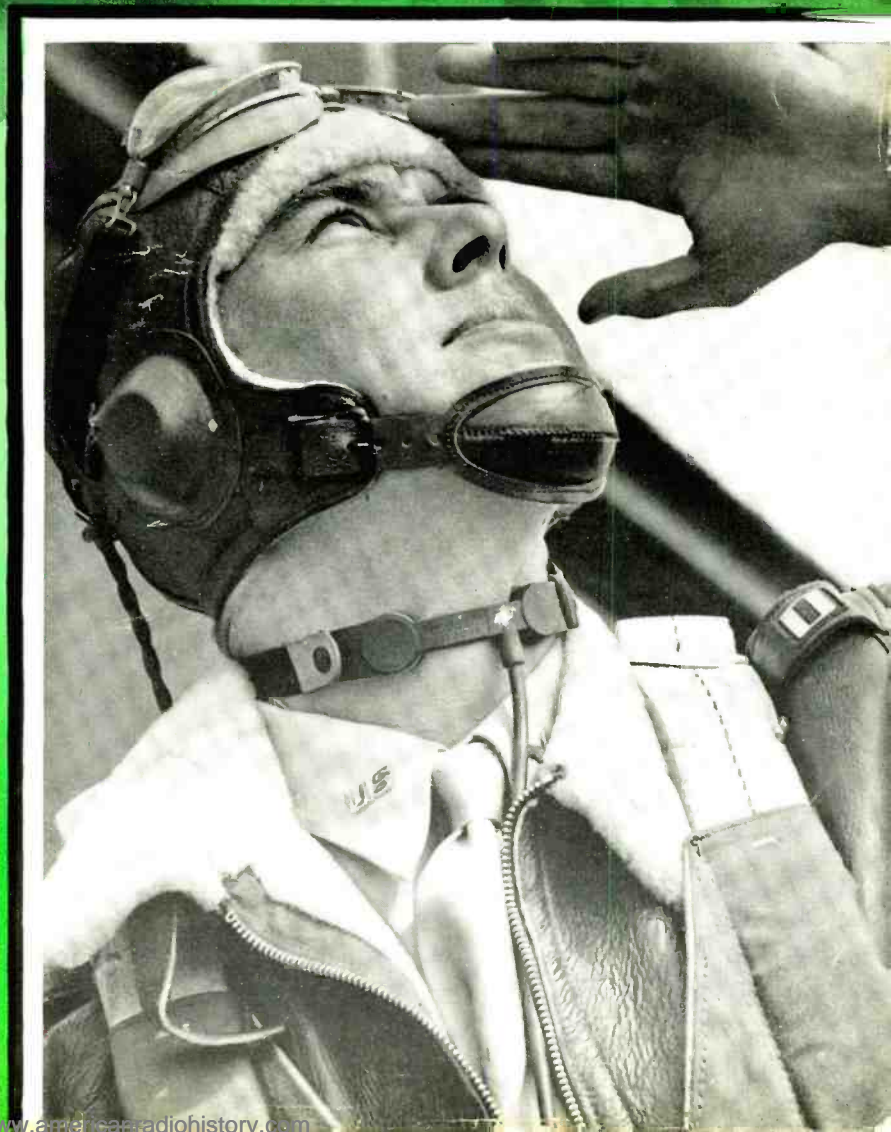
COMMUNICATIONS

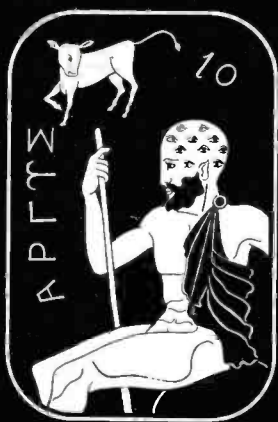
**INTERFERENCE
ANALYSES**

**CATHODE
APPLICATIONS**

**NATIONAL
DEFENSE**

**OCTOBER
1941**





Argus, Guardian

Watchful, hundred-eyed Argus, of mythological fame, had a principal role. He was guardian for the gods.

Equally important in the radio field is the part played by another guardian—Collins inspection department. All-seeing as Argus, inspection's concern is the close surveillance of components and parts that go to make up a transmitter. Inspection

examines all units, its concern to see that all meet fully the rigid specifications demanded of them.

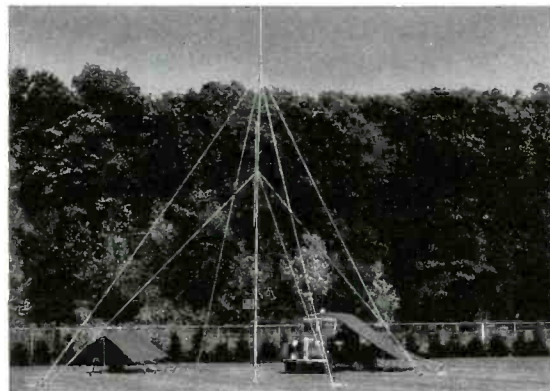
With modern precision testing devices and up-to-date methods, Collins inspection department is our keeper of quality, your guardian of reliability in your Collins transmitter.

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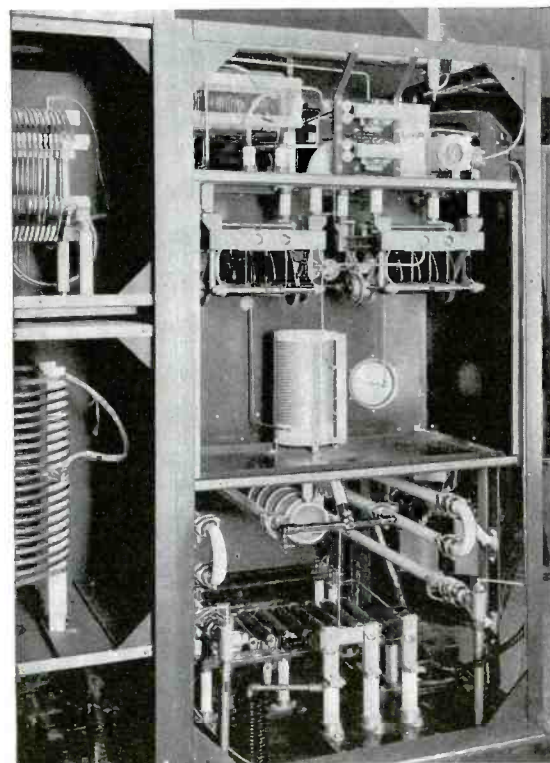


INSULATION HIGHLIGHTS

(Left) COLLAPSIBLE ANTENNA, designated type KS-10070 by the Western Electric Co., Inc., is designed for easy transportation by truck to scene of a field emergency. Photographs illustrate the individual sections in a specially built truck compartment and a completely erected antenna with support ready for use in the field. Isolantite* and Western Electric engineers collaborated in the design and development of this antenna using a special internal coupling which makes for speedy assembly and mechanical stability. The Radio Specialty Division of Isolantite, Inc. is equipped to assist in the development and manufacture of custom-built antenna equipment such as illustrated, in addition to offering a complete line of radio transmission line equipment.



(Below) IN BROADCAST TRANSMITTERS, also, Western Electric makes extensive use of Isolantite's desirable properties. Photo shows rear view of the 50 KW transmitter at Station WJSV, Washington, D. C.



(Above) TELEVISION ANTENNA developed by the General Electric Co. at Schenectady for use with their studio-to-station transmitter. Main transmitting station is located in the Helderberg Mountains—12 miles away. Isolantite insulators of stand-off and lead, in variety and radio transmission line equipment are extensively used in connection with special television apparatus.

*Registered trade-name for the products of Isolantite, Inc.

ISOLANTITE

CERAMIC INSULATORS

ISOLANTITE, INC. FACTORY: BELLEVILLE, NEW JERSEY
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 F. WALEN, Associate Editor

COMMUNICATIONS

Including Television Engineering, Radio Engineering, Communication & Broadcast Engineering, The Broadcast Engineer. Registered U.S. Patent Office.
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We See...

THE RECENT SPAB RULING COVERING curtailment of public or private construction projects, using critical materials such as steel, copper, bronze, aluminum, etc., has a heartening word for those in the communications world. For the ruling also says that if these projects are either necessary for direct National Defense, or are essential to the health and safety of the people, full permission to proceed will be granted. Thus, the communications industry, serving so many public essentials will be able to proceed with its plans of development, design and construction. This green light will only prevail, of course, if these plans include truly vital projects. If they are just additional projects that will do little to improve the effectiveness of transmission and thus not materially benefit public service, restrictive measures will have to be enforced. In this respect, the FCC will undoubtedly become a new major factor.

ENGINEERING CONVENTIONS AND MEETINGS today have become major centers of importance to everyone. With the advent of an unusual cycle of engineering developments, including intense activity prompted by National Defense, the papers now presented are full of technical "dynamite." And with the close material alliances established by the priority situation, attendance at not only at radio engineering meetings is imperative, but also at meetings of the plastic, chemistry, mechanical, motion picture and other associated engineering groups. Outstanding specialists are presenting data that are invaluable in design, development and manufacture today.

MOBILITY IS RAPIDLY BECOMING THE by-word of design today. With increased pressure being exerted on plane, tank, truck and boat manufacturers, transmitter and receiver units with mobile characteristics are first in line of development. As a result we shall see new trends of design that will set new standards of structure.—L. W.

OCTOBER, 1941

VOLUME 21 NUMBER 10

COVER ILLUSTRATION

Held snugly against the throat of this airman are two microphones that permit him to converse in battle by radio, unhampered by the conventional microphone. Sensitive only to the vibrations of his vocal cords, the "throat" microphone transmits no noise of wind, gun or motor.
(Photo courtesy Western Electric Co.)

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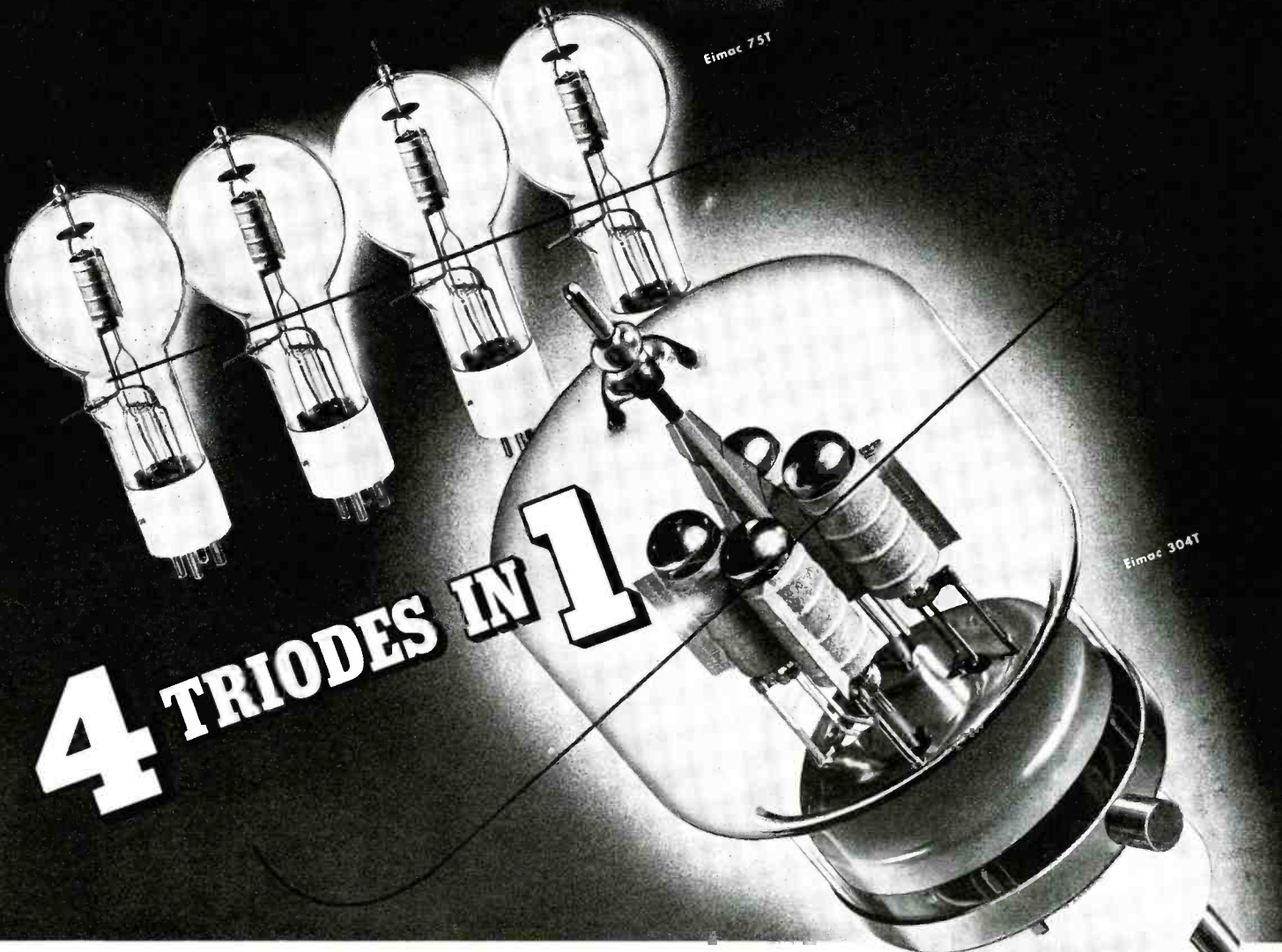
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4 TRIODES IN 1

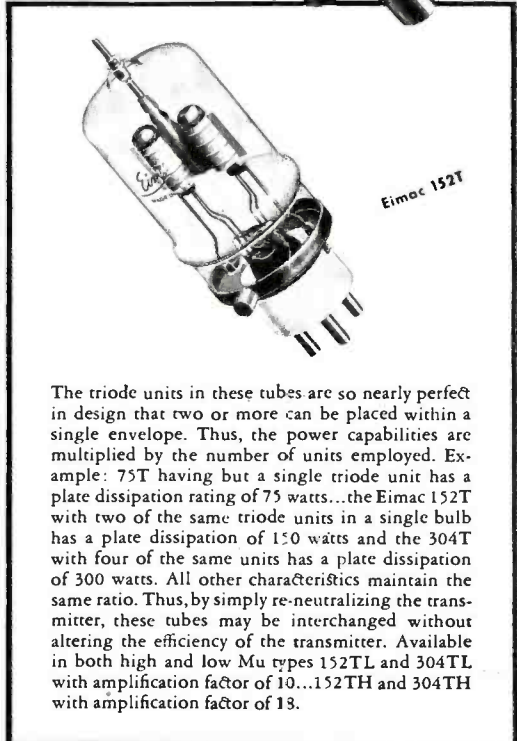
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- Distortion less than 3%, 50-7,500 cycles
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The RCA Model 1-K consists basically of the Model 250-K transmitter plus a matching amplifier unit. 250-watt stations with Model 250-K can increase power to 1,000 watts easily and at very low cost.



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CATHODE DESIGN

Vital to tube efficiency, cathodes demand critical supervision in their choice in various type vacuum tubes.

by O. W. PIKE

Vacuum Tube Eng. Dept., General Electric Co.

BY DEFINITION, a vacuum or electron tube is a device consisting of an evacuated enclosure containing a number of electrodes, between two or more of which conduction of electricity through the vacuum or contained gas may take place. Such conduction requires a source of electrons either to carry the current or to initiate the gaseous discharge. Therefore, such a source, which is normally the cathode of the tube, is a basic part of all vacuum tubes.

Cathodes for vacuum tubes are of three basic forms, namely, the hot or thermionic type, the pool type, and the so-called cold cathode.

The pure metallic type is the oldest form of hot cathode. It consists usually of a wire heated to an incandescent temperature by current passing through it. Drawn tungsten is by far the most common material, although other materials, such as tantalum, are used on occasion.

One advantage of this type of cathode is that the electron emission produced has a relatively high stability in comparison with other forms. It is true that the surface condition affects the emission somewhat, but from a practical standpoint it is the most predictable of all cathodes. Another advantage is that pure metal does not contain activating materials which act as a source of contamination of other parts of the tube. Furthermore, the gas content is low and the filament can easily be exhausted by flashing at higher than normal temperature.

The main disadvantage is that the emission efficiency is relatively low; a secondary disadvantage is that the high temperature involves some difficulty from the standpoint of mechanical support.

Practically any life within reason can be obtained from pure-tungsten cath-

odes by designing for sufficiently low temperature. However, the emission efficiency drops as the temperature is lowered; thus greater wattage for the same emission is required. It follows that the life of this cathode is basically a function of the wattage for which it is designed. There are two limitations with regard to this wattage. First, it has to be dissipated within the tube, with the result that the size of the tube, and the cost, increases with the wattage. Second, there is the limitation of power cost which in effect determines the optimum design of the cathode. Where the power cost is low a long-life tube, i. e., one operated at lower temperature, is justified. This in turn justifies the higher initial tube cost necessary for dissipating the power. Where the power cost is high, a high temperature and shorter life tube with lower first cost is indicated.

During life the filament evaporates. If it is operated at constant current, the temperature increases with resultant accelerated evaporation and greatly increased emission. Operation at constant voltage is recommended, therefore, as this prevents the accelerated evaporation. Some decrease in emission is encountered during life, but this is partially offset by improved surface conditions.

Where the tube operates intermittently, it is desirable to remove filament power, if the off-period is over two hours, or to operate at 80 per cent of normal voltage if the off-period is less. This has no detrimental effect on the emission in a tungsten filament tube and should be done wherever possible in order to increase filament life.

The cold resistance of pure-tungsten filaments is about one-tenth that at operating temperature. The initial cur-



Figure 1

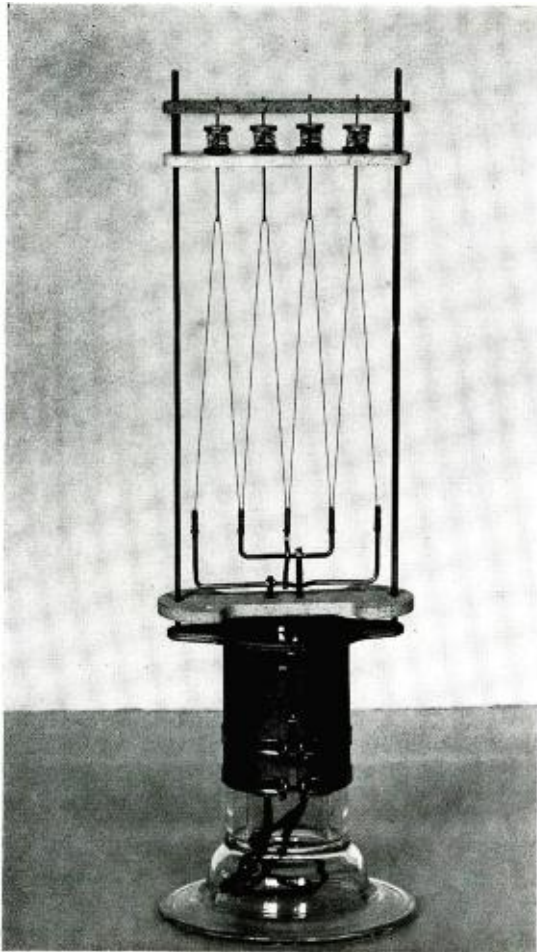


Figure 2
 Typical Thoriated
 Tungsten Cathode
 for low voltage
 transmitting tube.
 This particular ca-
 thode has a com-
 paratively high
 emission factor,
 with a correspond-
 ing low gas content.

rent is, therefore, extremely high and with the larger filaments some form of current limitation at starting is necessary. It is usually recommended that the initial surge be kept below one and one-half to twice normal current.

Large tungsten filaments, when used in radio tubes, sometimes produce appreciable hum due to modulations resulting from the filament voltage and current. One method of minimizing this hum is to design the filament for poly-phase operation in such a manner as to neutralize these effects. Although this method is being used successfully in many tube types, it does increase their complexity and cost and is of doubtful economic value in comparison with hum-reducing, circuit feedback schemes, or d-c filament excitation. Figure 1 shows a highly developed form of pure-tungsten multi-phase cathode for a high-voltage transmitting tube.

The thoriated-tungsten filament utilizes a means for improving the emission efficiency over that obtained with pure tungsten. The filament material in this case is activated by the introduc-

tion of thorium oxide into the base metal, which is later reduced to pure thorium and forms a mono-molecular layer on the surface of the filament. The emission efficiency of this layer is many times that of pure tungsten and depends upon the percentage of the tungsten surface covered. The cathode is operated at the optimum temperature for the replenishment and maintenance of this layer. Too high a temperature tends to evaporate the thorium. The surface can also be harmed by positive ion bombardment resulting from gas in the tube. Figure 2 illustrates a typical thoriated-tungsten cathode for a low-voltage radio transmitting tube.

The advantage of this cathode lies in the relatively high emission efficiency and the fact that the filament has the same low gas content as pure tungsten.

The disadvantages are that the emission, which is proportional to the perfection of the thorium layer, depends for its stability not only upon design, but also upon careful processing so as to form the layer properly. Furthermore, sufficient exhaust to minimize

positive ion bombardment is necessary. In addition, the emission stability depends upon operating with proper cathode temperatures and under such tube load conditions that the gas content of the tube is kept at a low level. This type of filament is a possible source of contamination as the thorium may, under certain conditions, tend to activate other parts of the tube, such as the grids. It is necessary, therefore, to design the tube so that these parts are sufficiently cool to prevent excessive emission.

The choice of temperature for the filament is a rather delicate one. The normal figure is around 2000 K at which a filament has several thousand hours life. This life for some operating conditions can be increased by reducing the filament temperature, but the emission stability tends to suffer due to less replenishment. Under certain severe uses it is even desirable to increase the temperature beyond this figure in order to provide greater emission stability at the expense of life. Under practical conditions filament voltages are seldom maintained constant. Where the variations are excessive it is always safer to set the filament voltage higher than normal in order that, with the minimum filament voltage, ample emission is available. Emission-limited operation of thoriated filament tubes may easily cause damage to the filament.

Where the load on the tube is intermittent, it is recommended that the filament be maintained at 80 per cent of normal voltage during standby periods of less than two hours. This tends to keep the cathode surface replenished and makes it more quickly available when raised to normal filament voltage. If the off period is less than a few minutes, it is probably best to operate the filament at full voltage continuously, as an excessive number of heating and cooling cycles tend to distort this type of filament.

Oxide-coated cathodes consist essentially of a base metal which was originally platinum, but is now almost always nickel or some alloy of nickel that has been coated with one or more carbonates of materials having high emission frequency. These carbonates are commonly those of barium, strontium and, in some cases, calcium. They are reduced during exhaust to a combination of oxide and pure metal. It is generally accepted that the actual emission is obtained from this pure metal which is in greatest concentration at the interface between the coating and the base metal.

One advantage of the oxide-coated surface for cathodes is that its emission stability is not too high plate volt-

ages, is greater than the thoriated type, although not so good as that of pure tungsten. This emission source is subject to some chemical contamination by gas within the tube, but it will stand up under considerable positive ion bombardment. Such a filament, therefore, is suitable for use in gaseous discharge tubes where the bombarding voltage is not allowed to become too high. It will also operate in high-vacuum tubes with considerable gas content. The emission efficiency is even higher than that of the thoriated type, approaching in many cases 100 ma per watt for filaments in vacuum. In gaseous tubes this efficiency can be increased many fold by heat-conserving cathode designs and by field emission. The latter is a phenomenon, whereby emission currents, greatly in excess of those accountable by purely thermionic means, are obtained. The operating temperature of oxide cathodes is relatively low which is also an advantage from the standpoint of tube construction.

One disadvantage of these cathodes is that they are a potent source of gas. Although much of this gas is removed during the exhaust process of the tube, its presence does place a limitation on the voltage at which tubes employing this cathode may be used in the case of high-vacuum tubes. Here their use at greater than 1000 volts is not common, except in European practice. These cathodes are also a very active source of contamination and require very careful tube design to minimize emission from other parts of the tube. This is accomplished by operating these parts sufficiently cool and, particularly in gas tubes, by shielding other parts from the cathode.

Oxide-coated cathodes take many physical forms. For high-vacuum tubes, ribbon filaments and simple cathode surfaces, such as cylinders, are commonly used. In gas tubes, however, due to the elimination of space-charge drop, large distances between the cathode and other parts of the tubes are permissible and the cathode may actually consist of cavities without affecting the tube drop appreciably. For this reason, oxide-coated cathodes in gaseous tubes have taken the form of a variety of surfaces around which are one or more heat-conserving shields. Figure 3 shows a filamentary-oxide-coated cathode with a single shield. By this means the emission efficiencies have been increased to as high as one ampere per watt. Due to the thermal capacity of such cathodes, the heating time necessary for bringing them to operating temperature is very long, in extreme cases as much as one-half hour. In general, it can be said that the efficiency and heating time are roughly propor-

Figure 3
 Filamentary Oxide
 Coated Cathode
 with Single Shield.
 With the aid of this
 special heat-conserv-
 ing shield, it is pos-
 sible to increase the
 emission efficiency
 to as high as one
 ampere per watt.



tional. A single shield around a filament increases the efficiency to about three times that of an open filament, while increasing the heating time from the order of five to the order of 30 seconds.

Oxide-coated cathode surfaces may be heated in a number of ways. The cathode can consist of a filament carrying its own current and heated thereby. It can also consist of a tungsten filament radiating to an adjacent surface. Similarly, this surface may receive its heat by conduction. Another method is to apply a voltage between the heater and the cathode surface, and draw current from the heater to the surface, thus heating the actual emission surface by bombardment. The choice of these several methods depends upon the detail tube design.

The optimum temperature for the operation of oxide-coated cathodes depends to a considerable extent upon their use. In general, the trend in the high-vacuum type has been toward lower temperatures, as the cathodes under these conditions obtain some activation by the current carried through the tube, and grid emission is mini-

mized. From 700-800 C. is common for this type. In the gas types, including mercury vapor tubes, the tendency has been toward increased cathode temperatures. Under many severe uses, temperatures in excess of 900 C. are common. High temperatures are largely for the purpose of providing more rapid replenishment of the emissive metals, thereby compensating for the chemical contamination and positive ion bombardment encountered in gaseous tubes. In general low-voltage tubes have less contaminating effect and, therefore, can be operated at a somewhat lower cathode temperature with a resultant increase in life.

When variation in filament voltage is encountered, it is very important to choose properly the voltage for any given application. In general, the tendency of most users is to set the filament at too low a voltage in the expectation of obtaining longer life. This has resulted in the most common cause of failure of these cathodes, namely, loss of emission due to too low a replenishment rate. It is recommended that the published value of filament voltage be

used except where excessive voltage variations occur. In that case, the filament voltage should be set so that it is never more than five per cent below the published value. In the case of intermittent operation, it is recommended that filament voltage be maintained at the full value at all times, unless the off period is greater than two hours, in which case it is usually suggested that it be removed entirely during that time.

In the case of filamentary-oxide-coated cathodes, if the value of tube current is appreciable in comparison with the load current, uneven heating is encountered under load. In extreme cases this affects tube life, but the effect may be minimized by placing the cathode voltage as nearly to 90 degrees out of phase with the anode voltage as possible. Even a 60 degree displacement is quite effective.

Recently a new form of cathode has been given considerable use. A hybrid between the thoriated and oxide-coated varieties, it is known as the thoria-coated type; here the base metal, usually consisting of tungsten or molybdenum, is coated with thorium oxide. It is operated at temperatures approximating the thoriated filament, and the emission comes from pure thorium. The emission surface is produced by reduction in a manner similar to that in a barium cathode, and the emissive metal is probably located at the inter-face as in the case of barium cathodes. Compared with the thoriated filament, its emission stability is very high, perhaps even higher than that of the oxide-coated forms. The emission efficiency is approximately the same as that of thoriated filaments. However, the thoria-coated cathode is more like the oxide-coated type in the amount of gas and contamination it produces. The extent to which this type of cathode will be used is still problematical.

Generally speaking, in all forms of hot-cathode tubes, correct filament voltage is of utmost importance if good operation and long life are to be obtained. The majority of the troubles encountered with these tubes can be assigned to incorrect voltage. Filament connections should be adequate in design, and all measurements of voltage should be made directly at the terminals in order to detect poor connections. Regulating transformers that minimize voltage variations are available, and are justified economically much more often than realized.

The second general form of cathode is the pool type, which has been used for many years in mercury-arc rectifiers. It consists essentially of a metallic pool which is usually liquid mercury rendered active by a cathode spot on the surface. In the original form this

spot is maintained by an arc discharge between the pool and a holding anode, and the cathode is continually active. The arc can be initiated in a number of different ways. Tilting the tube so as to place the mercury in contact with the holding anode is the method generally used in the old mercury-arc rectifiers. A modification utilizes the so-called "grasshopper" starter in which a metal point is brought in contact with the pool by means of an external magnet, and an arc drawn as this contact is released. The arc can also be started by means of high-frequency discharge applied either to the external wall of the tube or to an internal electrode. In an elaboration of this latter method, an insulated conductor is placed adjacent to the mercury pool, and the arc initiated either by high frequency or high voltage applied to this conductor. Finally the arc can be initiated by immersing a pencil-like electrode, consisting principally of boron carbide, in the pool, and passing current through this electrode, which is called an ignitor.

These last two methods of initiating the arc on a mercury pool are sufficiently accurate so that the arc can be produced every cycle and at any time in the cycle that is desired. When the first of these methods is used, the tube is known as the capacitron, while the immersed electrode type is known as the ignitron. An ignitron for welding control is illustrated by Figure 4. There is a real advantage in not maintaining an arc at all times on the cathode surface,

particularly in conjunction with single-anode tubes, because such tubes completely deionize on the inverse half of the cycle, and improved ability to withstand inverse voltages results. Moreover, since the arc-drop in ignitors is lower than that in conventional mercury-arc rectifiers, higher efficiency results.

The pool type of cathode has some positive advantages. Once the cathode spot is initiated, it is practically an unlimited source of current. Therefore, it is very useful where large values of currents are required, as in resistance welding. Furthermore, a pool cathode is practically indestructible in the sense that the emission is independent of gas in the tube, or of the usual forms of cathode poisoning. It is difficult, of course, to compare the efficiency of a pool cathode with the various forms of hot cathodes. In the holding-arc type some 250 watts are required to maintain the arc, while in the case of the capacitron or ignitron very little actual power is needed to initiate the arc. In either case these are fixed losses, so that the efficiency is dependent purely on the amount of current drawn. From the standpoint of contamination of other electrodes, the pool cathode is excellent in that there is no activating material commonly used in connection with it.

The disadvantages of the pool cathode have to do with the difficulty of initiating the arc. Considerable auxiliary apparatus is required either by the holding anode or the cycle-by-cycle type. For this reason it is not particularly suitable for low currents. Mechanically it has limitations due to the fact that the pool is usually liquid.

In practice today, very large multi-anode mercury rectifiers still use the holding anode principle, but these rectifiers are fast being supplanted for power purposes by single-anode ignitron units. This type of tube is used almost entirely for high-current control. Capacitrons have limited use in comparison with ignitrons, due to their poor reproducibility of starting characteristics during life.

Ignitrons are energized in a number of different ways. In any case, it is necessary to prevent any great amount of reverse current, that is, current from the pool to the ignitor, as this disintegrates the ignitor. It is necessary, therefore, to energize them through some form of rectifier. This may be either a hot-cathode tube or a copper-oxide rectifier receiving power from the anode of the tube or from a separate source. The trend at present is to use anode firing in the simpler forms of control uses, and separate excitation in the power field. Where control of the start-



Figure 4
Ignitron for welding control.

(Concluded on page 28)

THE IRE FALL MEETING

THOSE attending the Fall meeting of the IRE will hear a most interesting group of papers, with National Defense and its effect on many phases of radio engineering receiving the spotlight, in many instances. For instance, W. E. Ruder, of General Electric will discuss various types of new magnetic materials that have been developed, many due to the priority situation. Iron cores and their use in audio frequency applications will be treated by W. J. Polydoroff in his talk on the latest advances in iron cores. This will be the first analysis of this application of powdered iron to AF.

The plastic situation will be covered by H. M. Richardson, who is Chief Engineer of the plastic division of General Electric. How various substitutions have been made and will be made, will be told. As head of one of the largest producers of plastic projects, Mr. Richardson is most capable of analyzing this field, that has become one of the most talked-about industries of the day.

Another interesting discussion on National Defense and its problems, will be given by Dorman Israel, Chief Engineer of Emerson. Specifically, Mr.

H. M. Richardson, Chief Engineer of General Electric Plastic Department at Pittsfield, Mass., who will address the IRE at Rochester on Wednesday, Nov. 12. He will discuss the many articles that may eventually be 'plastic-made', as his studies with items shown at right have proved.



Israel will describe the receiver of 1942, with its many new points of design, based on material restrictions. As a member of the committee devoted to study and solve the many difficulties receiver manufacturers may have, Mr.

Israel has compiled vital data that will be of immeasurable design aid.

The popular "alert receiver" that has received so much comment recently, will be demonstrated and discussed by two
(Continued on page 35)

PROGRAM

Monday, November 10

- 8:30 A.M. Registration.
Inspection of Exhibits.
- 9:30 A.M. Technical Session:
"A Method of Introducing Good Synthetic Bass Response Into Small Receivers" (With Demonstration), F. H. Shephard, Jr., Revelation Patent Holding Corporation.
- "The Design of Solid Dielectric Flexible R-F Transmission Line," Dr. Harner Selvidge, American Phenolic Corporation.
- "Some New Aspects of Radio Engineering Economics," E. L. Hulse, General Electric Company.
- 12:30 P.M. Group Luncheon and Committee Luncheons.
- 2:00 P.M. Technical Session:
"Design Considerations for a Video Signal Generator with Monoscope Signal Source," O. H. Schade and H. De Ryder, RCA Mfg. Company, Radiotron Division.
- "The Skin Effect and the Depth of Penetration," H. A. Wheeler, Hazeltine Service Corporation.
- 4:00 P.M. Inspection of Exhibits.
Committee Meetings.
- 6:30 P.M. Group Dinner.
- 8:00 P.M. Technical Session:
"A Three Hundred Kilovolt Electron Microscope," V. K. Zworykin, J. Hilliar, and A. W. Vance, RCA Mfg. Co., Victor Division.

Tuesday, November 11

- 8:30 A.M. Registration. -
Inspection of Exhibits.
- 9:30 A.M. Technical Session:
"Annual Message of RMA Director of Engineering," W. R. G. Baker.
- "Discussion of Tube Noise Phenomena," W. L. Krahl, Hygrade Sylvania Corporation.
- "Design of a F-M Signal Generator," C. J. Franks, Boonton Radio Corporation.
- 12:30 P.M. Group Luncheon and Committee Luncheons.
- 2:00 P.M. Technical Session.
"New Magnetic Materials," W. E. Ruder, General Electric Company.
- "Design of a Modern 400 Mc. Signal Generator," John M. Van Beuren, Measurements Corporation.
- "New Advances in Iron Cores," W. J. Polydoroff, Consulting Engineer.
- 4:00 P.M. Inspection of Exhibits.
Committee Meetings.
- 6:30 P.M. Fall Meeting Dinner (Stag).
Toastmaster, L. C. F. Horle. (Speaker and Subject—to be announced later.)

Wednesday, November 12

- 9:00 A.M. Inspection of Exhibits.
- 9:30 A.M. Technical Session:
"Some Observations Concerning the Transient Behavior of Radio Noise Meters," C. M. Burrill, RCA Mfg. Company, Victor Division.
- "The Use of Plastics in the Radio Industry," H. M. Richardson, General Electric Company.
- "Civilian Receiver Design, 1942," Dorman D. Israel, Emerson Radio & Phonograph Corporation.
- 12:30 P.M.— Group Luncheon and Committee Luncheons.
- 2:00 P.M. Technical Session:
"Alternate Carrier Synchronization in Television," F. J. Bingley, Philco Corporation.
- "Receiver Controlled by Transmitted Signal—Alert Receiver" (with Demonstration), S. W. Seeley and H. B. Deal, RCA License Laboratory.
- 4:00 P.M. Committee Meetings.
Exhibits Closed.
- 6:30 P.M. Group Dinner.

WABC AT COLUMBIA ISLAND

A VARIETY of physical, electrical and mechanical innovations have been incorporated in the new WABC 50 kw transmitter at Columbia Island, near New Rochelle, New York, the first self-contained island transmitting unit ever successfully constructed.

Two transmitters are housed on this island. One is the 50 kw unit, which is normally in operation, and the other is an emergency 5 kw transmitter. In the event that trouble exists in the driver circuit of the 50 kw station, it is possible to energize RF relays that will connect the output of the 5 kw transmitter to a driving position for the 50 kw unit. Or, if trouble exists in the 50 kw amplifier, the 5 kw transmitter can be put on the air completely independent of any equipment associated with the larger transmitter.

Each transmitter contains duplicate low level amplifiers and crystal oscillator buffer stages, all of which are mounted on shelf-like trays, which can be removed for maintenance on a convenient bench. There are also two complete audio channels, which, through a system of selective relays, feed audio signals into whichever transmitter is on the air.

Sea Water for Cooling

Sea water is used for cooling the water-cooled system. This does not mean that the sea water is pumped from the sea to spray and cool the tubes directly. Instead, the sea water is used to cool radiators which carry distilled water that cools the tubes. There is a distinct advantage to this unique system, in that sea water changes very little in temperature as the seasons

Island, formerly completely barren, now houses unique transmission system, with a host of new features.

by DONALD PHILLIPS

change, whereas the normally used air for cooling is naturally subject to many seasonal changes. It is, however, entirely possible to operate without this sea water cooling system, in the event that the surrounding waters happen to freeze. In that event, the conventional air system can be inducted into service.

All of the transmitter equipment is air conditioned for the purpose of removing salt from the air. This affords an additional safety factor on equipment rating.

Harmonic Suppression

An interesting method of harmonic suppression is used to afford maximum efficiency. A concentric transmission line, under pressure with nitrogen gas to keep out moisture, folded back and forth over the length of the building, and hanging from the ceiling of the basement, is used to afford a quarter wave stub. This method is one which is usually employed with high frequency stations, but not in standard broadcast. This line, in shunt with the antenna, is far more positive than the customary method of tuned trap circuits.

Unique Antenna Mounting

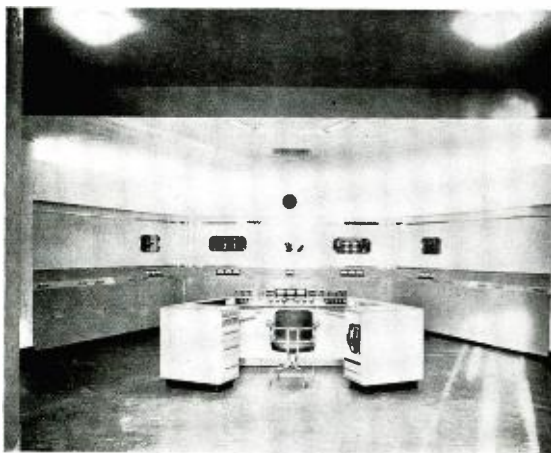
The antenna itself rests on concrete

anchor blocks in the basement of the building, with columns rising through the building and above the roof, to a point where the base insulators are located. Incidentally, these columns do not touch the building. Air space actually surrounds the columns. This system has been adopted to avoid the transmission of any tower vibration into the transmitting equipment via the building, and causing consequential disturbances. Rubber braces on the bases of the tower deflect any possible water seepage. The tower, using welded tubular steel, is self-supporting. The structure is such that it is possible to remove the insulator from any one of the four corners, with the remaining three affording sufficient support for the tower. Incidentally, the tower weighs about 180 tons, and rises 380 feet above the roof of the building. To permit men to scale the tower safely for repairs, a ladder with a protective cage surrounding it has been built into the structure.

Pie Network for Antenna

The antenna is connected to the transmitter by way of a pie network. This network serves the purpose of matching the two transmitters to the antenna. It is simply a tuned circuit with a coil and balancing condensers, that match the impedance of the transmitter output circuits to the antenna.

A 72-ohm concentric cable, used in all of the feeder systems, connects the output of the transmitters to the pie network. The impedance that is now used, was selected for its ability to maintain a reasonably low voltage in all of the tuned circuits, thus preventing flash-overs in the individual pieces of apparatus. At the same time, it is a convenient impedance for switching the 5 kw amplifier into either the 50 kw amplifier or the antenna circuit. In this instance, the 5 kw amplifier must look into the antenna circuit and be properly modulated, or without modulation, look into the 50



Interior of new WABC. In center is the master control board. In addition to the customary essential operating controls, tell-tale lamps linked to overload circuit breakers are also included.



Approach to building. At right and left are the flagpoles, which also serve as emergency antenna. Although the base of the master antenna appears to be secured to the building, it is in reality held to huge pillars that run through the building.

kw amplifier, the 50 kw amplifier having its own modulator.

Emergency antennas are also available, just in case the antenna goes out of order, or the towers fall over. This latter possibility is most remote, but the advanced engineering has even allowed for this emergency. Co-axial cables have been run to the base of each of four flagpoles, thus making it possible to use any two or three of the poles to support the emergency system.

The ground system consists of radials anchored to the bottom of the sea. These radials are 300 feet out and about 30 degrees apart. Number eight, seven-strand wire is used. This system is brought through the concrete sea wall and into the transmitter with copper bus.

Special Locking Systems

A system of inter-locks and electric locks make it possible to remove the amplifier and crystal oscillator buffer stage trays from the transmitter only when they are not being used as driver units. Thus, when one unit is in operation, its companion unit along side of it can be removed from the transmitter and serviced at bench, without disturbing the unit in use. Since each of the transmitters has these units in duplicate, and the units from the 5 kw transmitter are interchangeable with the units of the 50 kw transmitter, there are actually four units which can be used in any one position.

Dummy Antenna

With either transmitter on the air, the other transmitter, through selective relays, is connected to a dummy antenna. This makes it possible to test the transmitter on the dummy antenna. This antenna is a water cooled device consisting of four "ohm-spun" resistances, within a piece of porcelain tub-

ing, and with water circulating through these resistances to dissipate the heat developed from the output of either transmitter. Heretofore, a dummy antenna for a 50 kw transmitter was usually the size of an average room. This dummy antenna porcelain tubing is only 3 inches in diameter and about 28 inches long. The usual dummy antenna is air cooled, while this one is water cooled, thus affording this tremendous saving of space.

Only Circuit Breakers Used

Circuit breakers provide all circuits with overload protection, no fuses being used. The operating position of these overload circuit breakers appears in tell-tale lamps on the operator's control console.

In the audio systems, feedback is used, while overall feedback is used between the final radio frequency amplifiers and the input audio amplifiers.

Should the power system fail, an emergency gasoline generator is auto-

matically placed into operation. There are two power cables coming from the mainland. One is a preferred service, and the other is an emergency circuit. Should both these lines fail, the generator starts automatically to furnish power.

Water-cooled tubes, each with an anode dissipation rating of 40 watts, are used in the final radio frequency amplifier. The two tubes are capable of providing a 50 kw carrier and, at 100% modulation, deliver the necessary 200 kw peak power. The filaments are AC heated, thus avoiding rotating machinery and additional maintenance. In the audio channel of the main transmitter are two 40 kw tubes capable of fully modulating the transmitting output, without being driven to grid current.

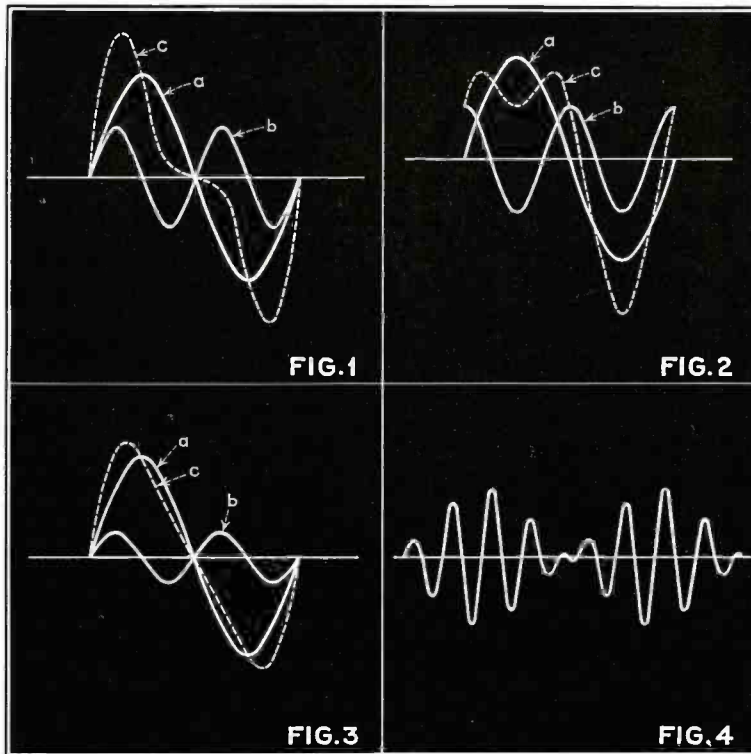
All frames, panels and component parts of the transmitters have been specially finished to assure protection against corrosive effects of salt air. The front paneling is independent of the transmitting apparatus behind it. It stands on a large steel trough, in which all the inter-unit wiring and control circuit wires are placed. All meters and auxiliary controls are installed in a sloping panel at waist level to avoid any difficulties in reading indicators, because of light reflection. The transmitting equipment was built by Federal Telegraph, an affiliate of I. T. & T., in accordance the specifications of CBS engineers.

In the event that the operating personnel should find it necessary to stay on the island for days or weeks they need not fear isolation for complete living quarters are provided. There are three bedrooms with double beds, a lounge, dining room and kitchen, with a cook on constant duty. A 30-foot cabin cruiser serves to transport the personnel to and fro.



James L. Middlebrooks, engineer in charge of building the transmitter, testing one of the amplifiers, built on removable trays. These trays can be completely removed for repair while a duplicate next to it is used.

THE GENERATION OF INTERMODULATION FREQUENCIES*



A lucid explanation of an unusual phenomenon we meet constantly in all types of present-day applications.

by **HERBERT J. REICH**

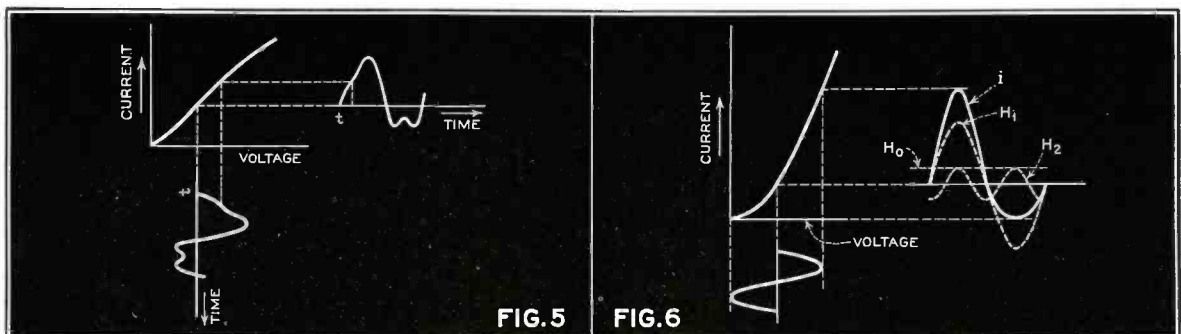
Professor of Electrical Engineering, University of Illinois

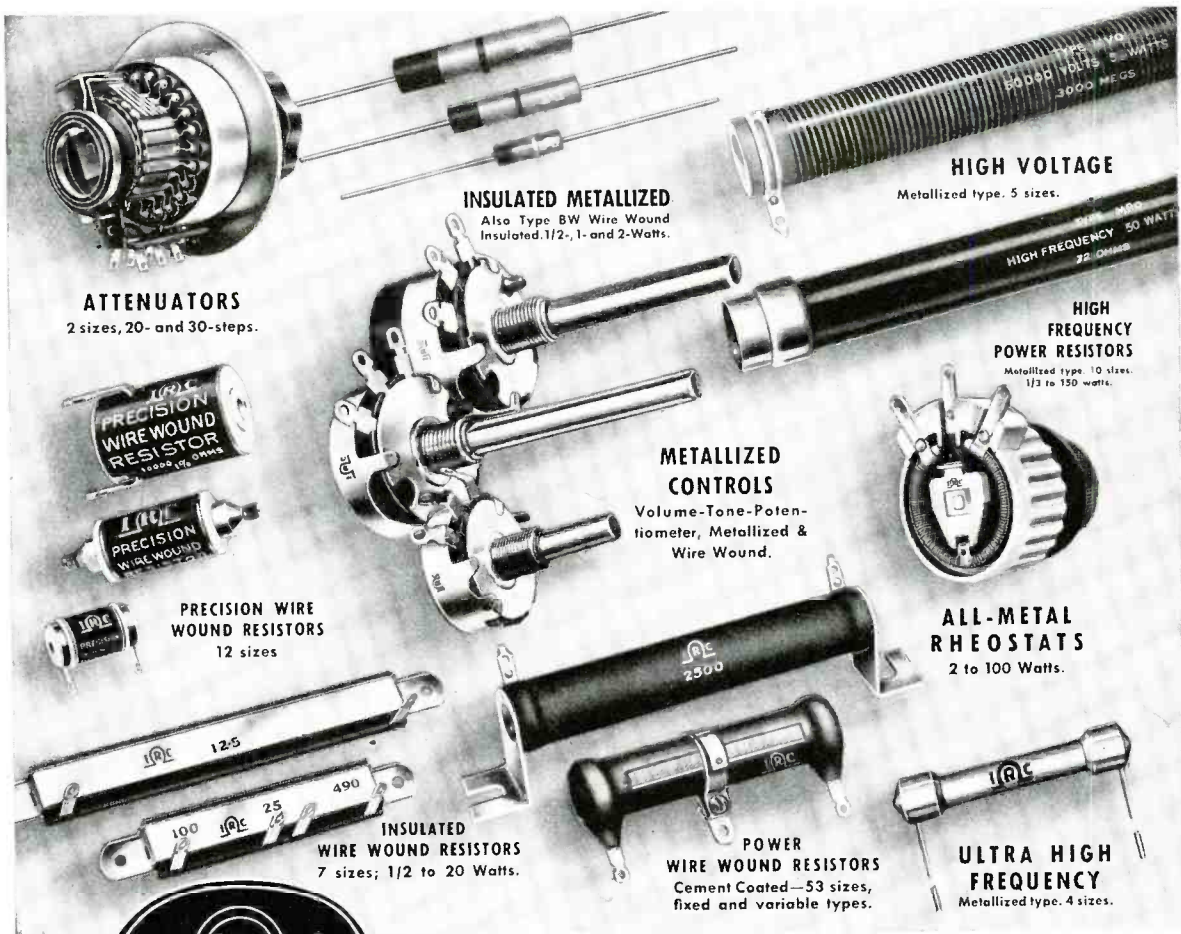
THE importance, in the communication field, of intermodulation, the production of frequencies equal to the sums and differences of integer multiples of frequencies impressed upon a circuit containing a non-

linear element, arises from the fact that this process is essential to the functioning of certain devices and results in objectionable distortion in others. The theory underlying this phenomenon will be briefly discussed here. First, let us review the principles of wave synthesis and analysis.

In Fig. 1, curves (a) and (b) show the time variation of two sinusoidal voltages or currents, whose frequencies bear a 2:1 ratio. Addition of the instantaneous values of the two varying quantities gives the resultant wave (c). Fig. 2 shows similar component and resultant waves for a different phase relation of the two components. In Fig. 3 the two component waves have the same frequency ratio and phase relation as in Fig. 1, but the relative amplitudes of the two components are different. Fig. 4 shows the resultant wave obtained by adding two waves that have a 5:4 frequency ratio and equal amplitudes. Examination of Figs. 1 to 4 shows clearly that the form of the resultant wave changes with the frequency ratio, the relative amplitudes, and the phase relation of the two components, but that in each case the resultant is in itself a periodic wave. Extension of this process of wave addition to the more complex case in which a large number of waves are added shows that the addition of any number of waves having integer frequency ratios always produces a resultant wave that is periodic. Conversely, it may be shown mathematically, graphically, and experimentally that any complex periodic wave, whatever its shape, may be broken up into two or more component waves whose frequencies are integer multiples of the fundamental frequency of the complex

*Presented before Radio Interference Conference held May 11th at the University of Illinois.





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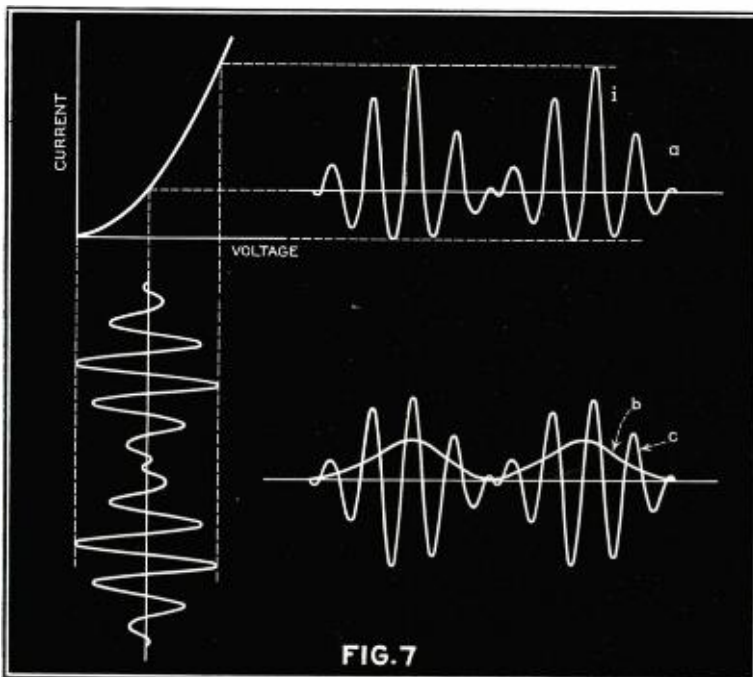


FIG. 7

wave. It must be remembered that a given periodic complex wave is equivalent to one and only one combination of component waves, the frequencies, amplitudes, and relative phases of which are determined by the shape of the complex wave.

The simplest method of illustrating frequency generation by a non-linear circuit element is a graphical one that makes use of a current-voltage characteristic curve of the element. It is therefore necessary to understand how such a characteristic curve can be used to determine the form of a current wave when the form of the impressed voltage wave is known. In Fig. 5 the characteristic curve shows the manner in which the current through a circuit element varies with the voltage impressed across it. Suppose that the voltage across this element is caused to vary with time in a manner indicated by curve (a). Then at any instant t , the instantaneous current through the element can be found by projecting from the corresponding point on the wave of impressed voltage to the characteristic curve, as shown by the dotted lines. By repeating this pro-

cedure for various values of t it is possible to construct the wave of current through the element.

Although the fact hardly needs proof, a construction like that of Fig. 5, performed for an element in which the current is at all times proportional to the voltage across it, i. e., one in which the characteristic curve is a straight line through the origin, shows that the wave form of the current is identical with that of the voltage. Since a periodic wave of given form is the equivalent of only one possible combination of component waves, it follows that the current wave can contain only the frequencies that are present in the impressed voltage wave. Therefore, a circuit that contains only linear elements, such as a constant resistance, a fixed condenser, or an air-core inductance, cannot give rise to frequencies not present in the impressed voltage. If two or more frequencies are impressed simultaneously upon such a circuit, the current contains only the impressed frequencies. (This fact is not altered by the seeming resemblance of the curve of Fig. 4 to an amplitude-modulated wave, from

which it differs, in that the curve of Fig. 4 does not cross the axis at equally spaced points.)

The characteristic curve of Fig. 6 is parabolic in form and thus represents a circuit element in which the current is proportional to the square of the voltage across it. The solid curve i of Fig. 6 shows the form of the wave of current that flows through the element when the impressed voltage is sinusoidal, i. e., when it contains only a single frequency. This current wave may be broken up into the components H_1 , H_2 , and H_0 drawn with dashed lines. That this is true may be readily verified by adding the three dashed curves at various instants in the cycle. Inspection shows that the frequency of H_1 is the same as the frequency of the applied voltage, that the frequency of H_2 is twice the applied frequency, and that H_0 is a steady or direct component. Thus, when a voltage of only a single frequency is impressed upon a circuit containing a parabolic circuit element, the current contains not only the impressed fundamental frequency, but also the second fundamental harmonic of the impressed frequency.

In general, non-linear circuit elements are seldom parabolic, and it is found that the current contains not only the fundamental and second-harmonic components, but also third, fourth, and higher-harmonic components. The relative magnitudes of these depend upon the form of the characteristic curve, the linear impedance in series with it, and the amplitude of the impressed voltage.

Fig. 7 shows the form of the wave of current that flows through a parabolic circuit element as the result of the application of a voltage, which is the sum of two sinusoidal voltages of equal amplitudes and a 4:5 frequency ratio. Analysis of the current wave shows it to be made up of the sum of seven components: a steady or d-c component, plus components whose frequencies are the impressed frequencies, their second harmonics, the sum of the two impressed frequencies, and the difference between the two impressed frequencies. The presence of the difference-frequency component in the current wave may be readily shown by breaking up

(Continued on page 26)

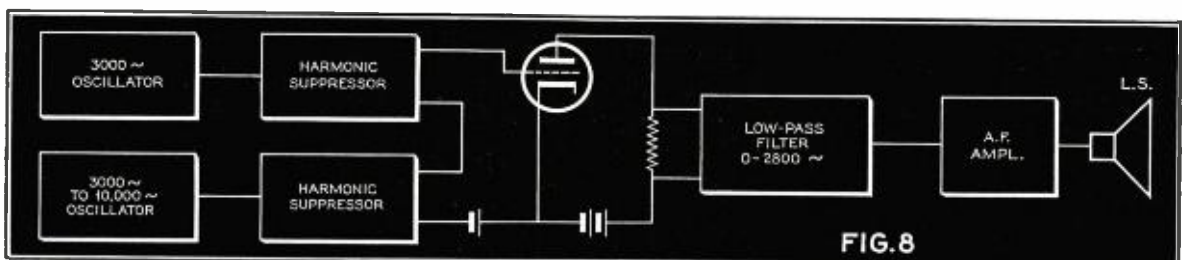


FIG. 8

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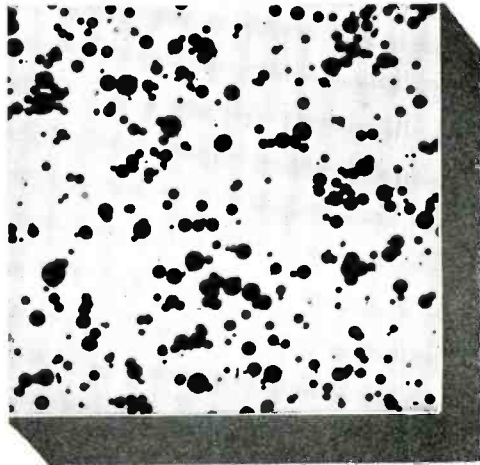
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ANALYZING INSULATED WIRE REQUIREMENTS

by **RAYMOND G. ZENDER**

Chief Engineer, Lenz Electric Mfg. Co.

IN the last five or six years, new materials have been introduced on the market that have resulted in marked improvements in the electrical characteristics of hookup wires used in the construction of Radio Receivers, Transmitters, Direction Finders, Frequency Modulation equipment, etc. With the advent of this new equipment, the scope of electrical and mechanical requirements has increased tremendously, and the expert services of the specialists in the proper choice of insulated wire has thus become most essential. These specialists, who are continuously on the scene of development are cognizant of the variety of problems that may be met in the field. As a result, they are fully equipped to make honest recommendations out of their findings and experience.

Selection of Wires

The selection of wires can be best

accomplished if Design Engineers bear in mind the actual working conditions to which the wire will be subjected. The study and application of various types of textile materials, such as cotton, silk, celanese, glass, extruded material and silk, has afforded a variety of methods of use, the choice of which must be followed with extreme care. It must be remembered, too, that since many of these various covers are identical in appearance their physical, chemical and electrical properties must be thoroughly investigated before selection. For instance, a wire containing a double glass braid, lacquered, has a breakdown voltage of 1300 volts rms, when immersed in one foot of mercury. A wire the same in appearance, containing a double glass braid, but with two wraps of plastic tape, has a breakdown voltage of 10,000 volts rms, when immersed in one foot of mercury. It is obvious to note therefore that while ap-

pearance is the same, a vast difference in electrical characteristics is realized.

Tests conducted at room temperature will not show a great deal of variation, whereas if these materials are checked under heat and humidity and with the introduction of direct current through the insulation, deficiencies in the way of impurities in such insulation will be more obvious.

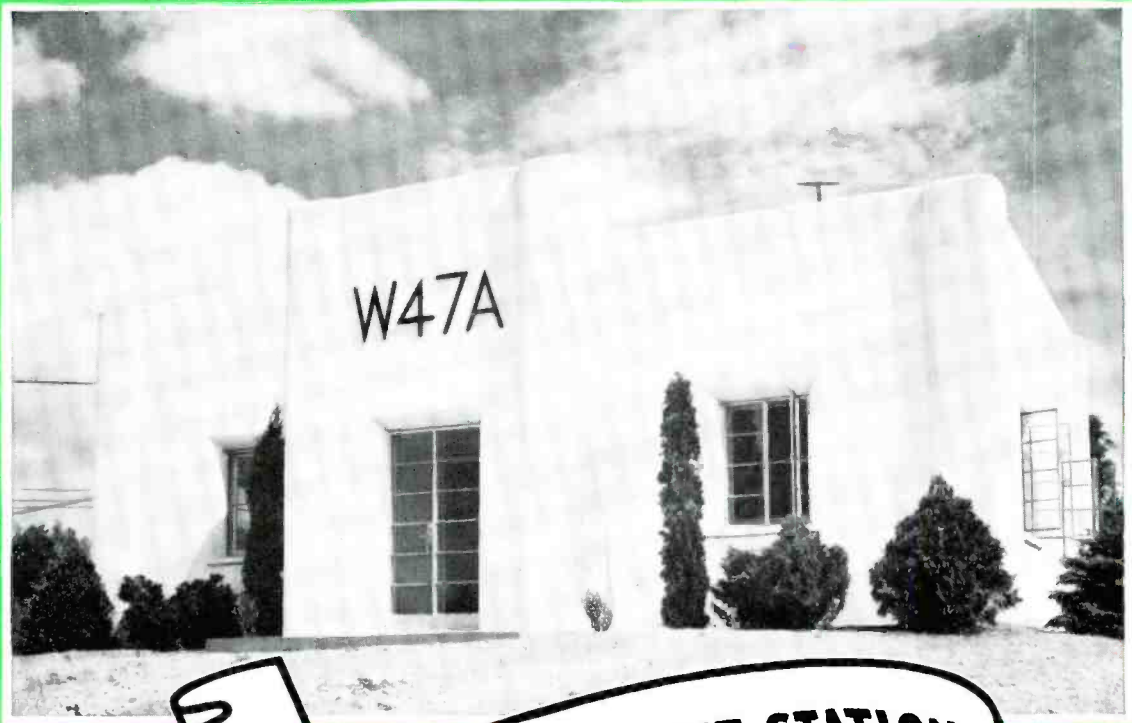
Wire Vital to Aircraft

In the aircraft industry today, wire plays a leading role. Carefully prescribed weights and small outside diameters, in addition to suitable electrical characteristics are essential. Rigid government specifications for defense work must be adhered to. These include tinning tests, insulation resistance tests, electrolysis tests for corrosion, abrasion tests, flame tests, combustion tests, accelerated aging tests and immersion tests, wherein the wire is dipped into various types of fluids at various temperatures. In chart at left, comparative test data on one type of wire designed by the author is shown. This particular wire has the combined essential properties of high electrical characteristics, both before and after humidity applications. The insulation on this wire known as Aeroglass consists of two spiral wraps of plastic material, plus a double fiber glass braid, coated with a flame resistant lacquer. An insulation of this combination will not support combustion when the conductor is heated to incandescence.

It is quite evident from the foregoing that wire design today represents an exhaustive study of many branches of science. This is essential to afford the rigid efficiencies imperative today. Thus, the wire industry with wire for every purpose offers engineers their specialized assistance for their wire and cable requirements and the author stresses the importance of Design Engineers accepting the invitation of the wire manufacturers to take advantage of the facilities of such engineering services.

AT ROOM TEMPERATURE		UNDER HUMIDITY AFTER 48 HOURS 90% R. H. 100° F	
VOLTAGE BREAK- DOWN	INSULATION RESISTANCE AT 500 V. DC.	VOLTAGE BREAK- DOWN	INSULATION RESISTANCE AT 500 V. DC.
10,000 V. AC.	300,000 Megohms	5,000 V. AC.	100 Megohms
METHOD OF TESTS			
Voltage Breakdown and Insulation Resistance Tests made on one foot sample in Mercury			
EQUIPMENT			
General Radio Megohm Bridge No. 544BS6 Sound Engineering Breakdown Tester			

Chart showing comparative test data
for a wire designed by author.



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W47A is also the first station in the country to get a construction permit from the F.C.C. for STL equipment. It will operate on 331 megacycles with W2XEO as the call letters. This studio-to-transmitter equipment is being built by G.E. and will soon be installed.

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Dwelle S. Hoag, Chief Engineer of W47A, takes readings on the 1-kw FM transmitter



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A PURCHASING GUIDE

Based On National Defense Program

PART II

by **LEWIS WINNER**

Editor

MATERIAL	ORIGIN OF BASIC ORE	FULL PRIORITY	CRITICAL LIST	SUPPLY	HOW TO BUY
MOLYBDENUM	Arizona Colorado	...	Yes	Fair.	Avoid over-purchasing. Rush to use this to supplant Tungsten may cause undue strain and shortage.
MICA	New Hampshire North Carolina India Brazil	...	Yes	Import from Brazil still available. Domestic stock still not suitable for highest efficiency.	Build conservative reserve, if necessary.
NICKEL	Canada	Yes	...	Canadian production increasing, but not enough for ordinary needs.	Use for essentials only. Plan for substitutes.
ROSIN	Georgia Alabama North Carolina Mississippi	...	...	Plentiful.	Buy as needed. No need to overstock. No substantial price rises likely.
SILVER	Tennessee Missouri South Dakota Colorado Oregon Alabama Montana Idaho Arizona Nevada Washington	...	...	Sufficient, in view of increased domestic production of major metals of which Silver is by-product.	Buy in customary "as needed" fashion.
STEEL	Pennsylvania Michigan Alabama West Virginia Illinois	Yes	...	Demand in complete excess of production.	Civilian purchasing will have to be practically completely curtailed, except for drastic essentials.
TIN	Alabama Bolivia Mexico Dutch East Indies British Malaya China	Yes	...	Sufficient production on hand. Shipping presents greatest problem.	Follow same policy as steel, except that Government is at present more lenient with civilian needs.
TUNGSTEN	South Dakota Nevada Burma Rd. (China)	Yes	...	Heavy demand for tools, causing drastic shortages.	Curtail and substitute.
ZINC	New York New Jersey Oklahoma Kansas New Mexico Iowa Montana Idaho Nevada Utah Washington Missouri	Yes	...	Demand in excess of production, and situation becoming increasingly intense.	Simply hold to appropriated quantities.

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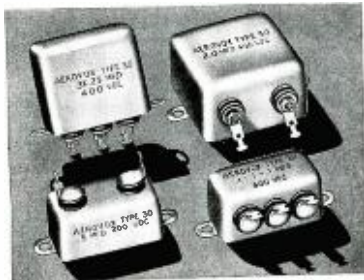
150 VARICK STREET ★ NEW YORK, N. Y.
EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"

THE INDUSTRY OFFERS.

AEROVOX'S NEW DEVELOPMENTS

A new midget or so-called "postage stamp" molded-in-bakelite receiving circuit mica capacitor, Type 1478, is now available from Aerovox Corporation of New Bedford, Mass. This capacitor is an elongated version of the types heretofore offered in the "postage stamp" series, its body measurements being 1 1/16" long by 7/16" wide by 3/16" thick. Hot-tinned brass wire leads provide the connections. The same molded casing is used for Type 1479 with silvered mica section. Both types, because of the longer casing, provide for higher capacity values at the given 1000 v. D.C. Test (500 v. D.C.W.) rating. The standard mica Type 1478 is available in from .0001 to .002 mfd., while the silvered mica Type 1479 comes in .0001 to .001 mfd. capacity.

Another new development from Aerovox includes the popular bathtub oil-filled non-inductive paper section condensers used in commercial radio and electronic assemblies, with a new, wider choice of terminals. Normally not included among the standard metal-can types, but rather intended for extra-heavy-duty requirements, these units usually have their terminals on one side of the case, but terminals can also be placed on top or bottom, on special order. The terminals are constructed of the exclusive Aerovox "double-rubber" bakelite, permanently riveted to the case, for a sturdy, hermetically-sealed, absolutely immersion-proof terminal assembly. The fixed, riveted lug type terminal is standard, but stud-and-nut terminals with movable lugs can be had on special order.



* * *

MICROPHONE ABSORPTION MOUNTINGS

In motion picture work, the microphone must oftentimes be moved very rapidly. To accomplish this, it is usually mounted on the end of a large boom which can be easily controlled and moved to any desired position quickly. This action must be accomplished without any mechanical noise or shock reaching the microphone. Such disturbances would spoil the recording and result in expensive retakes. To isolate their microphones from such conditions, Audio Productions of Long Island City, New York, mount these instruments on standard Lord Shear Type Plate Form Mountings. These Bonded Rubber Mountings effectively absorb all vibration and shock and in addition, provide an electrically insulated support for the mike.

These mountings made by the Lord Manufacturing Company, Erie, Pa. are widely used in supporting broadcast and recording microphones.

DUOTONE'S NEW SAPPHIRE NEEDLE

A new duraluminum shaft sapphire playback needle, curved to meet the record straight on, without drag, has just been brought out by Duotone, Inc., 799 Broadway, N. Y. C. The sapphire used is small, perfect, not easily broken. The effect of this method of engineering is to reduce surface noise to the vanishing point. This needle is attractively packed, and is designed for the most critical professional use, as well as for homes.



* * *

KENYON TRANSFORMER FOR NEW 931

The Kenyon Transformer Co., Inc., of 841 Barry Street, Bronx, New York, has just announced a new Transformer designed especially for use with the new R. C. A. 931 Electron Multiplier Tube. This Transformer is housed in a standard 4A case and is known as the Kenyon Type T-211. It can be used on 0/105, 115, 125 volts, 60 cycles, while secondary No. 1 is for 0/100, 200, 300, 400, 500, 600, 700, 800, 900, 1000 volts at 10 MA rms, and secondary No. 2 is for 2.5 volts at 1.75 amperes. Further data, as well as the new 1941 catalog, are free upon request.



* * *

NEW GLASS BASE SHIPPING CARTONS

As a result of extensive research, Audio Devices, Inc., 1600 Broadway, New York, N.Y., announces a new shipping carton for from one to three recording glass base instantaneous blanks. Each carton consists of a double corrugated container and a sufficient supply of shredded lint-proof wax paper. They are available in 12" and 16" sizes, and are primarily to be used for the shipment of recordings from station to station or from recording studio to processing plant.

LATEST HALLICRAFTER RECEIVERS

Such important features as two tuned r. f. stages, six degrees of selectivity (three with crystal filter), wide-angle illuminated "S" meter, six tuning ranges for most satisfactory L/C ratios and uniformly high sensitivity, temperature-compensated oscillator, bandspread dial directly calibrated for 80, 40, 20 and 10-meter ham bands, antenna trimmer control on front panel for precise resonance at all frequencies, phono jacks, and a. c. line operation with optional choice of battery or external vibrapack operation through instantaneous change-over plug, have been included in the new Hallicrafter SX-32.

The tuning range is from 500 kc. to 40 mc. in six overlapping bands. All bands are fully calibrated on main dial and the electrical bandspread system permits spread of any portion of the receiver's tuning range. Thirteen tubes are employed including separate h. f. oscillator and mixer tubes, two tuned r. f. stages, two dual tuned i. f. stages, a v. c. amplifier, automatic noise limiting, b. f. o., audio voltage amplifier and push-pull 6V6 output.

Supplied with steel cabinet, or equally well suited to standard rack mounting. Chassis 14-gauge flame-welded. Panel is 1/4-inch steel and box-girder type of construction is used for r. f. housing assembly.

Complete in cabinet, the receiver is 20 1/2" long, 14 1/2" deep and 9 1/2" high. The thoroughly ventilated cabinet is finished in machine-tool gray wrinkle with stainless satin trim.



* * *

AIR-OPERATED PROJECTION WELDER

The Eisler Engineering Company, Inc. of Newark, New Jersey has recently placed on the market a special air-operated projection spot welding machine No. 600-KKD. This machine is arranged with special welding jigs and fixtures for welding fins to steel tubing. No individual jig is needed for loading the work. There are 56 points of heat control and the transformer secondary, welding dies, and mandrel are water cooled throughout.

The rotating mandrel is operated by air and fully automatically controlled.

The pressure for each set of air cylinders can be regulated individually to meet any specific requirement. The machine is so wired that the ejector mechanism cannot operate while the welding dies are in motion, nor will the welding dies operate while the ejector mechanism is in motion. The actual welding time is controlled by automatic timing equipment.

Three separate fins are spot welded to each steel tube. Production is approximately 200 finished pieces per hour.

(Continued on page 29)

COPPER IN NATIONAL DEFENSE

Emergency places huge demand on metal, lifeline communication material, practically curtailing its civilian use.

by ELLIOTT MARSHALL

AS the series of drastic metal priority regulations were being issued none probably caused so much concern as the one covering the restriction on copper. A year ago there was plenty of copper, and now we have a shortage. It seems odd. The what-when-where-why of the shortage isn't as sharply outlined as it might be. Statistics are hard to pin down, for facts change fast. But there are facts, hard and cold, and inescapable as they may be.

For one thing, the defense needs for copper are big and getting bigger. In addition, there just isn't enough copper for both civilian use and defense. As a result, civilian uses must be cut.

The reason for the shortage is pretty clear. When the Battle for Britain started, all the military experts in the world had figures on how many shells it takes to keep a modern army going in a pitched battle, and how many aircraft and anti-aircraft shells it takes to defend the skies. But fighting it out with the Nazis on the land and in the air, cost the British hundreds more shells every day than any paper figures had ever shown. These shell casings are brass, and brass is 70% copper, and only 30% zinc. As a result of these demands, the brass and copper requirements were increased. That meant more of the red metal for military brass, but it also meant a more accurate knowledge of real battle needs and hence more safety.

Now let us take a look at another side of the fence. A few months ago, American factories were tooling up. Today production lines are really rolling. A fast moving line chews up precious metal at a breath-taking pace. With airplane production pushing rapidly ahead, that means more and more copper.

One type of bomber requires more than two miles of copper wire alone to keep it flying. Another needs 500 pounds of copper per ship. How many receivers and transmitters could be wired up with that length of wire is staggering. And every time a battle-

ship slides down the way, it means that another two million pounds of copper are going to sea.

Whenever a shortage arises, we naturally come to the question: "What can be done about it?" Some things are being done. Copper supplies are being increased by imports from South America and domestic production is being located. Far-seeing manufacturers of civilian goods have already turned to substitutes for copper.

Despite the sincerest of efforts to conserve and be thrifty with copper, there is no use in hiding from the fact that a shortage stares us in the face. The copper we have must be distributed as wisely and as equitably as possible.

How the shortage will actually shape up is a question that has plenty of government statisticians stabbing away at adding machines. And when the adding machines whirred to a stop in mid-

September, the situation looked something like this:

		1941	
		(short tons)	
Supply			
Domestic production	.....	950,000	
Imports (Latin America)	.....	500,000	
Other imports (Canada, Mexico)	.....	100,000	
Secondary copper	.....	100,000	
Total	.....	1,650,000	1,650,000
Demand			
All military (including foreign)	.....	600,000	
Essential civilian	.....	400,000	
Other civilian	.....	880,000	
Total	.....	1,880,000	1,880,000
1941 shortage	.....		230,000

You can debate these figures. It can be said that the shortage isn't quite as bad as it looks, because inventory buying and hoarding have created an "artificial demand." But it can also be pointed out that the Latin American copper needed this year hasn't all arrived and that shipping difficulties may make the shortage worse.

But the one thing that nobody argues about is the fact that, putting the decimal points aside, America faces a shortage for 1941 and 1942. The 1942 estimates, also made in September, looked like this:

		1942	
		(short tons)	
Supply			
Domestic production	.....	1,100,000	
Imports (Latin America)	.....	500,000	
Other imports (Canada, Mexico)	.....	100,000	
Secondary copper	.....	100,000	
Total	.....	1,800,000	1,800,000
Demand			
All military (including foreign)	.....	1,000,000	
Essential civilian	.....	400,000	
Other civilian	.....	1,170,000	
Total	.....	2,570,000	2,570,000
Shortage	.....		770,000

The figures given for civilian demand, of course, are based on the theory of unrestricted consumption, in accordance with the anticipated rise in national income. That is, the amount of potential buying power created by bigger payrolls should theoretically increase the demand for copper.

Some of this demand represents relatively non-essential uses, but from any point of view, the shortage is a real one, and means that some civilian needs must be lessened so that the defense pro-

(Continued on page 33)

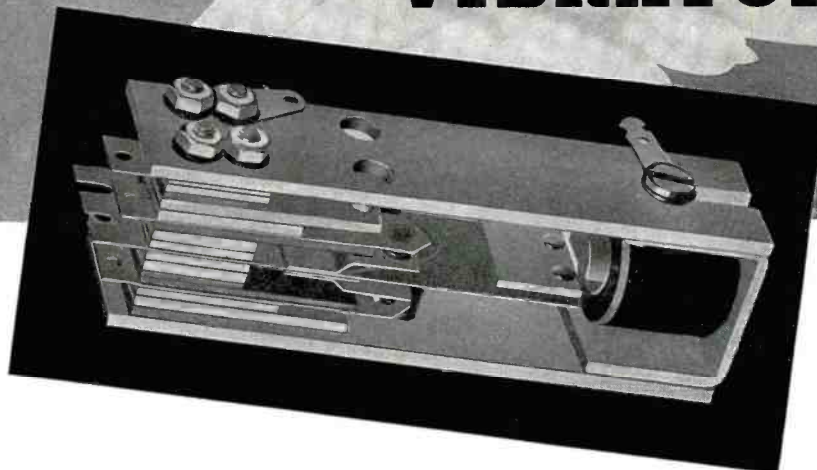


OEM Defense Photo

One of the huge new 35-ton electric arc melting furnaces recently put into operation to accelerate National Defense production. This unit converts scrap iron and steel into high quality steel alloys. In this view we see alloying elements being added to the bath of molten steel.

Military and Civil Aircraft

...rely on **ELECTRONIC VIBRATORS**



Electronic Vibrator . . . heart of Electronic Converters . . . as used in Sperry Directional Compass.

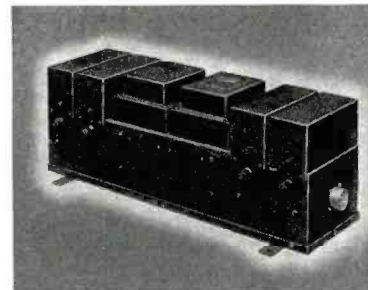


Military and civil aircraft require power sources of unflinching dependability under *all operating conditions*. That's why Electronic Vibrator Power Supplies are so widely used on U. S. Army, Navy and Coast Guard planes . . . as well as commercial airliners and privately owned aircraft.

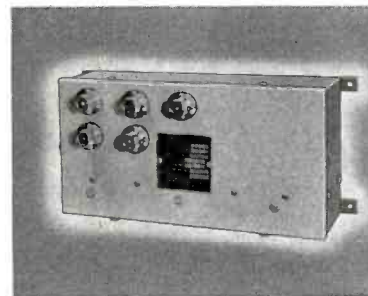
The exceptional preference for Electronic Vibrators is the direct result of many vitally important features found only in this product: . . . light but rugged construction . . . constant frequencies . . . synchronous operation . . . range of 0 to 500 watts at any voltage . . . long trouble-free performance! . . . That's why there are more Electronic Vibrator Power Supplies flying *than all other makes combined*.

In addition to Vibrator-Type Power Supplies, Inverters and Control Boxes, Electronic Laboratories supply the aviation industry with Ultra-Violet "Black Light," a significant advance in aircraft instrument illumination . . . fluorescent cabin lighting . . . custom-built lamp assemblies and fixtures . . . a combination of services seldom found in one organization.

Electronic products are *trusted flight companions* of both military and civil airmen. For further technical information, address the Aircraft Division of Electronic Laboratories.



Electronic Autosyn Inverter Type S-525 . . . power source for instruments of the great Boeing Flying Fortress.



Electronic Type S-665 . . . converts 12 or 24 Volt DC to 110 AC for operation of fluorescent lamps.

ELECTRONIC LABORATORIES, INC.

AIRCRAFT DIVISION, INDIANAPOLIS, INDIANA





VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGONIGLE, President

RCA BUILDING, 30 Rockefeller Plaza, New York, N. Y.

GEORGE H. CLARK, Secretary



General Mauborgne

IN the latter part of October, 1941, our Association will tender a Testimonial Dinner to a wireless pioneer, Major General J. O. Mauborgne, who retired as Chief Signal Officer of the Army on September 30, 1941, after a four year tour of duty in that office. General Mauborgne's biography follows.

Major General Mauborgne, born in New York City and a graduate of its St. Francis Xavier College, entered the army in 1903 as a second lieutenant of infantry. He brought with him some knowledge of wireless, as he had carried on amateur experiments as early as 1898, using coherers.

In 1909 he was selected to attend the Signal School at Fort Leavenworth, Kansas, and at the end of the year's course was put in charge of the laboratory at the School and was also detailed as instructor.

In 1912 he was sent to Fort Riley, Kansas, to install a small spark transmitter on an observation airplane to be used in the first Army tests of aircraft radio control of artillery fire. Installation included tests to determine the best form of antenna to be used, on which no data were available, and a long hanging wire was decided upon. During the entire series of tests he operated the receiver on the ground to receive instructions from the airplane radio transmitter. This was a milestone in Army radio history.

In 1913 he was ordered to service in the Philippines. While in the Philippines, in 1914 he conducted for the first time in Army history two-way communication between plane and ground using a pocket-size receiving set, with a detector which would not burn out under strong transmitting signals.

In 1917 he was ordered to duty in the office of the Chief Signal Officer, and in February, 1918, he was placed in charge of the electrical engineering section of that office.

During the War, Lieutenant Colonel

Mauborgne was largely responsible for Signal Corps training and for the development of all Army radio, wire and cipher equipment. For his outstanding service on these duties he was awarded the Distinguished Service Medal.

The citation awarded to Lieutenant Colonel Mauborgne read:

"Joseph O. Mauborgne, Lieutenant Colonel, United States Army. As head of the Engineering and Research Division of the Signal Corps he rendered conspicuous service in connection with co-ordinating the design and supply of new technical apparatus for the Signal Corps. He was largely responsible for the high type of radio equipment developed for our Army and rendered unusual service in connection with cipher telegraphy."

After the War, Lieutenant Colonel Mauborgne was transferred to the Signal Corps. He developed the cylindrical cipher device which is still in use.

He represented the United States as technical adviser to the American delegations at the Interallied Radio Conference, Paris, 1919, the Interallied Technical Committee on Radio Communication, Paris, 1921, the Inter-American Committee on Electrical Communication, Mexico City, 1924, the International Telegraph Conference, Paris, 1925, and the International Radio Telegraph Conference, Washington, 1927.

Lieutenant Colonel Mauborgne served as Signal Officer, Sixth Corps Area, in 1923. Returning to Washington, he performed notable service for the Judge Advocate General, and afterward commanded the Signal Corps Laboratory, Bureau of Standards. He was then assigned as Signal Officer, Panama Canal Department. He was recalled from this duty at the request of the State Department to assist the War Claims Arbitrer in Washington. After graduation from the Army War College in 1932, he was assigned as Signal Officer, Ninth Corp Area, and later as Director of the Signal Corps Aircraft Radio Laboratory at Wright Field, Ohio, at which point he was stationed when he received his appointment as Chief Signal Officer.

Our Association presented a Marconi Memorial Medal of Service to General Mauborgne on the occasion of our Sixteenth Anniversary Dinner-Cruise on February 11, 1941. We also tendered him Honorary membership in our Association.

In his message to our Association, included in our 1941 Year Book, General Mauborgne said:

"I have been highly honored by the tender of honorary membership in your Association which binds together in fraternal organization those outstanding heroes of communication, without whom national defense would be a complete failure.

"Without communications in national defense, whether furnished by commercial companies or by communication agencies of the national defense forces—and both are absolutely essential as a team—military and naval movements and combat would undoubtedly fail.

"Wireless operators are the back-bone of wireless communication so essential to 'blitzkrieg' warfare with tanks, combat cars, mechanized artillery and infantry, observation and dive-bombing aircraft, and in fact all operations of the Army and those associated with the G.H.Q. Air Force. The inspiration and stimulus given by your organization to young and old operators in the defense service to fight to the last gasp to get their messages through before they are obliterated is your contribution to national defense.

"By bringing to the attention of all operators the aims and purposes of your organization, namely; to foster and extend an esprit de corps among wireless operators; to afford opportunity for social intercourse, and to promote a fraternal and comradeship sentiment between and among its members; to recognize meritorious service rendered by wireless operators on land, at sea, or in the air, by the erection of memorials and by the bestowal of testimonials, medals, scholarships, or other suitable awards; to acquaint the public with the work, traditions and ideals of wireless operators and to perform and encourage any other purely fraternal activity or activities adjudged helpful to the wireless profession; you will fill them with the esprit de corps of existing and departed wireless operators and will so imbue them with your ideals that they too, under the most severe conditions that can try man's soul, will be true to their creed and their resolution to equal the performance of the heroes who have gone down in history—in your history—as being worthy of the appellation of the Veteran Wireless Operators Association.

"Gentlemen, your duty to national defense is clear and your contribution will heap greater and greater glory on your organization."

The Testimonial Dinner of the Association to Major General J. O. Mauborgne, will be given on October 25th at the Officer's Club on Governor's Island, at 8:00 P. M. Tickets will be priced at \$3.00.

MEMO TO:

Radio and Electrical Engineers

In these busy times - when you are facing more vital problems in a day than you formerly met in a month - competent assistance is more than welcome. We are offering to help lighten your burden by extending the services and facilities of our engineering department.

These facilities are at your disposal for the selection of the right wire for the job. We understand how important to your equipment the matter of Insulated Wire can be and are prepared to make a thorough study of your requirements and make honest recommendations out of our findings and experience.

Frequently a type of insulation that had not been under consideration will best serve the purpose electrically, mechanically and more economically.

It has been our experience that the most outstanding service obtained from Lenz Insulated Wire has been in such cases where we were favored with the complete confidence of the Designing Engineer and together solved his wire problems.

Lenz makes a complete line of Insulated Wire for Radio Transmitters, Receivers, Aviation Instruments, and Aeronautical Army-Navy Wire. Call on us for consultation - such service and wire samples are without charge.

Ray G. Zender



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1759 North Western Avenue
CHICAGO, ILL., U. S. A.

ENJOYING ITS 36TH YEAR OF SUCCESSFUL BUSINESS

THE GENERATION OF INTERMODULATION FREQUENCIES

(Continued from page 14)



- Four out of five times you can find just the type electrolytic condenser you require among standard Aerovox listings. This is because the line is so extensive and complete. And the fifth time it's easy, quick, inexpensive to base a special type, matched to your specs., on the Aerovox wide choice of cans, mountings, terminals, capacities, foils, voltages.

Virtually a complete plant in its own right and importance, the Aerovox Electrolytic Department's vast production facilities these days are still more than a match for the tremendous demand of National Defense and trade alike.

Submit that Problem . .

- Send us that capacitance problem—whether it calls for electrolytic or other types. Engineering collaboration, specifications, quotations, samples, cheerfully submitted to responsible parties.



the wave (a) into the two components (b) and (c). The frequency of (b) is the same as that of the envelope of the impressed voltage wave, which is the difference between the frequencies of the two impressed components.

Because the characteristic curves of actual circuit elements are not parabolic, but more complex in curvature, the current in general contains not only the two impressed frequencies and their second harmonics and sum and differences, but also other integer multiples of the impressed frequencies, and frequencies equal to the sums and differences of these integer multiples of the impressed frequencies. When more than two frequencies are impressed, the current contains the impressed frequencies, integer multiples of these impressed frequencies, and frequencies that may be obtained by adding and subtracting various combinations of multiples of the impressed frequencies (such as twice one impressed frequency plus three times another impressed frequency minus twice a third impressed frequency). Fortunately, all but a few of these complex sum and difference frequencies usually have negligible amplitudes.

A rigorous mathematical analysis, which cannot even be outlined in this brief treatment, shows that with non-linear circuit elements ordinarily used, such as vacuum tubes and copper-oxide rectifiers, the alternating component of current through the element may be expressed by a series of the following form:

$$i = a_0 e + a_2 e^2 + a_3 e^3 + a_4 e^4 + \dots \quad (1)$$

in which e is the alternating voltage impressed in the circuit containing the non-linear element, and a_1, a_2, \dots , are constants whose values are fixed by the characteristic curve of the element and the circuit impedance in series with it.

If the impressed voltage contains two frequencies, e is of the form

$$e = E_1 \sin \omega_1 t + E_2 \sin \omega_2 t \quad (2)$$

in which ω is 2π times the frequency. Substitution of equation (2) in equation (1) gives the following components of current:

From the first term of (1):

$$a_1 E_1 \sin \omega_1 t + a_2 E_2 \sin \omega_2 t$$

From the second term of (1):

$$\begin{aligned} & a_2 (E_1 \sin \omega_1 t + E_2 \sin \omega_2 t)^2 \\ &= \frac{1}{2} a_2 E_1^2 + \frac{1}{2} a_2 E_2^2 + \frac{1}{2} a_2 E_1^2 \cos 2 \omega_1 t \\ &+ \frac{1}{2} a_2 E_2^2 \cos 2 \omega_2 t \\ &+ a_2 E_1 E_2 \cos (\omega_1 - \omega_2) t \\ &- a_2 E_1 E_2 \cos (\omega_1 + \omega_2) t \end{aligned}$$

This indicates that the first term of

the series gives rise to current components whose frequencies are equal to the impressed frequencies, and the second term to a steady current and to current components whose frequencies are equal to twice the impressed frequencies and to the sums and differences of the impressed frequencies. Similar analysis shows that the third term of the series gives rise to current components whose frequencies are equal to the impressed frequencies, three times the impressed frequencies, and twice either impressed frequency minus the other impressed frequency.

The forms of the coefficients a_n , etc., of equation (1) are too complicated for discussion here, but an analysis of the expressions for the coefficients shows that if the characteristic curve is linear, all coefficients except a_1 are zero. Thus in the special case of a linear circuit element, the current contains only the frequencies contained in the impressed voltage. Hence the production of harmonics and of sum and difference frequencies is associated with non-linearity of the circuit element. The mathematical analysis therefore leads to the same conclusion as the graphical analysis.

The production of difference frequencies by a non-linear element, a vacuum tube, can be demonstrated in a striking manner by the circuit of Fig. 8. The voltages from two audio-frequency oscillators are filtered to remove harmonics and are applied in series to the grid circuit of a vacuum tube. The voltage developed across a plate load resistance is applied to the input of a 0-2800 cycle low-pass filter, the output of which is amplified and applied to a loud-speaker. The oscillator frequencies are made high enough so that the fundamental components of the output voltage cannot pass through the filter. Various combinations of oscillator frequencies can be found at which one or more frequencies are heard, the pitch of which varies with the tuning of either oscillator. The frequencies are always found to be equal to the difference between one oscillator frequency or a multiple thereof and the other oscillator frequency or a multiple thereof. Since harmonics are suppressed from the exciting voltage applied to the tube, the frequencies that are heard must be generated by the tube. That the tube is indeed essential to the generation of the difference frequencies is proved by the fact that they are not heard when the exciting voltage is applied directly to the input of the low-pass filter. instead

(Concluded on page 28)

NEWS BRIEFS

LAPP BUYS HEINTZ AND KAUFMAN COMPRESSED GAS CONDENSER BUSINESS

The Lapp Insulator Company, LeRoy, New York, has purchased outright, the Heintz and Kaufman compressed gas condenser business, including all tools, dies, patterns, designs and stock of parts covering this project. All communications covering H and K condensers should hereafter be directed to Lapp Insulator Company. Heintz and Kaufman is devoting its facilities to transmitting tube manufacture.

* * *

IRE AT COMMODORE IN 1942

The National IRE convention for 1942 will be held at the Hotel Commodore, New York City, on January 12, 13 and 14.

* * *

SMITH 1942 APCO PRESIDENT

At the Oakland Conference, C. M. Smith, Jr., chief engineer for the North Carolina State Highway Patrol, was elected president of APCO for 1942. Other officers chosen were: First Vice-President J. A. Wilt, Police Department, Kansas City, Kans.; Second Vice-President R. M. Schuler, Police Department, Fresno, Calif.; Sergeant-at-Arms H. H. Joy, Iowa Department of Public Safety. Re-elected to their respective offices were Secretary-Treasurer James H. Teeter, Police Department, St. Louis, Mo., and Bulletin Editor J. M. Wherritt, of the Missouri State Highway Patrol.

The 1942 Police Communication Conference will be held in St. Louis, Missouri.

* * *

GRIMDITCH AIDS NATIONAL DEFENSE

William H. Grimditch, Vice-President in Charge of Engineering, Philco Corporation, has accepted an appointment as Vice-President of Hazeltine Service Corporation, to aid expansion, acceleration and improved coordination between research and production in communication fields important to National Defense. Mr. Grimditch will also continue his activities at Philco.

Throughout the past months, the scientists and engineers in the laboratories of Hazeltine Service Corporation have been actively engaged on National Defense problems. The above company is a subsidiary of Hazeltine Corporation, many of whose forty-six licensees of radio broadcast receivers and thirty-two licensees of communication equipment are already producing apparatus in substantial quantities for the military services.

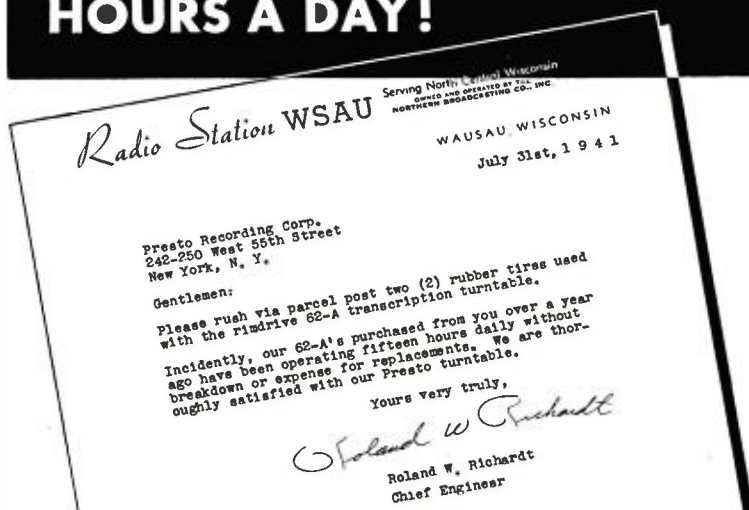
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WORNER PUBLISHES NEW BOOK

A 44 page book, entitled "Photoelectric Control," has just been published by the Worner Products Corp., Chicago, Ill. How factory-made, self-contained photoelectric units, may be applied to business and industrial problems and to matters of personal and national safety are clearly explained. A variety of diagrams, pictures and charts are also included, to further explain the interesting photoelectric subject.

(Continued on page 24)

STILL GOING STRONG 15 HOURS A DAY!



● It takes a real transcription table to keep up with a busy radio station. WSAU found what they wanted in the Presto 62-A...5000 hours of trouble-free service, one simple, inexpensive tire renewal.

If you want a table that gives you a quick jerkless start, always coming up to speed in exactly $\frac{1}{3}$ revolution . . . if you want a table so completely vibrationless you don't know it's running . . . if you want a "wow-free" table that runs $3\frac{1}{3}$ or 78 RPM. on the button . . . BUY PRESTO.

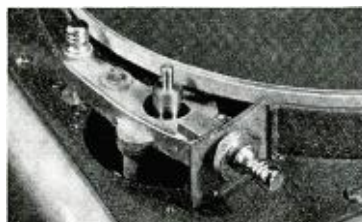
Once you see this Presto table in operation you'll know why an average of 15 radio stations a month are installing 1 to 3 Presto tables to replace their present equipment.

Presto tables give you the performance you've always wanted and they're ready for *immediate delivery*.

Write today for literature and the name of your nearest Presto distributor.



● Presto 62-A transcription table for lateral recordings, list price, \$385.00.



● Simple, foolproof Presto drive system—steel motor pulley drives against rubber tire on turntable rim, only 2 moving parts.



● Presto 16" dual speed turntable chassis only, list price, \$155.00.

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- Can be extended to 210 mc
- Low Resistance Attenuator
- Terminated Transmission Line
- Output 2 to 100,000 microvolts
- Panel Jack for 2 volts output
- 400-1000 cycles and External Modulation

WRITE for new catalog C-10; illustrates and gives complete details and specifications for the complete line of Ferris Instruments.

FERRIS INSTRUMENT CORP.
BOONTON NEW JERSEY

CATHODE DESIGN

(Continued from page 8)

ing time during each cycle is required, the tube rectifier has advantages over the copper-oxide type in that the grid of the tube may be used accurately to determine the point of firing.

In some of the more complicated circuits, it is desirable to initiate the arc with an ignitor, and then to hold the arc a number of electrical degrees by means of a holding anode. This allows the use of conventional grids in the pool tube, which results in more accurate control than is possible with the ignitor alone.

Cold Cathodes

In the case of cold cathodes, the electrons are extracted from the cathode by means of a high potential gradient at the surface. This form of cathode is suitable for inert gas-filled tubes only. The cathode surface may be pure metal or it may be a surface activated to decrease the voltage gradient required. The advantage of a cold cathode is that it requires no standby power. However, it is suitable only for very low average

currents, and the voltage necessary to start the tube is rather high. Although the cathode itself takes no power, the overall efficiency of tubes in which it is used is low, as a high-arc drop is encountered.

Summary

In summarizing, hot-cathodes have the most general usage. In various forms they serve as electron sources for all high-vacuum tubes and most control tubes of the gaseous type. Pure tungsten filaments are used for high-vacuum rectifiers having inverse voltages greater than 20,000 volts, and for high-vacuum grid-control tubes with ratings of 5000 volts and above. Large rectifiers of less than 20,000 volts rating are of the gaseous type and, therefore, employ oxide-coated cathodes, while the high-vacuum grid-type tubes utilize thoriated filaments for the range between 500 and 5000 volts. The oxide-coated type, either in filament or cathode form, is used for all low-voltage, hot-cathode tubes, occasionally at as high as 1000 volts. Hot cathodes have not been found very successful, however, for high-current control tubes, nor for power tubes. Here the pool cathode in ignitor form appears to be well established.

TERMINAL FILLS MY ORDERS!

NOW, MORE THAN EVER, I RELY ON TERMINAL. THEY'VE ALWAYS GOT THE RADIO PARTS I NEED IN STOCK—THAT MEANS PROMPT DELIVERIES FOR US—MAKES MY JOB SO MUCH EASIER! WHY DON'T YOU TRY TERMINAL?



For Example—
We carry a complete stock of **CANNON** sound plugs and receptacles. Broadcast stations, recording studios, etc., can now order direct from us instead of waiting for factory deliveries from Los Angeles, as heretofore.

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INTERMODULATION

(Continued from page 26)

of to the tube. A similar experiment, performed with a high-pass filter in place of the low-pass filter, demonstrates the production of frequencies equal to the sums of the oscillator frequencies and their multiples.

The graphical and mathematical analyses and the laboratory experiments all show that harmonics and sum and difference frequencies are generated in circuits containing one or more non-linear elements, but cannot be generated in circuits containing only linear circuit elements.

VISITORS DAYS DISCONTINUED AT SYLVANIA

Due to the requirements of National Defense, it has become necessary to restrict visitors from Emporium plant of Hygrade Sylvania. Beginning immediately, only those persons having business to transact with the company will be admitted. In the near future work will be started on a fence which will completely encircle the Sylvania property. There will be two entrances, with a guard at each.

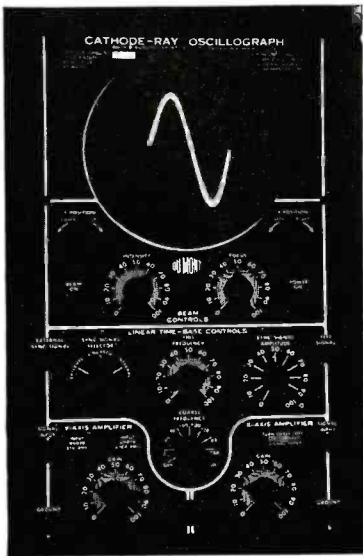
THE INDUSTRY OFFERS

(Continued from page 21)

BLACKOUT-PANEL OSCILLOGRAPH

In keeping with the growing blackout consciousness of the times, the Allen B. Du Mont Laboratories, Inc., of Passaic, N. J., announce their new Blackout-Panel Type 208 Oscillograph which can be used under adverse lighting conditions or in total blackness when necessary. This feature may be particularly desirable in certain military applications.

The specially processed steel panel is treated with a non-radio active luminous paint that retains its maximum luminosity for several minutes after exposure to ordinary light, and can be comfortably observed for an hour or more after that. The glow is of the same color and intensity as the standard medium persistence screen of the cathode-ray tube used, thereby minimizing eye-strain. The Blackout Panel is now an optional feature with the Type 208 Oscillograph, providing still another refinement in this general-purpose instrument.



* * *

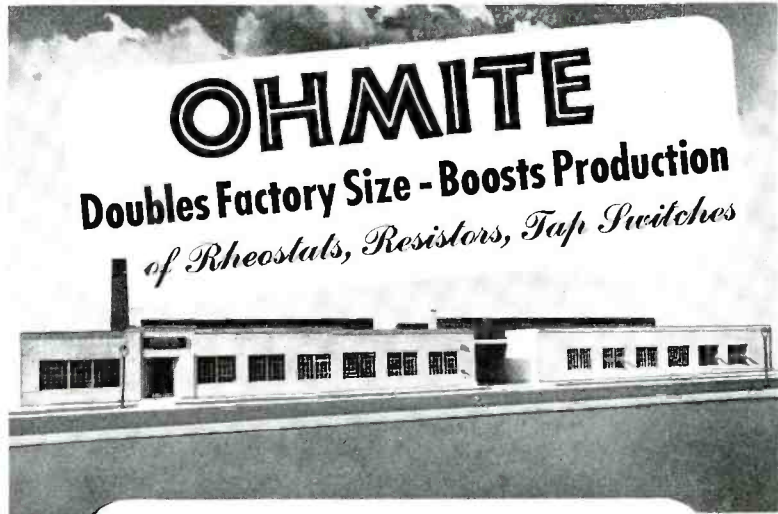
ACTUATOR FOR MU SWITCHES

Combining the advantages of 3/8" over-travel, large reduction in effective operating pressure, and construction suited to high speed cam operation, a new Type Y Actuator for Mu-Switches is now available.

The Type Y actuator, illustrated on both A.C. and D.C. Mu-Switches, comprises a nickle-plated steel arm carrying at one end a graphite impregnated, self-lubricating bakelite roller and pivoted on an oil-less bearing at the other end. A "U" spring of phosphor bronze, riveted to the under side of the arm, transmits actuating force to the operating button of the switch and absorbs excess movement at the roller.

The design of the attachment bracket permits the Type Y Actuator to be applied with equal facility to either side of the

(Continued on page 30)



OHMITE
Doubles Factory Size - Boosts Production
of Rheostats, Resistors, Tap Switches

TO MEET the increased requirements of Industry and National Defense, Ohmite has completed a large new factory addition and greatly expanded production facilities. The enlarged plant, devoted exclusively to the manufacture of quality Rheostats, Resistors, Chokes and Tap Switches, is working day and night to provide dependable units for radio, aviation, electronic, industrial and scientific applications.

Ohmite Products are veterans of service. They are available in the most extensive range of types and sizes to meet each need best. There are over 1,000 stock items. Special units are produced to exact specifications or engineered for you.



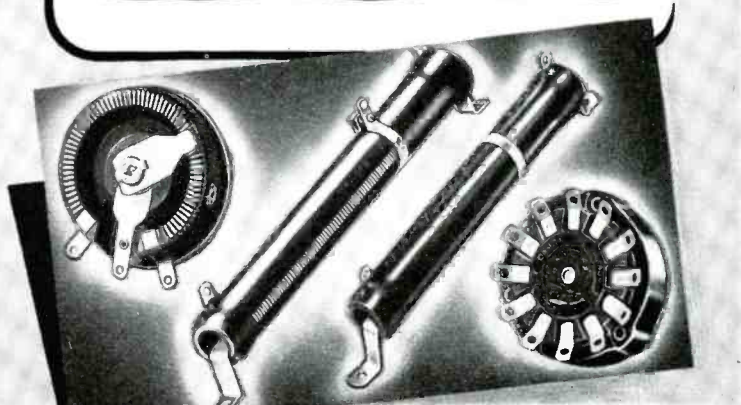
Write today on company letterhead for helpful 96-page Ohmite Catalog and Engineering Manual No. 40.

OHMITE MANUFACTURING CO.

4870 Flournoy Street

Chicago, Illinois

Be Right with **OHMITE**
 RHEOSTATS • RESISTORS • TAP SWITCHES



Just use the RIGHT DISC...

Since the finest mechanical and electrical recording equipment is available to ALL sound engineers, there can be no "secrets" or so called "exclusive" techniques in producing good recordings.

Comparative results will justify your selection of GOULD-MOODY "Perfected" glass base recording blanks which are available either with center hole only, or with both center and drive pin holes. Aluminum discs may be re-coated at a nominal charge.

★
DINAH
SHORE



IMMEDIATE DELIVERIES

Recording Blank Div.

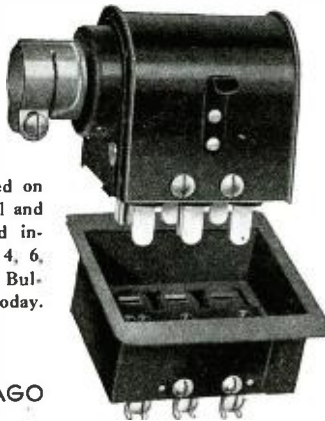
THE GOULD-MOODY CO.

395 BROADWAY

NEW YORK, N. Y.

JONES 500 SERIES PLUGS AND SOCKETS

Designed for 5,000 volts and 25 amperes. All sizes polarized to prevent incorrect connections, no matter how many sizes used on a single installation. Fulfills every electrical and mechanical requirement. Easy to wire and instantly accessible for inspection. Sizes: 2, 4, 6, 8, 10, and 12 contacts. Send for a copy of Bulletin 500 for complete information. Write today.



HOWARD B. JONES

2300 WABANSIA AVENUE, CHICAGO

Communications for November

will publish an exacting report of happenings at the Rochester IRE meeting.

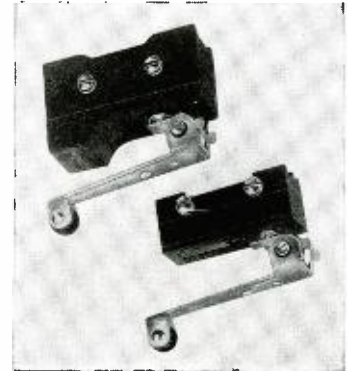
NEXT IRE CONVENTION

January 12-13-14, 1942

HOTEL COMMODORE, NEW YORK CITY

standard Type M (A.C.) Mu-Switch and the heavy duty Type D (D.C.) Mu-Switch. No special provision is required for applying the actuator because it is attached by means of the same screws that hold the switch in place.

Details of the Type Y Actuator and its application may be obtained from the Mu-Switch Corporation, Canton, Massachusetts.



* * *

CRYSTAL-CONTROLLED RECEIVERS

The new crystal-controlled receivers introduced by RME are divided into 3 general classes. These include: the SPD-11, for 6-channel operation within an octave tuning range; the SPD-13 single-frequency receiver designed for low and medium-frequency operation; and the SPD-15 for ultra-high-frequency single-channel reception. All these receivers have the same general appearance and physical size. All use lock-in type tubes in the superheterodyne circuit.

The SPD-11 with its six-channel tuning range is ideal for multi-frequency operation. The "tuning" range of this unit is limited to a frequency of 10 mc. And each series of frequencies must fall within 1 octave tuning; that is, for example, within 2000 to 4000 kilocycles, 3000 to 6000 kilocycles, 4000 to 8000 kilocycles, etc.

The SPD-13 receiver has been designed for single-channel operation and is suitable for state-wide low-frequency police stations where only one channel is used for communication. This receiver is limited to one specified frequency up to 10 mc.

The SPD-15 is identical to the SPD-13 with the exception that additional frequency doubler tubes and associated apparatus are incorporated providing ultra-high-frequency operation. Its range extends from 10 mc to an upper limit of 40 mc. This receiver is for replacement of receivers in present use in ultra-high frequency police stations.

* * *

COMPACT AIRCRAFT DRILL

Extremely light in weight and developing approximately twice the power of ordinary, similarly rated, production-duty electric drills, a U14FS series— $\frac{1}{4}$ " "Aircraft" Drills—has been announced by the Independent Pneumatic Tool Company of Chicago.

Particularly useful for operation in very limited space or in unusually difficult positions these U14FS drills have the power reserve and construction ruggedness necessary for high speed production. Of small

size and compact design they are available in three different speeds and have side switch style handle for either continuous or intermittent drilling.

For further information on this tool write to the Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.



* * *

SPRAGUE ADDS FERRULE END RESISTORS

A new line of Sprague Koolohm Resistors with ferrule-end type construction for "fuse clip" mounting and designed to meet the U. S. Navy Department's resistor specification No. RE13A372J has been announced by the Sprague Specialties Company, Resistor Division, North Adams, Mass.

The units are available in 10, 20, 35, 50, 90 and 120-watt sizes, in high resistance values heretofore unobtainable. They are supplied in either inductive or non-inductive types, the latter having a residual inductance at all values of essentially zero.

Known as Type F, the new units have standard Koolohm layer windings, the wire being insulated before winding with a 1000° C. heat-proof, moisture-proof inorganic material. An outer shell of 1/8" thick, heat-treated Pyrex glass, provides high voltage insulation as well as additional protection against humidity. Standard tolerance is 5%, although closer tolerances are available on special order at somewhat higher cost.



* * *

MECK DUPLEX AMPLIFIERS

A high-powered duplex amplifier, for either 70-watts or 140-watts, is now offered by John Meck Industries, 1313 W. Randolph St., Chicago. It makes possible centralized control of a complicated system of microphones and speakers. The dual channel feature permits accurate control of speaker sound levels, binaural sound effects, etc.

The Model B-70D contains two 35-watt chassis, which provide two 35-watt channels or one 70-watt channel. The Model B-140D contains two 70-watt chassis, providing two 70-watt channels or one 140-watt channel. Each model is mounted complete in a 17 1/2" high streamlined cabinet. Built-in monitor speaker and volume level meter, with switch for monitoring and metering each output channel separately, are provided. Outputs of each

(Continued on page 32)

BLILEY CRYSTAL UNITS

Engineered for Accurate Frequency Control



LEFT: Type M03 temperature controlled unit specially designed for high frequencies.

CENTER: Type M02 unit is ruggedly built for portable and mobile transmitters; 2,000kc. to 30,000kc.

RIGHT: Type BC46T Precision Variable Air Gap Temperature controlled unit primarily for Broadcast frequencies. Approved by F. C. C.



BLILEY Crystal Units for frequencies from 20kc. to 30mc.—three of which are illustrated—conform to highest commercial standards of design and performance. Write for your copy of Catalog G-12 describing the complete line.

BLILEY ELECTRIC COMPANY
UNION STATION BUILDING ERIE, PA.



✓ Check

THE IMPROVED FEATURES OF THIS BETTER PANEL LIGHT ASSEMBLY

1. Bulb instantly replaceable from panel front.
2. "Slip-fit" bezel of polished chrome slides out from front—exposing bulb.
3. Supplied with clear white "Bulls-eye" and removable color disc.
4. Different colored discs quickly inserted.
5. Colors show only when lamp is lighted.
6. Also supplied with colored glass . . . smooth or diamond cut type.
7. Precision engineered . . . made of finest materials.
8. Can be adapted to many various applications.

No. 75 Type is only one of the big line of standard and special Dial and Jewel Pilot Light Assemblies we make. They are used by most leading electrical, radio, and airplane manufacturers.

Will You Write for Our Catalog?

DRAKE MANUFACTURING CO.
1713 W. HUBBARD ST. • CHICAGO, U. S. A.

MR. ENGINEER..

Have you any needle problems? If so, let our engineers help you solve them. We specialize in playback and cutting needles for hill-and-dale, embossing on film, acetate instantaneous, wax recording. Permanent needles for record changers. The more "special" your needs, the better we can serve you. . .

No obligation . . . write today

The DUOTONE "Star" Sapphire has been acclaimed by leading engineers as the finest playback needle in its class. Reproduces without a trace of surface noise . . . excellent for dubbing work.

DUOTONE CO., Inc.
799 Broadway, New York City

NEW ASTATIC PRODUCTS FOR COMMUNICATIONS AND PUBLIC ADDRESS



**MOBILE MODEL
AB-8M PICKUP**

This new Astatic Crystal Pickup is designed especially for sound trucks and other mobile units. Counterbalanced to track on recordings even in a vertical position without jumping groove. Hinged head for quick changing of needles.

Model AB-8M, List Price \$12.50

N-SERIES MICROPHONES

Exceptionally smooth frequency response makes this an ideal public address microphone. Swivel joint, tilting head. Concentric cable connector. Chrome finish. Available in Wide Range Model N-30, and Voice Range Model N-80. List price, each \$17.50.

See your Astatic Jobber
or write for catalog.

ASTATIC

THE ASTATIC CORPORATION

YOUNGSTOWN, OHIO

Licensed Under Brush
Development Co. Patents

In Canada:
Canadian Astatic Ltd.
Toronto, Ontario



to 224 per inch. Provision is made for changing the direction and speed of the turret feeds with relation to the carriage feeds. Twelve spindle speeds ranging from 10 to 731 R.P.M. are available. A two-speed motor permits quick change from high to low speed for reaming and tapping operations.

Complete information on this new turret lathe will be supplied on request by the South Bend Lathe Works, Dept. X7, South Bend, Indiana.

* * *

FLEXIBLE DECADE VOLTAGE DIVIDERS

Decade Voltage Dividers in any capacity and calibration desired can now be had from the Shallcross Mfg. Co., Collingdale, Pa.

Due to the standard design of the Shallcross rotary instrument switches and Decade Resistance Boxes, this flexible arrangement affords any desired series of Decade Voltage Dividers with a constant internal resistance.

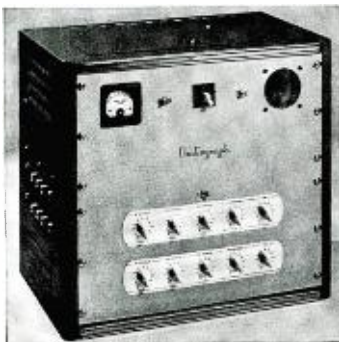
The diagram shows a set-up having four dials. The resistance "AB" and "CD" may be used independently (as a resistance box). When the dials are rotated clockwise, resistance "AB" will be increased . . . and resistance "CD" will be decreased. When used as a Voltage Divider, a link (provided with the set) is placed across "B" and "C" . . . this makes the resistance "AD" constant at all settings of the dials. If a voltage "E" is impressed on "AD", voltage "e" across "AB" will be

$$e = pE$$

p is the voltage ratio indicated by the dial settings. Voltage ratios of 0.0001 to 1.0 may be obtained. Other ranges are available.

(Continued from page 31)
channel may be used separately or combined.

Eight input channels are available, each with separate volume control. Lower feedback is obtained by individual master gain control which limits volume of each output channel, yet allows use of full microphone power.



A AND B POWER SUPPLY

A vibrator type power supply developed by Electro Products Labs., of Chicago furnishes 6 volts filament and 300 volts, 100 milliamperes DC power from a 6 volt storage battery. Complete radio-audio filter system, input and output battery cable, plug, clips and fuse are provided with this unit. It is well suited for use

as a power supply for portable public address systems, low power radio transmitter-receiver units and any service where high efficiency, light weight (8 pounds), low cost power source is required.

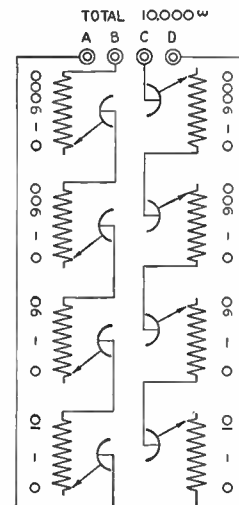


* * *

NEW 16" TURRET LATHE

A new 16" swing turret lathe designed for rapid production on chucking operations and bar work has been announced by the South Bend Lathe Works. This lathe has a 16 1/4" swing over the bed ways and saddle wings, 9 5/8" swing over the tool post saddle cross slide, 1 3/8" hole through the headstock spindle and 1" capacity through the collet.

The ram type turret has both power feed and hand feed, with automatic indexing and individual stop for each of the six turret faces. A quick change gear box provides 48 changes of turret power feeds. also 48 changes of both the cross and longitudinal feeds for the tool post carriage and a series of 48 screw threads, 4



COPPER IN NATIONAL DEFENSE

(Continued from page 22)

duction can be continued at an ever-increasing tempo.

It is perhaps ironical that copper, like many other critical metals, is so essential for many civilian uses. Wiring, for example, is certainly a big user of copper, and for electrical efficiency, there are few ready substitutes. Just as copper is needed for civilian purposes, it is for much the same reasons more essential for military uses.

A supplementary order recently issued directs the full conservation of copper scrap and copper base alloy scrap under full priority regulations. In this order, a series of definitions of scrap copper and supplementary products are included.

The order for instance, defines copper scrap as a basic material for the production of electrolytic copper, copper ingot and copper alloy ingot. Scrap means all copper of copper base alloy materials or objects which are the waste or by-product of industrial fabrication, or which have been discarded on account of obsolescence, failure or other reason.

Copper is defined as copper metal, which has been refined by any process of electrolysis or fire refining to a grade and in a form (cathodes, wire bars, ingot bars, ingots, cakes, billets, wedge bars, or other refined shapes) suitable for fabrication. Copper base alloy means any alloy in the composition of which the percentage of copper metal by weight equals or exceeds the percentage of all other metals. Brass mill scrap means that scrap which is a waste or by-product of industrial fabrication of products produced by brass mills. A brass mill refers to one which mills, draws, or extrudes castings made in its own plant of copper or copper base alloys, or one which rolls, draws or extrudes refinery shapes of copper or copper base alloys.

It does not, however, include a mill which re-rolls, re-draws or re-extrudes products produced from refinery shapes or castings of copper or copper base alloys. Secondary copper means copper or copper base alloy produced as a raw material by any process of melting scrap. A dealer is defined as any person regularly engaged in the business of buying and selling scrap, while a foundry means any person who melts and casts copper and copper base alloys into shapes and forms suitable for use without reforming.

In the copper-zinc branch of OPM at Washington are J. A. Church who is chief of the office. Assisting him are G. C. Heikes and Frank Ayer. This office is under the general direction of Philip Reed, who is deputy director. Assisting him is C. H. Matthiesson, Jr. These men are charged with duty of keeping an accurate eye on the vagaries of conditions and are in a position to be of inestimable help to those with problems.

The ordering of these materials and others and the specific letters attached to ordering has been simplified in a supplementary regulation. In the "M" classification, for instance, how a given material may be distributed is specified, while a "P" order helps the company or companies holding it to get the material. Thus an "M" order regulates distribution of steel, while a "P" order may have been granted to a freight car builder to help him get the steel. The "E" order stands for equipment. Thus far, only machine tools and cutting tools have been covered by these orders. An "E" order is similar to an "M" order in that it affects the distributor of the item covered, so that defense needs can be filled first. There are also "L" orders which are limitation orders, setting limits on production.

To Serve Well the
Professional Radioman

REPUTATION for RESULTS

The records of hundreds of CREI Students throughout the commercial and manufacturing fields, who today hold positions of importance, are proof of the high standards and thoroughness of CREI technical training in Practical Radio Engineering.

The success of an educational institution is not marked by dollars and cents . . . but by the achievements and results enjoyed by its students.

The remarkable achievements made by CREI men in every branch of radio are convincing testimony that our efforts, properly confined to this one important course in Practical Radio Engineering, have been of real value to radio in the training of better engineers. The fact that more than 5000 professional radiomen are enrolled for CREI training to increase their ability proves the point.

Alert chief engineers are quick to recognize the value of CREI technical training and the important part it plays in increasing the efficiency of their own personnel. CREI-trained men are the ones to whom added responsibilities and added technical duties can be relegated.

We, at CREI, are proud to add our contribution to the radio industry by training men who are equipped to fulfill your demands. The recommendation of our home study courses to your associates is a step in the right direction for them and for you. May we send you our interesting booklet and pertinent facts?

"Since 1927"

CAPITOL RADIO

ENGINEERING INSTITUTE

E. H. Rietzke, President

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Washington, D. C.



"TENSITE"
the 1.4 volt
FILAMENT

WILBUR B. DRIVER CO.
NEWARK, NEW JERSEY

NEWS BRIEFS

UNIVERSAL MICROPHONE EXPANDS

Universal Microphone Co., Inglewood, Cal., has increased its production facilities with a factory annex connected with the main plant by an enclosed archway. National defense production will be the prime factor in this new annex.

The building, of composite material construction and of semi-blackout design, was built under the supervision of Arthur Porter, Inglewood construction engineer. It will be air cooled in summer, dry heated in winter, and will be installed with fluorescent lighting.

METAL EXPOSITION FEATURES DEFENSE SUBSTITUTES

Lacquers and synthetic enamels used on defense materials were exhibited by Maas & Waldstein Company, makers of industrial finishes, Newark, New Jersey, at the recent National Metal Exposition in Philadelphia. Finishes to take the place of those using aluminum powder and other prod-

ucts that have been affected by the National Defense program were also featured. Included in the exhibit were quick-drying and baking finishes of great durability and protective qualities, in addition to all types of finishes that can be effectively baked by the new infra-red radiation process.

FINCH TO TRANSMIT ON FM SOON

A new 10 kw FM transmitter, W55NY, operated by W. G. H. Finch, will soon be on the air. The transmitter will be located on the 48th floor of 10 East 40th Street, New York City.

SHALLCROSS VISITS COAST

John S. Shallcross, of the Shallcross Mfg. Co., Collingdale, Pennsylvania, manufacturers of rotary switches, akra-ohms, and laboratory test equipment, recently visited the factory's West Coast Representative, Don C. Wallace, of Long Beach, California.

LEAR'S NEW OFFICES

Lear Avia, Inc., has opened new offices at Hangar "C", Roosevelt Field, Long Is-

land, New York. A sales room, modern workshop, stockroom, executive and secretarial offices are included in this two floor unit, Sydney M. Nesbitt, sales manager, is in charge.

ELLISON NOW ADVERTISING DIRECTOR

Paul S. Ellison has been appointed Director of Advertising and Sales Promotion for the Hygrade Sylvania Corporation. Mr. Ellison joined the company ten years ago and has held the post of Advertising Manager and Renewal Sales Manager of the Radio Tube Division.

In his new post, he will be responsible for all advertising, sales promotion, market research and general publicity for the entire company.

GI ISSUES NEW PRICE LIST

The General Industries Company, Elyria, Ohio, have just issued a new price list, in which the prices have been adjusted to take care of increased costs due to labor and materials, in addition to the new 10% Federal Excise Tax. Incidentally all GI mechanisms will be sold tax paid.

AMPEREX
WATER and AIR COOLED
TRANSMITTING and RECTIFYING TUBES

AMPEREX ELECTRONIC PRODUCTS
 79 WASHINGTON STREET BROOKLYN, NEW YORK
 Export Division: 100 Varick Street, New York, U.S.A. Codes: "ARLAB"

RADIO CATALOG NO. 58
 164 PAGES SETS-PARTS SUPPLIES FLUORESCENT
Burstein-Applebee Co.

BIG FREE CATALOG
BROADCASTING EQUIPMENT
 A complete line of transmitting tubes and equipment for broadcasting stations and studios as well as sets, parts, supplies, testers, public address systems, etc.

HUGE STOCKS AT YOUR COMMAND
 Even with the great demand made by the Defense Program our huge stocks bought months ago enable us to fill orders promptly and efficiently. Start sending your orders to B-A now.

BURSTEIN-APPLEBEE COMPANY
 1012-14 MCGEE STREET * KANSAS CITY, MISSOURI

We manufacture a complete line of Electric Spot Welders, 1/2 to 250 KVA. Standard and Special Transformers. Incandescent lamp, radio tube, neon tube and fluorescent tube making equipment. Glass cutting, siling and working equipment. College laboratory units. Vacuum pumps. Wire Butt Welders. A.C. Arc Welders from 100-400 Amps.
 Write for information.

Eisler Engineering Company
 CHAS. EISLER, Pres.
 741 S. 13th St. (Avon Ave.) Newark, N. J.

CRYSTALS by HIPOWER

The Hipower Crystal Company, one of America's oldest and largest manufacturers of precision crystal units, is able to offer the broadcaster and manufacturer attractive prices because of their large production and the exclusive Hipower grinding process. Whatever your crystal need may be, Hipower can supply it. Write today for full information.

HIPOWER CRYSTAL CO.
 Sales Division—205 W. Wacker Drive, Chicago
 Factory—2035 Charleston Street, Chicago, Ill.

AMATEUR UNCONDITIONALLY GUARANTEED

COMMERCIAL WRITE US FOR PRICES Fast Service

PETERSEN RADIO CO., Council Bluffs, Iowa

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Remember the Group Rate—\$1.00 a year for four or more subscriptions.

Regular Rate—\$2.00 a year in U. S. A.—\$3.00 in foreign countries

THE IRE FALL MEETING

(Continued from page 9)

RCA License Laboratory engineers, S. W. Seeley and H. B. Deal, who developed this novel unit, as part of our National Defense efforts.

Television will also receive its share of interest, with a discussion of a video signal generator with a monoscope signal source, by O. H. Schade and H. de Ryder of RCA. An alternate carrier synchronization system in television, one of the standard systems meeting the FCC requirements that is being discussed for possible use as a standard, will be discussed by F. J. Bingley of Philco Corporation.

The design of an FM signal generator that will also cover AM, will be the topic of discussion by C. J. Franks of Boonton Radio. A modern 400 mc signal generator, its design and application, will be covered by John M. Van Beuren of Measurements Corporation. Noises in radio will be analyzed by C. M. Burrill of RCA, in his talk on observations of the transient behavior of radio noise meters. This talk is one of a series given in conjunction with groups studying the problem of noise, and represents the latest developments in that field.

Small receivers that can be made to have console tone with corresponding volume, will be discussed by F. H. Shepard, Jr., chief engineer of the Revelation Patent Holding Corporation. Mr. Shepard has developed a new system, already adopted by some receiver manufacturers and hearing-aid people, that produces an artificial bass response affording unusual fidelity effects in the smallest type of receivers. Demonstrations with receivers, scanning units, and recording units will serve to point out these unusual effects.

The 300 kv electron microscope that has captured the interest of everyone, will be covered by three eminent scientists. V. K. Zworykin, J. Hilliar and A. W. Vance. Other topics of discussion will include radio engineering economics by E. L. Hulse, financial expert at GE; a new type of solid dielectric flexible RF co-axial line by the research specialist Dr. Harner Selvidge, and a careful analysis of skin effect by H. A. Wheeler of Hazeltine.

The meetings will take place in the Sagamore Hotel, Rochester.

HOW TO APPLY FOR A RESEARCH LABORATORY PREFERENCE RATING

THERE has been some misunderstanding among research laboratories as to the proper method of applying for the A-2 preference rating assigned to deliveries of materials and equipment to them, in Preference Rating Order P-43.

All applications should be filed on PD-88, and directed to the Chemical Branch, Office of Production Management, Washington, D. C.

The fact that the National Academy of Sciences is being asked by the Priorities Division to pass upon certain applications does not mean that any requests should be addressed directly to the Academy by laboratories interested in the plan. All correspondence should be with the OPM Chemical Branch.

In filling out these forms, it is imperative that the specific work for which the material is intended, be carefully explained. The fact that a civilian application may be basis of the research work does not necessarily mean that preference ratings will not be granted. Many civilian projects have wide use and are necessary to health and other equally important essentials and are thus essential to defense.

Yes! Prompt Delivery



• D. C. Voltmeter:

Stabilized, balanced, degenerative amplifiers eliminate "zero drift" — no change of zero with range selection. Polarity reversal switch. Linear scale calibration. Meter not damaged by severe overload.

• A. C. Voltmeter:

Balanced diode circuit reduces zero drift. Compact, low-loss, low-capacity probe designed for accurate measurement for frequencies from 30 cycles to over 150 megacycles. Built-in blocking condenser to remove d.c. component. Calibrated to read r.m.s. values of a sine-wave or 71% of the peak value of a complex wave.

• Specifications

Ranges: Push button selection of five ranges, 1, 3, 10, 30, and 100 volts full scale either a.c. or d.c.

Accuracy: 2% of full scale on each range either a.c. or d.c.

Power Supply: 115 volts, 60 cycles—no batteries.

Dimensions: 4¾" wide, 6" high, and 8½" deep.

Weight: Approximately six pounds.

Price: \$135.00 f.o.b. Boonton, N. J.

MEASUREMENTS CORPORATION



BOONTON

NEW JERSEY

FIXED FREQUENCY CRYSTAL CONTROLLED RECEIVER



MODEL 82-A

Designed especially for Police, Airport Traffic Control, and Airline Ground Stations • Local or remote operation • Compact—Mounted on Standard 3½" Rack Panel • Aligning and Tubes changed from Rear—Unnecessary to remove from Rack • Excellent image rejection, Squelch Circuit, Amplified A.V.C., etc. Supplied for operation on any single frequency between 1.5 to 12 mc. • Moderately priced.

Write for complete information.

COMMUNICATIONS CO., Inc.

2700 Ponce de Leon Blvd. - Coral Gables, Florida

NO Flickers with LITTELFUSE MERCURY SWITCH



QUICK DEPENDABLE SWITCH for HUNDREDS OF USES

Note in cutaway, baffle at end of electrode. Prevents splashing of mercury. Keeps light flicker-free. Central position of electrode makes it instantly operative in any position. For low-voltage circuits up to 25 A.C. or D.C., up to 10 amps. at 6 volts, and 5 amps. at 25 volts.

For lights in auto glove compartment, trunk, or hood—radio or refrigerator door lights, pin games many and varied services.



Sectional view showing Littelfuse anti-splash baffle



FUSE POSTS

No. 1075 for 3 AG Fuses. Meets Underwriters' requirements. Tool and finger operated types.

Specials quickly designed. Covers range from small glow fuses to industrial fuses up to 30 amps. Your need can be met most promptly by Littelfuse. Write for catalog.

Littelfuse makes types covering all requirements of small fuse applications and instruments. Many types are standard and stocked.

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**TOOLS • DIES
STAMPINGS
HEAT
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LAMINATIONS

For
Output
Transformers
of highest
permeability

Standard
Sizes for
Audio, Choke,
Output and Power
Transformers in
Stock.

Write for
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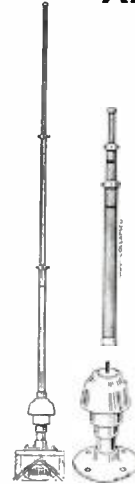
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- **IMPROVED CIRCUIT**—battery placed in measuring loop without any controlling resistances; low-resistance limit determined by internal resistance of battery.
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- **LOW VOLTAGE ON UNKNOWN**—does not exceed 22½ volts and varies with meter reading.

TYPE 729-A MEGOHMMETER (complete with tube and batteries) . . . \$85.00

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"How's The Weather Up There?"

THE PART THAT
MALLORY PLAYS

YOU probably remember when "How's the weather up there?" was considered pretty witty. But here's a case where that old saw is anything but funny. It is a serious inquiry into conditions that have far-reaching effects upon man's well-being... even his destiny for months to come. Meteorologists believe that Nature lays her weather plans months in advance, miles up in the stratosphere. Far higher than man personally has ever reached.

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