PRICE TWENTY-FIVE CENTS

# FM

# RADIO-ELECTRONIC ENGINEERING & DESIGN

MAY 1942

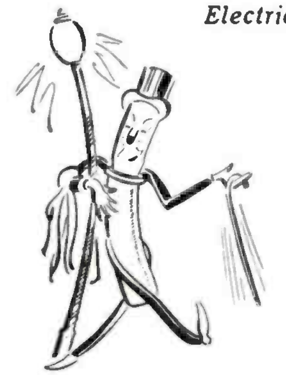
STATE POLICE BARRACKS, TRENTON, N. J.

Radio-Electronic Products Directory

THE JOURNAL OF WARTIME RADIO-ELECTRONIC DEVELOPMENT, ENGINEERING & MANUFACTURING ★ Edited by M. B. Sleeper ★

# 9 WAYS to Make Your Tungsten-filament Tubes LAST LONGER

Here are a few suggestions for prolonging the life of pure-tungsten-filament tubes. Specific installation and operating instructions are available for *every* General Electric tube, as well as general instructions for water-cooled and air-cooled types. Send us a list of the G-E tubes you use. We shall be glad to furnish you with complete service information. A brief review of these instruction sheets will enable you in many cases to get thousands of extra hours from hard-to-get tubes. *General Electric, Schenectady, N. Y.*



**1** Keep filament voltage as low as possible consistent with output and permissible distortion.

**2** Minimize anode dissipation by careful tuning of transmitter.

**3** Be sure there is plenty of water flowing on water-cooled anodes and plenty of air on air-cooled anodes to prevent hot-spotting and gassing.


**4** Keep plenty of air on the glass bulb—particularly on the seals where glass joins metal or leads go through—to reduce electrolysis and gas evolution from glass.

**5** Switch leads every 500 hours, preferably once a week, when filaments operate on d-c.

**6** During starting cycle be sure the instantaneous current does not exceed 150 per cent of normal current.

**7** Raise plate voltage in easy steps when starting.

**8** Prevent damage caused by overloading the plate circuit. Use protective devices such as a fuse or relay.

**9** Hard water (over 10 grains per gallon) should not be used for water-cooling. Distilled water will reduce scale formation on anode.

E

General Electric and its employees are proud of the Navy award of Excellence made to its Erie Works for the manufacture of naval ordnance.

**GENERAL ELECTRIC**

161-37-8850

# *ADVERTISING~*

# Is it an admissible item of expense on Government Contracts?

WIDESPREAD PUBLICITY HAS been given to the Government policy that "expenses ordinarily recognized as selling expenses incurred for the distribution of the products of an enterprise through usual trade and business channels and methods are not regarded as admissible costs under Government contracts."

This has been widely interpreted as requiring cancellation or sharp curtailment of advertising by manufacturers who have gone all-out on War production.

*But is this Government restriction intended to be so drastic in its effect? Or has there been some misunderstanding of this policy?*

The exact answer is set forth in a new U. S. Government publication entitled:

EXPLANATION OF PRINCIPLES FOR DETERMINING COSTS UNDER GOVERNMENT CONTRACTS — WAR DEPARTMENT, NAVY DEPARTMENT.

In the section on Limitations on Admissible Costs, there appears the following:

"As a general rule advertising is an inadmissible item of cost, on the reasoning that advertising is not required in order to do business with the Government. However, certain kinds of advertising of an industrial or institutional character, placed in trade or technical journals, not primarily with the object of selling particular products but essentially for the purpose of offering financial support to such trade or technical journals, because they are of value for the dissemination of trade or technical information for the industry are not really an advertising expense to effect sales so much as an operating expense incurred as a matter of policy for the benefit of the business and the industry."

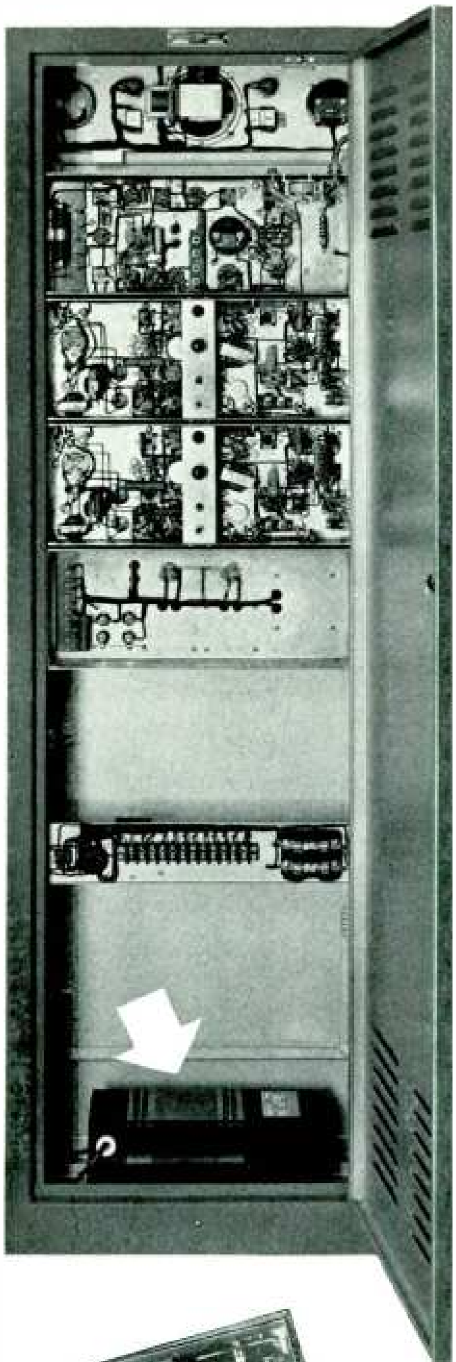
The circulation of FM RADIO-ELECTRONIC ENGINEERING is concentrated among (1) civilian and military engineers and executives concerned with the development, manufacture, and procurement of radio and associated equipment for our Armed Forces, (2) supervisors of police radio communication, (3) airport radio operators, (4) radio broadcast stations, and (5) purchasing missions of the Allied Countries in the United States.

Furthermore, this publication is performing a distinguished service in the dissemination of trade and engineering data of vital usefulness to all those engaged in radio-electronic activities on behalf of our War efforts.

In the light of the official interpretation quoted here, advertising in FM RADIO-ELECTRONIC ENGINEERING is an admissible item of cost under Government Contracts, as well as being allowable as a deduction from taxable income for the purpose of computing Federal income taxes.

## RADIO-ELECTRONIC ENGINEERING & DESIGN

FM



# SOLA

# *Constant Voltage*

# TRANSFORMERS

## keep these FM transmitters on the alert 24 hours a day

Into each of the FM transmitters in the state-wide radio system of the New Jersey state police, the Link Radio Company has built safety and positive, reliable operation with SOLA Constant Voltage Transformers.

Remote . . . unattended . . . and subjected to line voltage fluctuations that may vary as much as 30%, SOLA Constant Voltage Transformers keep these important transmitters constantly on the alert, ready for instant operation 24 hours a day, 365 days a year.

SOLA Constant Voltage Transformers are instantaneous in action . . . automatic in operation . . . fully protected against short circuits . . . have no moving parts . . . nothing to get out of order . . . and require no supervision. They alone can provide positive, automatic protection to all types of electrically operated equipment.


ask for bulletin **5CV-74**

**SOLA ELECTRIC COMPANY**
**2525 Clybourn Avenue, Chicago, Illinois**

# CONSTANT VOLTAGE TRANSFORMERS

# FM RADIO-ELECTRONIC ENGINEERING & DESIGN

COMBINED WITH: APPLIED ELECTRONIC ENGINEERING

VOL. 2 — MAY, 1942 — NO. 7

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M. B. SLEEPER, *Editor and Publisher*

S. R. Cowan, *Advertising Manager*

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*Editorial and Advertising Office:*
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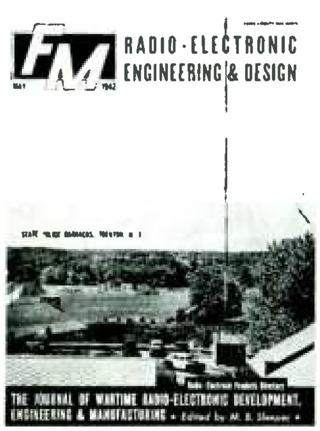
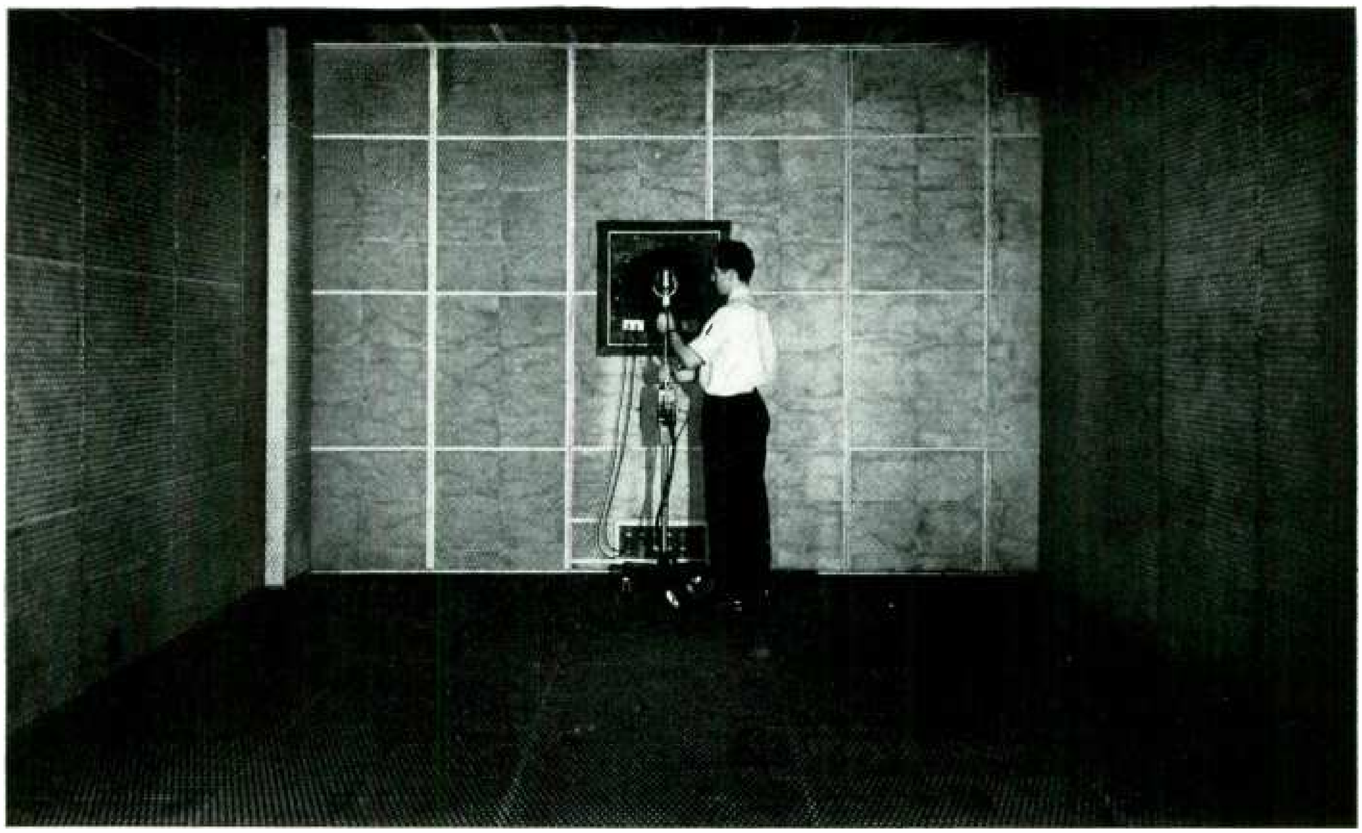
A charge of 25¢ each will be made for duplicating copies returned because of subscriber's failure to give change of address.

The publishers will be pleased to receive articles, particularly those well illustrated with photos and drawings, concerning all phases of FM developments. Manuscripts should be sent to the publication office, at New York City. Contributions will be neither acknowledged nor returned unless accompanied by adequate postage, packing, and directions, nor will FM Magazine be responsible for their safe handling in its office or in transit.

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


Although the priority rating assigned to police radio is not high, the WPB coöperated with New Jersey in getting the necessary release for this state-wide system because of the strategic position of the territory on the Atlantic seaboard. This system may play an important part in the defense of the coast if ever an attempt is made by the Axis powers to invade the United States.



*Main Sound Room at Shure Brothers*

# THE QUIETEST FIELD OF ACTION

In Total War, Microphones are weapons — for planes, tanks, and ships. These weapons are being built to new and higher standards.

Very important in the development of Microphones, is the accurate measurement of output level and frequency response. In measuring Microphones, the ideal medium is a free field without interference from atmospheric elements, outside noises, or reflections from nearby objects.

To achieve this goal, a special new room has been designed at Shure Brothers with a large area of sound absorbing surfaces. All four walls, floor and ceiling are covered with thick layers of sound insulation and sound absorption materials. The floor is provided with an open grill to offer good support without affecting the sound absorption properties. The room is completely shielded to avoid electrical disturbances. The high fidelity sound field is measured by means of standard Microphones calibrated at the U. S. Bureau of Standards. Electrical equipment for measurement purposes is located outside the room. In this room, the response of Microphones is measured with extreme accuracy.

In addition to close tolerances in output and response, Shure Microphones must survive electrical and mechanical tests which are far more destructive than any conditions they meet in actual service.

**Millions of lives may depend on a Microphone. Shure Engineers know this. Shure Microphones are made to do their part.**

**Send for Booklet No. 172 F.** *It describes Super-Cardioid performance and the latest Shure Broadcast Microphone, the Super-Cardioid.*

SHURE

**SHURE BROTHERS**

*Designers and Manufacturers of Microphones and Acoustic Devices*

**225 West Huron Street, Chicago, Illinois**

# FROZEN ONLY ON THE SURFACE

## Six Years of Peacetime Radio Progress Achieved in Six War Months

BY M. B. SLEEPER

IN THE May 25th issue of NEWSWEEK, there appeared the following item: "Lack of materials for transmitters and receivers has completely halted development in television and frequency modulation."

This statement, no doubt based on the information which has been released by the WPB and the FCC, is sincere in its intent, but completely misleading to the general public who read this magazine.

True enough, materials and facilities for manufacturing all transmitting and receiving equipment for civilian use have been frozen, and frozen more tightly than many expected would be the case.

However, no one in possession of the facts would say that radio *development*, in any of its phases, has been halted. Exactly the reverse is true. Never, in the history of the radio art, has development moved forward at such a rapid rate.

This is true of AM, FM, and television transmitting and receiving apparatus, and of new applications of existing radio-electronic techniques.

The greatest progress of all is in the FM field, both for communications and for new applications, largely because freedom from interference encourages its use for all purposes which do not require great operating radius. In the latter connection, it is interesting to note that FM is being employed in some instances because it *is* limited in range by the height of the transmitting and receiving antennas.

Other services that have employed AM are being changed over to FM because the former system, particularly on the lower frequencies, is subject to the vagaries of night and day effects, while FM comes through at the same level of reception right around the clock.

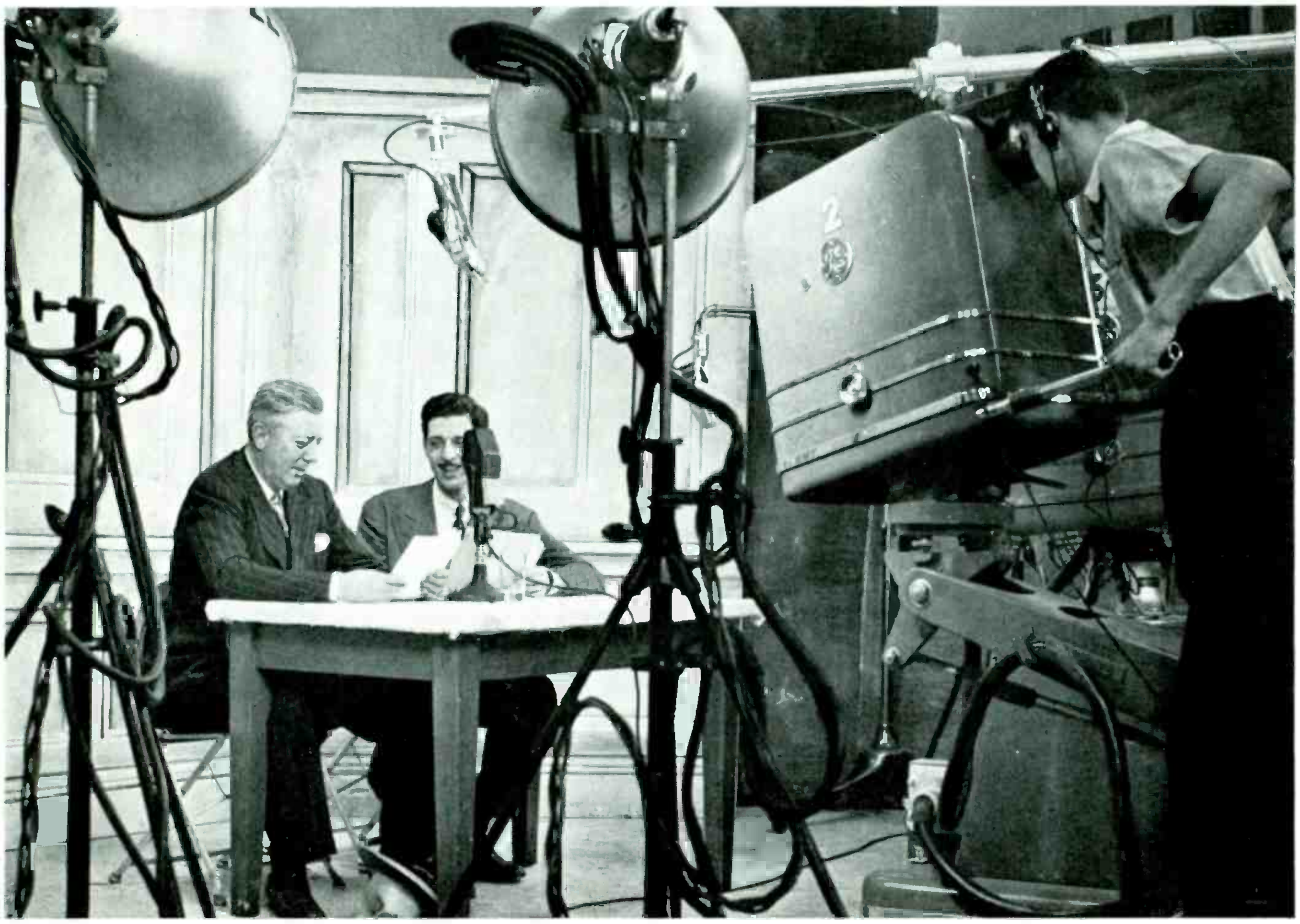
A very important effect of big-volume War production, although it may not be felt until the return of peace, concerns meters and, particularly, laboratory measuring equipment. Both these items will undergo substantial downward price revisions when the pressure of production for War is eased.

Many laboratory instruments that were largely hand-made are now being produced from tools at what would be, in normal times, greatly reduced costs. Quality has not suffered as a result of introducing production methods. In most cases, the degree of uniformity has been increased, and calibration has been simplified correspondingly.

In all factories engaged in radio War production, the call for speed and more speed has introduced a substantial element of increased cost. That is due to a large extent to stop-start assembly methods resulting from the uneven flow of materials.

Some manufacturers have been at least

(CONTINUED ON PAGE 23)



FRAZIER HUNT'S NEWS PROGRAM ON AM AND FM NETWORKS IS ALSO TELEVISED AT WRGB, G. E.'S SCHENECTADY STATION

COL. CHARLES H. SCHOEFFEL, SUPERINTENDENT OF N. J. STATE POLICE, CONTROLS ENTIRE SYSTEM FROM HIS DESK AT TRENTON

# NEW 2-WAY FM PLAN FOR JERSEY

## Network of 24 Main Stations with Link Low-Power Transmitters Cover 7,500 Square Miles

BY PROF. CARL NEITZERT* and LIEUT. JOHN E. MURNANE**

THE New Jersey Department of State Police was organized in 1921. The executive and administrative head of the Department is the Superintendent, who is appointed by the Governor with the advice and consent of the Senate.

**Basic Organization** ★ The Department is divided into four troops — Troop A, Troop B, Troop C, and Headquarters Troop. Troops A, B, and C are road Troops and are each composed of a Captain, two Lieutenants, one First-Sergeant and 74 Non-Commissioned Officers and Troopers. The responsibility for the administration and management of a Troop is placed on the Troop Commander, who is held strictly accountable and personally responsible to the Superintendent for the supervision and control of his Troop and for the criminal and traffic conditions within the limits of his Troop area.

**Stations** ★ Each Troop is divided into groups varying from 6 to 14 men. These groups are quartered at sub-stations in the Troop area and each is commanded by a Non-Commissioned Officer. The sub-station is the basic unit for the handling of criminal and traffic work in the Department.

**Administration** ★ Headquarters Troop is composed of personnel who are engaged in the administrative and supply work; in the training of recruits for the service, the compilation, classification and preservation of reports of arrests, investigations, accidents and other valuable statistical records. This Troop serves as a clearing-house for the following bureaus: Supply, Statistical, License, Safety Education, First Aid and Life Saving, Aviation, Crime Prevention, Automobile, Traffic, Detective, Teletype, and Identification.

In 1930, a state-wide teletype system was installed. At present, the teletype system is divided into four zones: The Newark Zone, which comprises the metropolitan area of the State, has 22 circuits connecting with sixty police departments. The zone sending station can reach every teletype receiver in the area simultaneously, or can reach each county group or each individual circuit separately.

The other three zones coincide with the troop areas and have their zone control stations in the troop headquarters. Every State Police sub-station is equipped with a teletype sending and receiving machine. The zone control stations are connected together through a master station in the State Headquarters in Trenton. Every sub-station can communicate, thru the zone control station, with any other station in the zone, and zone control stations can inter-communicate through the master station. The master station can send to every teletype point in every zone, simultaneously, or to all of the points in any one, two or three zones, simultaneously. Every alarm or message sent by any State Police Station is received at the master station in Trenton.

The state system is in turn connected with nine other state systems thru New York City, Hawthorne, N. Y., and Philadelphia, Penna. Alarms can therefore be disseminated and point-to-point messages relayed throughout the Nine-State System.

**Radio Communication** ★ The principal service that the Department requires of its radio system is that it provide continuous

*Assistant Professor, Stevens Institute of Technology, Hoboken, N. J., consultant to New Jersey Department of State Police.

**Communications Officer, New Jersey State Police.
Acknowledgement is also made to Radio Technicians trooper F. A. Kelly and trooper V. V. Mason for their assistance in the preparation of this data.

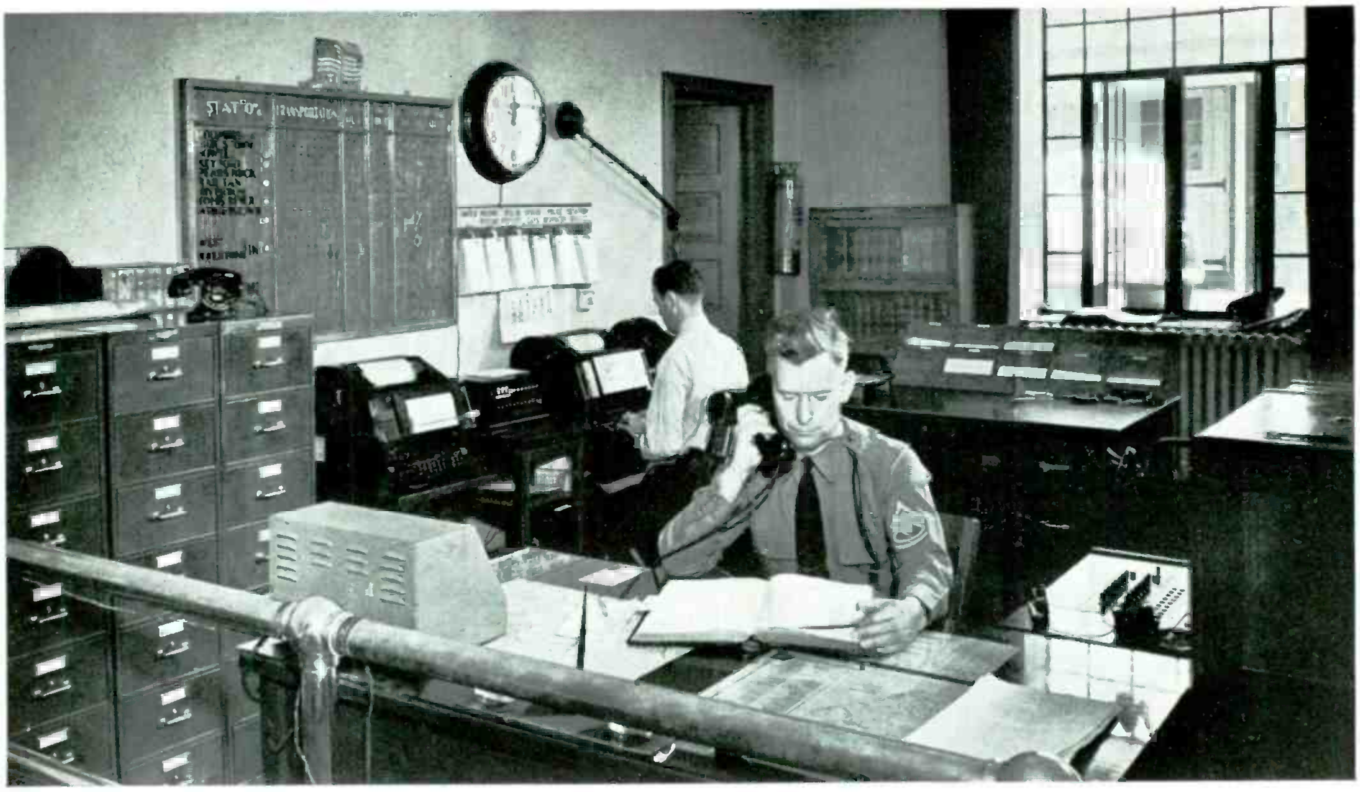


FIG. 1. SGT. P. J. SMITH AT THE RADIO IN THE COMMUNICATIONS ROOM OF THE TRENTON BARRACKS. CONTROL UNIT IS AT LEFT

communication between the station commander and his police cars on detail and patrol duty. Secondary requirements of a radio system are that it provide intercommunication between the three troop headquarters and between each troop headquarters and the sub-stations in each troop. This secondary service is provided by the teletype system so that radio need be used only in case of an emergency.

In 1936, a police radio commission was authorized by the Legislature to make a study and submit plans for a state-wide police radio system. The Committee proposed three 1-kw. transmitters to operate at a frequency of 1,610 kc. and provide one-way communication. At that time two-way communication with State Police cars was not considered feasible. The plan failed to materialize because the

FIG. 2. RADIO EQUIPMENT IS BEING INSTALLED ON THE PATROL CARS AS FAST AS IT IS RELEASED BY THE WPB FROM THE LINK FACTORY

Legislature considered the cost prohibitive and the heads of the police department preferred to wait until a two-way system could be obtained.

With the development of frequency modulation, and upon the completion of the Connecticut State Police System, it became evident that two-way radio communication for State Police use was practical at last. The New Jersey State Police immediately asked for funds to create such a system and these funds were appropriated by an act of the 1941 Legislature. The contract for the fixed and mobile installations was awarded to F.M. Link in December.

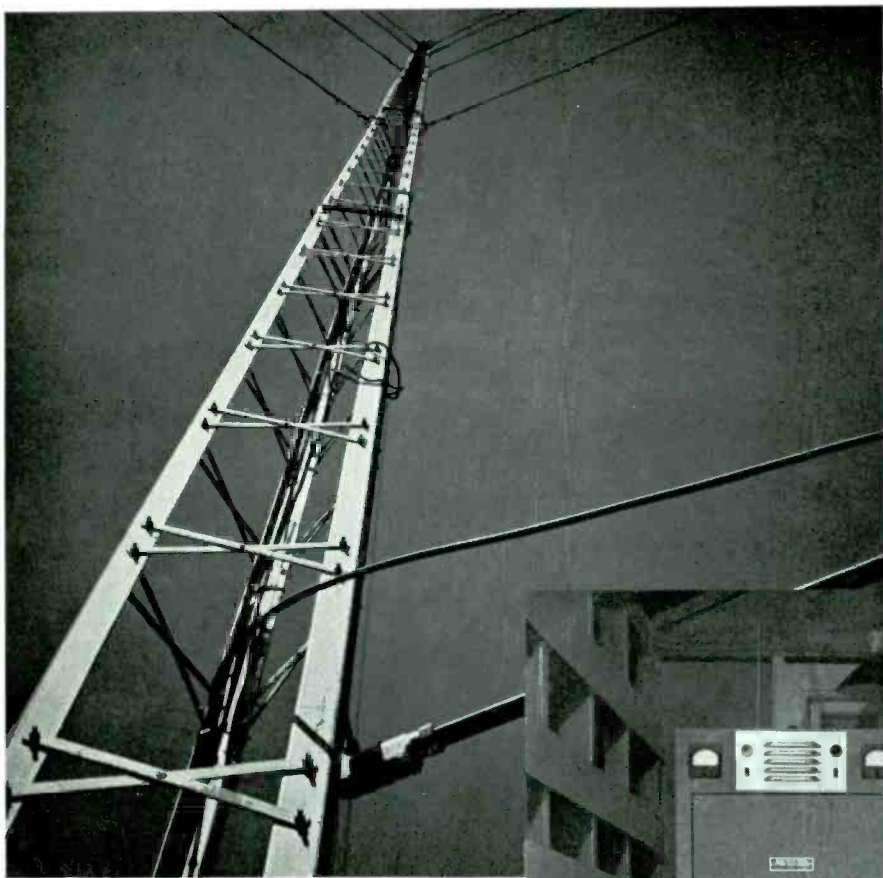
**2-Way Radio Survey ★** With the Department requirements in mind, a survey was made of the State to determine station-transmitter locations and equipment ratings. Three departmental cars were equipped with transmitters and receivers operating on a frequency of 39.78 mc. Because of the organization of the Department, it seemed best to provide a relatively low power transmitter at each station to serve the station district. This plan was later modified slightly in several instances.

**Control Box** Fig. 3 shows the telephone handset, and the control box which is mounted under the dash board. It contains the volume and squelch controls and separate pilot lights for the transmitter and receiver. Transmitter light goes on when the push-to-talk button on the handset is pressed. Receiver output is switched from speaker to earpiece when the handset is lifted from the hook. At the wheel of this car is trooper William Lambertson.

**FM Equipment** Fig. 4. Trooper John M. Buffin has one of the first radio-equipped patrol cars in the New Jersey system. The 2-way FM equipment is the Link type FMTR, comprising, left to right, the transmitter, receiver power supply, and receiving set. Quick-detachable cable plugs permit the removal of any unit. These units have shown remarkable stamina in standing up under the severe pounding they must take on police patrol service.

Since the terrain of the State varies from low mountains in the northern portion to flat sandy plains in the central portions of the State, separate surveys were made for most, but not all, of the police districts. The tests were made by stationing one car at the proposed transmitter site and sending the other two cars over previously planned routes in the district and in adjoining districts. Data was gathered by having the moving cars report their location at frequent intervals and especially where the location of hills, cliffs and valleys might cut down reception. The routes were carefully planned from contour and highway maps to provide ample indication of performance from the most disadvantageous locations.

No attempt was made to measure field strength and the only record made of results was the radio log. It was assumed that, if the reporting car could be identified at the proposed transmitter site, the final installation would give enough gain



from the standpoint of good radio communication.

The survey resulted in a plan calling for 24 fixed-station transmitters. Of these, 17 transmitter sites were located on the sub-station grounds, and 7, on leased land, required remote control. Of the 17, three will be controlled from two points, the second point being a remote control point.

The large number of municipal police radio stations in the state made the choice of a frequency in the 30- to 40-mc. band for the station transmitters impossible. The Federal Communications Commission therefore assigned the State a frequency of 27.925 mc., and permitted the continued use of 39.780 mc. for the mobile transmitters. Although these frequencies are rather widely separated, individual

**Antenna** Fig. 5. This view shows the extreme simplicity of the FM antenna installations. The upper conductor running to the mast is the coaxial cable from the transmitter. Below is a conduit carrying wires which run to the obstruction lights. The very simple vertical radiator is mounted on the top of the mast. Although the construction of the mast seems light, it has ample strength to withstand heavy winds, since it is not required to support any heavy load.

**Transmitter** Fig. 6. Here is the Link type 60 UFS transmitter set up in a small building at the foot of the mast shown in Fig. 5. Lieut. J. E. Murnane is checking the meters in accordance with a maintenance routine which has been established for keeping the entire radio system at peak performance. Most of the transmitters are unattended, but they have been designed with such factors of safety that the possibility of failure is virtually eliminated.

in power and antenna height and efficiency to provide the required results.

Because of the higher power output for a given load on the car battery and because of the virtual freedom from interference, and therefore the ability to operate successfully with a low signal strength, frequency-modulated equipment was used in the survey and no consideration was given to the use of amplitude-modulated equipment in the final installation.

For economic reasons it was attempted to locate the station transmitters and antenna towers on the sub-station grounds. In a few cases, the low elevation of the sub-station, relative to surrounding hills, made this impossible. In such cases, the transmitter site was chosen on or near the top of a near-by hill. The availability of power and telephone circuits had to be considered at each site and in some cases resulted in not choosing the best location receiving and transmitting antennas involve so much complication that it was decided to use the same antenna for both receiving and sending. The antennas are adjusted for maximum efficiency at the transmitter frequency and the resultant reduction in efficiency as a receiving antenna at the other frequency is compensated for by high receiver sensitivity.

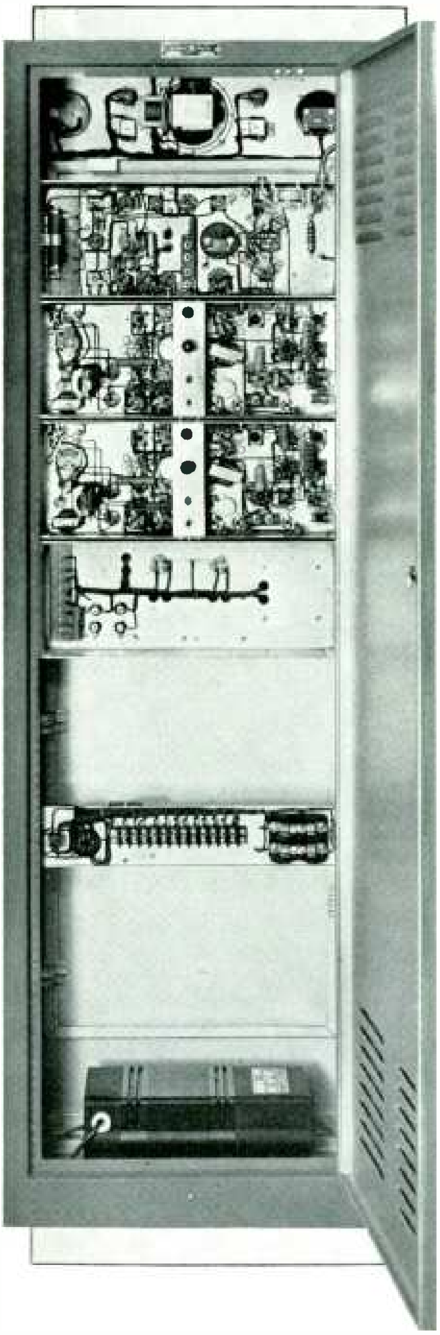
The towers for the station antennas were, in as many cases as possible, specified to be 85 ft. high. This height was chosen since little would be saved in cost by using a lower tower, and a higher one, in general, involves more elaborate obstruction lighting, considerable increase in cost, and does not give a corresponding increase in performance. Where local conditions dictated, higher towers were specified, the highest being 150 ft. The station antennas are of the half-wave concentric type, fed by a 3/8-in. gas-filled concentric transmission line.

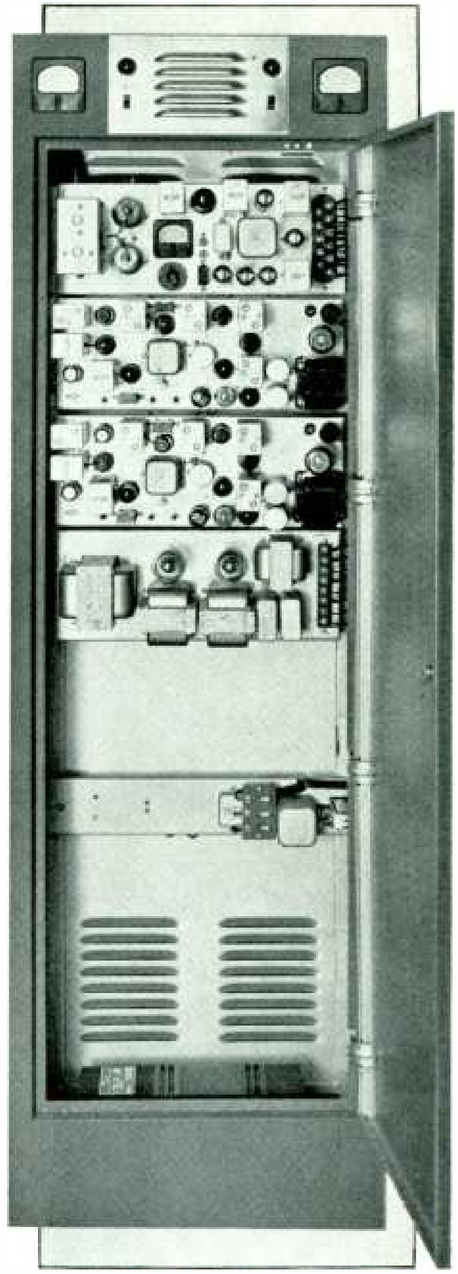
The rating of the fixed stations was specified as 60 watts output into the transmission line. This gives a liberal safety factor when it is considered that the survey was made with 25- and 30-watt transmitters located in cars using quarter-wave rooftop antennas. For the sake of uniformity, all transmitters were specified to be the same, regardless of local conditions. The particular value of 60 watts output was chosen largely because of the potential capacity of equipment currently being manufactured, and because it appeared that this power would give more than satisfactory results.

**Station Equipment** ★ The station equipment includes two receivers, one tuned to the fixed transmitter frequency, and the other tuned to the mobile transmitter frequency. This provides communication between stations as well as between any station and its cars, and allows a station to monitor the transmitter of adjacent stations, thereby minimizing the possibility of two adjacent stations interfering by transmitting at the same time.

Provision has been made so that a station transmitter cannot interfere with a message being received from a mobile transmitter. The receivers operate normally with a signal as low as 0.4 microvolts at the terminals of the receiver, and in the absence of noise they are able to receive signals of 0.1 microvolts at the terminals. This high sensitivity is deemed necessary to obtain the full benefits of frequency modulation and, in the case of the receiver for the mobile frequency, to compensate for the mis-tuned antenna.

The fixed transmitter and its receivers are housed in a single metal cabinet, as shown in the accompanying illustrations. The cabinet will also contain power supplies and a line-voltage-regulating transformer.





**Details** Fig. 7, left. Rear view of the Link 60 UFS equipment shown in Fig. 6. Fig. 8, right. Front view of the same unit. Panels are, from bottom to top: terminal board, transmitter power supply, receiver tuned to fixed station frequency, receiver tuned to car frequency, and 60-watt transmitter. Sola constant-voltage transformer at the bottom of the cabinet runs warm enough to keep out moisture at all times.

**Types of Installations** ★ The organization of the Department requires that all police officers in any sub-station be qualified to serve as dispatchers. To obtain satisfactory performance under such conditions, the mechanics of operation have been made as simple as possible. The control equipment is therefore as non-pretentious in appearance and as nearly like a telephone in its operation as is possible. The control units vary slightly with local conditions, but are essentially the same in all cases.

Three situations exist with respect to the relative positions of transmitter and control point. Ten transmitters are located in the offices of sub-stations and use a local control unit. In these instances, the total length of transmission line between the transmitter and the antenna does not exceed 225 feet. This type of installation is shown in Figs. 9 and 10.

Seven other stations have their transmitters located in small buildings on the station grounds and use a semi-remote control unit, as in the case of the Trenton barracks, views of which are shown here. In these cases, the distance from the antenna to the control point exceeds 225 ft. but in no case does the distance from the transmitter to the control point exceed 350 ft., and in all cases the transmitter building is located at the base of the antenna tower.

Seven transmitters are located off the station grounds at distances of 1 to 5 miles. These transmitters use remote control units which operate over a single pair of leased wires. In addition, the transmitter at the Wilburtha Station, which has semi-remote control from the Wilburtha office, will be remotely controlled from the Superintendent's office at State

Headquarters. In two other cases, a locally controlled transmitter will be remotely controlled from an adjacent sub-station a few miles away.

The remote and semi-remote control units are identical in all respects. The local control units differ only in that speech-level and carrier indicator meters are omitted. The control units are housed in metal cabinets requiring a table space of 12 by 15 ins., set up on or within reach of the office desk. The only adjustment which the dispatcher will be permitted to make is that of a volume control on the front of the panel. A hand set type of microphone normally hangs on the receiver hook at the edge of the desk. With the receiver hook down, reception is by means of a loud speaker in the control-unit cabinet. With the receiver hook up, reception is by means of the earphone in the handset. The only variation in the use of the radio from that of an ordinary telephone is that a press-to-talk button in the grip of the hand set must be depressed while transmitting.

**Car Installations ★** The mobile antenna is of the quarter-wave type, and is spring mounted on the center of the car roof. The antenna is connected to the transmitter by a concentric transmission line. However, rear-mounted antennas have been placed on the cars presently equipped and seem to be satisfactory.

The car transmitters have sufficient power to contact their stations from any point in their districts. Because of the relatively poor conditions under which the car antenna must operate, this dictated as large a transmitter power output as is consistent with space requirements of the apparatus and load on the car battery. The 35-watt rating of the New Jersey mobile transmitters meets these requirements and is consistent with the capacity of available equipment.

The mobile receivers meet the same standard of performance as the station receivers. The operation of the mobile equipment is the same as the station equipment except that an off-on switch is provided and the loudspeaker is muted by a switch instead of the receiver hook. Fig. 3 shows the very simple car control unit, and Fig. 4 the complete radio installation in the baggage compartment.

Three service and emergency trucks are to be equipped with 50-watt transmitters operating at the frequency of the station transmitters, and receivers tuned to the mobile-transmitter frequency. These trucks will also contain the regular mobile equipment. It is planned to use these trucks to direct activities at the scene of a disaster or for temporary station transmitters in case of failure at the fixed stations.

**Raritan Sub-Station** Fig. 9, left. Sgt. P. J. Smith has the radio control box on a corner of his desk, with the transmitter in the same room. Fig. 10. Corp. J. J. McCormack sits next to the transmitter at the Raritan sub-station. There is no chance of electrical shock, for even the outer conductor of the coaxial antenna lead is grounded, and all high-potential parts are enclosed.

## BOOK REVIEWS: ACOUSTIC DESIGN CHARTS

Acoustic Design Charts, by Frank Massa, B.S., M.Sc., in charge of Acoustic Division, Brush Development Company, 228 pages, 107 full-page charts, price $4.00. Published by The Blakiston Company, 1012-A Walnut Street, Philadelphia, Pa.

The purpose of this book is to present, in direct-reading charts and curves, comprehensive acoustic engineering data for the design of electro-acoustic apparatus.

It converts basic acoustic theory into quantitative charts which can be used without laborious computations and interpretations. The scales have been laid out with a view to obtaining constant precision in reading the large range of values plotted.

By giving families of curves on many of the charts, it is possible to see immediately the quantitative effect of varying parameters of a system. Sample problems are given to illustrate clearly the use of each chart.

This treatise covers the design of acoustic, mechanical, and electro-acoustic apparatus, vibrating mechanical systems, isolation of machinery, noise reduction, electro-magnetic and permanent magnet design, electrical circuits, and related data. Over 750 curves are shown.

The 10 sections are: Fundamental relations in plane and spherical sound waves; Attenuation of sound and vibration; Mechanical vibrating systems; Acoustical elements and vibrating systems; Radiation of sound from pistons; Directional radiation characteristics; Reverberation and sound reproduction; Exponential horn loudspeakers; Electro-magnetic design data; Miscellaneous data.

# SPOT NEWS NOTES

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

**Motto for War:** WPB offices are currently displaying signs which read: WE ARE FIGHTING THE AXIS, NOT EACH OTHER. This motto is a good one for offices and factories at radio plants where high pressure and long hours magnify little annoyances and make small grievances seem important.

**South Carolina:** May be the next of the Atlantic Coast states to install a state police radio system. Tentative plans call for 9 main stations and 175 mobile units. Probably the execution of this plan will depend upon getting a release for the equipment from the WPB.

**Dividends:** Directors of Stewart-Warner Corporation have voted payment of a semi-annual dividend of 25¢ per share of common stock, payable on June 30th to stockholders of record June 6th.

**Dismissed:** Without prejudice and retired to the closed files of the FCC is the application of the Bamberger Broadcasting Service for a construction permit for a new television station to operate on channel 6.

**S. T. Thompson:** Vice president of Zenith Radio Corporation, passed away on June 8th at Oak Park, Illinois, after a month's illness. This photograph was taken in 1937, when he spoke on Jessica Dragonette's program over the CBS network

**New Business:** Contracts have been awarded to F. M. Link for state-wide 2-way FM police systems by New York and Massachusetts. When completed, Link installations will be in operation in every state from Maine as far as South Carolina along the Atlantic seaboard. The only exception is New Hampshire, where no state police system has been installed so far.

**Profits:** Consolidated balance sheet for Zenith Radio Corporation as of April 30th shows a net profit, after deducting the amount of $1,436,097 for taxes, of $1,637,049. This equals $3.32 per share on the 492,464 shares outstanding. Total sales were $6,002,437, or 44% above the previous year, and the largest in the Company's history.

**Aircraft Cables:** General Electric has just issued a 16-page catalog on asbestos and synthetic-insulated aircraft wires and cables. These products are approved under Navy specification A-N-JC-48. Complete test data is presented.

**Frank S. Misterly:** Now assistant chief engineer of WPB Production Division, Contract Distribution Branch, at 122 E. 42nd Street, New York City. This office aids contractors with their procurement problems, and serves the procurement agencies of the Government.

**20th Anniversary:** Celebrated by Aerovox Corporation, at New Bedford, Mass. Mayor Blynn, at the anniversary party, paid his respects to S. I. Cole, Aerovox president, and to the Company employees. First button of the newly-formed Ten-Year Club went to Bill Hitt, San Francisco sales representative who joined the Company in 1923.

**MBS Ownership:** At a recent hearing on the Sanders Bill, calling for the reorganization of the FCC, testimony was given that the chief shareholders of the Mutual Broadcasting System are the Don Lee, R. H. Macy, and Chicago Tribune interests.

**City of New York:** The Municipal Broadcasting System, which operates WNYC, has asked for an extension of the date of completion of its FM transmitter from June 14th to November 14th, 1942.

**Minute Man Flag:** Displayed by Allied Radio Corporation of Chicago, where 100% of the employees have enrolled in the Payroll Savings Plan for the purchase of War Bonds. Within two days after Allied president A. D. Davis presented the plan, the enrollment was completed.

**High-Voltage Capacitors:** Solar Mfg. Corp., Bayonne, N. J., has brought out a line of high-voltage paper condensers for 6,000 to 25,000 volts DC. Mineral oil impregnation is used with vacuum treatment. Wide variety of casings and terminals is available. Normal tolerance is −5% +15% of rated capacity. Tolerance as close as −3% +10% can be provided.

**Arnold M. Weichert:** Is acting head for Signal Corps and Radio Section of the WPB Production Division at 122 E. 42nd Street, New York City. He is an old-timer on amateur frequencies, and has operated W8AOW, W1NEL, and more recently W2OOL. Radio servicemen, junior or senior engineers, draftmen, and amateur operators not now employed in War industries and who want to get into such work should write to him at the address above.

**FM Stations:** Latest survey shows 37 stations on regular schedule. Of these, 10 are still operating under experimental licenses, although they are on the air a minimum of six hours daily. Shepard FM stations at Paxton and Mt. Washington, because of their importance to national defense, are operating 24 hours, seven days a week. Also, educational stations in Cleveland and San Francisco are maintaining full schedules.

**L. B. Keim:** New general manager and chief engineer of Muzak station W47NY. He recently resigned as assistant secretary of the Institute of Radio Engineers.

**The Last Admiral:** Continental Radio and Television Corp., Chicago, recently presented the last Admiral radio set to come off their production lines to the Great Lakes Training Station. Plant is now 100% on War production.

# NEWS PICTURE

**Busy Man** right now is Paul W. Fuelling, chief engineer of WHN, for he is getting W63NY on the air, despite the handicaps and restrictions imposed by the FCC'S freezing order. The 1-kw. Western Electric FM transmitter and the Blaw-Knox tower, now installed on the New Jersey Palisades across the Hudson River from New York City, were delivered before the freezing order was issued, so that no equipment is being diverted from military use.

W63NY, the seventh FM station in the New York area, is on a seven-day schedule from 2:00 to 9:00 P.M. For the present, this station is using a Western Electric vertical radiator, but this will be replaced as soon as possible with a horizontally polarized array. Complete details of the installation will be presented in a forthcoming article by Paul Fuelling.

# THE FACTOR Q

## Significance of the Factor Q in Radio Circuits, and the Methods of Using the Q-Meter, Part 1

**Measurement of the Q factor of coils, condensers, resistors, and insulating materials is essential to the correct design of radio circuits. The data presented here, probably the most complete treatment ever written on this subject, was prepared by the Engineering Department of the Boonton Radio Corporation, at Boonton, N. J.**

THE symbol $Q$ is commonly used to designate the ratio of reactance to resistance of a coil ($Q = 2\pi fL/R$), of a condenser ($Q = 1/2\pi fCR$), or other circuit elements having two accessible terminals. This factor is of importance in circuit design since it constitutes a "figure of merit" for the reactive element in question.

**Significance of Q** ★ In circuit design, the first things arrived at usually are the values of the reactors, which are generally determined by frequency considerations, such as tuning range, cut-off frequencies and so forth. The engineer is then confronted with the practical problem of realizing their values of reactance physically. In the solution of this problem one of the most important considerations is the amount of loss, or resistance, that can be tolerated or, more accurately, to balance the cost of reducing the resistance against the improvement in circuit performance which is brought about thereby. Since $Q$ by definition expresses the ratio of a given reactance to its resistance, it can be advantageously employed for the purpose of quantitatively comparing various reactors.

In a simple resonant circuit with series impressed voltage, the ratio between the voltage across the coil or condenser to the impressed voltage (voltage step-up) is directly proportional to $Q$. In the case of more complicated circuits, the performance also depends upon $Q$ but naturally not in such a simple fashion. In general, it can be stated that the higher the $Q$'s of the reactive elements, the better will be the performance of the circuit. An example of the application of this principle in a complicated circuit is found in the case of a filter, where it is known that high $Q$'s in the reactors improve the transmission in the pass band and sharpen the cut-off.

These remarks on the significance of $Q$ in circuit design may be illustrated by a few simple examples.

Consider first the case of a simple resonant circuit comprising in series an inductor of inductance L and resistance $R_L$, and a condenser of capacitance $C$ and resistance $R_C$. If a voltage $E$ be introduced into the circuit the voltage across the inductor, or condenser, at resonance will be (very closely):

$$E_L = \frac{E\omega L}{R_C + R_L} \qquad (1)$$

Denoting the $Q$'s of the coil and condenser by $Q_L$, ($\omega L/R$) and $Q_C$, ($1/\omega CR_C$) respectively, (1) may be written:

$$E_L = \frac{E}{\frac{1}{Q_L} + \frac{1}{Q_C}} = E\frac{Q_L Q_C}{Q_L + Q_C} \qquad (2)$$

In well designed radio circuits the losses in the condenser will be negligible compared with the losses in the coil so that $Q_C$ will be much greater than $Q_L$. In this case (2) becomes

$$E_L = EQ_L \qquad (3)$$

or in other words the voltage step-up is directly proportional to the $Q$ of the coil.

In circuit combinations which are more complicated than the simple example considered above, $Q$ is also of significance, but naturally not so directly. Consider, for example, two coupled circuits, the first comprising inductance $L_1$, capacitance $C_1$, and resistance $R_1$ in series; the second comprising $L_2$, $C_2$, and $R_2$ in series. If a voltage $E$ be introduced into circuit 1, with both circuits in resonance, the voltage across the coil (or condenser) in the second circuit for optimum coupling will be:

$$E_2 = E\frac{\omega L_2}{2\sqrt{R_1 R_2}} \qquad (4)$$

$$= \frac{EQ_2}{2}\sqrt{\frac{R_2}{R_1}} \qquad (5)$$

where $Q_2$ represents the $Q$ of circuit 2. In this case we see that, so far as circuit 2 is concerned, the step-up varies as $\omega L_2/\sqrt{R_2}$ instead of as $\omega L_2/R_2 = Q_2$ and $Q$ does not directly determine the result. However, the same variations of the factors $\omega$, $L$ and $R$ which would increase $Q$ would undoubtedly increase the step-up also, even though this is not directly proportional to $Q$.

Consider a third case of practical interest, an inductor and condenser in parallel as a coupling element in a tube of the screen-grid type. With such tubes the plate resistance is generally so high compared with the anti-resonant impedance of the coupling circuit that the gain is approximately proportional to the coupling element impedance. In the case considered this impedance will be, at anti-resonance, a pure resistance of the value

$$\frac{\omega^2 L^2}{R} = Q\omega L = Q^2 R \qquad (6)$$

Here again the overall gain will not be directly proportional to $Q$ but to the product of $Q$ and $\omega L$; however, if the value of inductance be fixed by other considerations the gain will be proportional to $Q$.

We see that although the overall transmission is not always directly proportional to $Q$, $Q$ always enters as a positive factor; in no case does the transmission depend inversely on $Q$. We can sum up this discussion by saying that $Q$ is a measure of the "merit" of the reactive element and that in general the higher the $Q$'s of the reactive elements the better will be the performance of the circuit.

Other quantities, closely related to $Q$, which have been proposed or used to represent the merit of reactive elements may be noted here, as follows:

**Dissipation Factor: Power Ratio:** $\eta$ ★ This is defined as the ratio of resistance to reactance of an impedance: i.e.,

$$\eta = \frac{R}{X} = \frac{R}{\omega L} = R\omega C = \frac{1}{Q} \qquad (7)$$

While convenient for mathematical work, it is less desirable than $Q$ descriptively because it becomes smaller as the reactor gets better.

**Power Factor** ★ Power factor is the ratio of resistance to impedance and is equal to the cosine of the phase angle $\theta$:

$$\text{Power factor} = \cos\theta = \frac{R}{\sqrt{R^2 + X^2}} \qquad (8)$$

The reciprocal of this quantity approaches $Q$ as $Q$ increases. When $Q$ is greater than 10, the power factor is practically equal to the reciprocal of $Q$, the difference being less than 1 per cent. Thus, for impedances having a $Q$ over 10, the following relation is correct to better than 1%:

$$\text{Power factor} = \cos\theta = \frac{1}{Q} \qquad (9)$$

**Phase Angle:** $\theta$ ★ The phase angle of an impedance is the phase angle between the current through the impedance and the voltage across the impedance. It is the angle, in radians or degrees, whose cotangent is equal to $R/X$:

$$\cot\theta = \frac{R}{X} = \frac{R}{\omega L} = R\omega C = \frac{1}{Q} \qquad (10)$$

**Phase Difference:** $\psi$ ★ This is the complement of the phase angle $\theta$ and is the angle whose tangent is equal to R/X:

$$\tan\psi = \frac{R}{X} = \frac{R}{\omega L} = R\omega C = \frac{1}{Q} \qquad (11)$$

## THEORY OF THE METHOD OF MEASUREMENT

The theory of the method of measurement employed in the Boonton Radio Type 160-A Q-Meter may be explained with the aid of a schematic diagram of the fundamental circuit of the instrument, Fig. 1.

The oscillator furnishes a current, measured by means of the ammeter, which flows through the special resistor $R^1$. This resistance $R^1$ (0.04 ohm) will usually be small compared with the other resistances in the circuit and can be neglected or, if the circuit resistance is especially low, corrected for. A known voltage $E$ is thus introduced into the series circuit comprising the variable condenser $C$ and the inductive reactor under measurement, connected across the terminals $AB$. The condenser $C$ is contained in the instrument and its effective resistance is negligible.

By way of illustration, we shall consider the measurement of the $Q$ of a coil having inductance $L$, resistance $R$, and distributed capacitance $C_d$, as shown connected to the terminals $AB$.

In general any two-terminal inductive reactor which might be connected across $AB$ can be represented by an effective series inductance $L_e$ and an effective series resistance $R_e$. At resonance, the condenser reactance will balance the effective series reactance between $A$ and $B$ and the current will be (neglecting $R^1$):

$$I = \frac{E}{R_e} \qquad (12)$$

The voltage $E_c$ across the condenser $C$ is measured by means of a voltmeter having negligible power consumption. Then:

$$\frac{E_c}{E} = Q_e = \frac{1}{\omega C R_e} \qquad (13)$$

At resonance $1/\omega C = \omega L_e$ hence:

$$\frac{E_c}{E} = Q_e = \frac{\omega L_e}{R_e} \qquad (14)$$

This is defined as the effective $Q$ of the coil or other impedance connected to $AB$.

The method of measurement thus yields the "effective $Q$". This differs somewhat from the true $Q$, which is defined by:

$$Q = \frac{\omega L}{R} \qquad (15)$$

A detailed analysis shows that in the case of a coil, the difference between the true $Q$ and effective $Q$ depends on the distributed capacitance of the coil, and may be expressed very closely by:

$$Q = Q_e\left(1 + \frac{C_d}{C}\right) \qquad (16)$$

except for frequencies very near the natural frequency of the coil. Thus, the effective $Q$ approaches true $Q$ as the ratio of tuning capacitance to distributed capacitance increases.

From the practical viewpoint this difference is of little importance, since in the design of tuned circuits the minimum capacitance used to tune a coil is usually 10 to 20 times the distributed capacitance of the coil, so that the maximum difference between effective and true $Q$ will be 5 to 10 per cent when measured with the minimum tuning capacitance.

In special cases when coils having a high distributed capacitance are measured with low tuning capacitances and it is desired to know $Q$ with high accuracy, the above equation (16) may be used to obtain true $Q$.

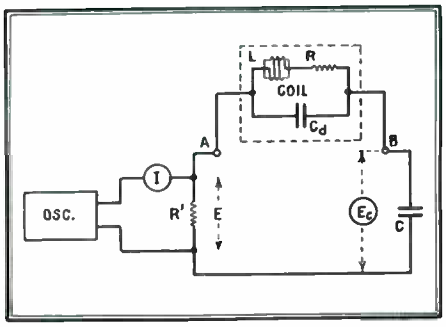



**FIG. 1. ELEMENTARY CIRCUIT DIAGRAM OF THE Q-METER UNDER DISCUSSION**

### UNITS USED IN FORMULAS

In all formulas which follow, unless otherwise stated, the units employed are:

$L$ = Inductance in microhenries.
$C$ = Capacitance in micro-microfarads.
$f$ = Frequency in kilocycles per second.
$R$ = Resistance in ohms.
$X$ = Reactance in ohms.
$Z$ = Impedance in ohms.

The subscripts used refer to the following values, unless otherwise stated:

$C_d$ = Distributed capacitance of a coil.
$f_o$ = Resonant frequency of an impedance.
$L_1$ = Inductance of the coil used in the Q circuit.
$C_1$, $Q_1$ = Capacitance and Q of the Q circuit alone (with coil only connected to the Q circuit).
$C_2$, $Q_2$ = Capacitance and Q of the Q circuit with the test component connected to the Q circuit.
$Q_x$ = Q of the test component.
$C_s$, $L_s$, $R_s$, $X_s$ = Effective series values of the test component.
$C_p$, $L_p$, $R_p$, $X_p$ = Effective parallel values of the test component.

## GENERAL METHODS OF MEASUREMENT

**1-A : Coil Measurements ★** The $Q$ circuit of the $Q$-Meter consists essentially of a calibrated variable condenser to which an external coil can be connected to form a simple resonant circuit. The inductance of the external coil is substantially the entire inductance of the $Q$ circuit. A calibrated voltage is inserted in series in this circuit and a voltmeter connected across the condenser measures the $Q$ of the circuit.

There are two general methods of making measurements with the $Q$-Meter. One method, which is applicable to measuring coils, consists of connecting the unknown coil to the $Q$ circuit, thus making the coil the inductive element of a simple resonant circuit which at resonance indicates, directly, values of tuning capacitance and circuit $Q$. From these values and the frequency of measurement, the effective $Q$, inductance, and resistance of the coil can be determined. Because of its simplicity, this method is used for most coil measurements. The theory of this method has been discussed already, and the procedure for measuring coils is described in more detail in section 3.

**1-B: Measurement of Any Impedance ★** A second method of measurement which is applicable to any two-terminal impedance (within the limits of measurements of the $Q$-Meter) consists first, of providing a simple resonant circuit by connecting a coil to the $Q$ circuit of the $Q$-Meter and resonating the circuit and, second, connecting the unknown impedance to the resonant circuit, either in series or in parallel, and re-resonating the circuit. Two values of circuit tuning capacitance and two $Q$ readings are thus obtained. From these values and the frequency of measurement obtained from the $Q$-Meter may be calculated effective values of $Q$, resistance, reactance, inductance, or capacitance of the unknown impedance.

Any two-terminal impedance, $Z$, may be considered as consisting of two elements, one an effective resistance and the other an effective reactance which may be inductive or capacitive. These elements may be thought of as connected either in series, as represented in Fig. 2A, or in parallel as represented in Fig. 2B.

$R_s$ = Effective series resistance.
$X_s$ = Effective series reactance.
$L_s$ = Effective series inductance.
$C_s$ = Effective series capacitance.
$R_p$ = Effective parallel resistance.
$X_p$ = Effective parallel reactance.
$L_p$ = Effective parallel inductance.
$C_p$ = Effective parallel capacitance.

The values of the resistance, reactance, inductance and capacitance for the series arrangement may be expressed as effective series values and represented by $R_s$, $X_s$, $L_s$ and $C_s$. The corresponding values for the parallel arrangement may be expressed as effective parallel values and represented by $R_p$, $X_p$, $L_p$ and $C_p$.

The $Q$ of the impedance has the same value whether the impedance is considered as a series or parallel arrangement. The effective series values of the resistance and reactance elements however, may be quite different from their effective parallel values. The general relations between these quantities are shown in the following formulas (17) to (21) which appear on the following page.

$$Q_x = \frac{X_s}{R_s} = \frac{6.28 \times 10^{-3} f L_s}{R_s} = \frac{1.59 \times 10^8}{f R_s C_s} = \frac{R_p}{X_p} = \frac{159 R_p}{f L_p} = 6.28 \times 10^{-9} f R_p C_p \quad (17)$$

$$R_s = \frac{R_p}{1 + Q_x^2} \quad (18a) \qquad R_p = R_s(1 + Q_x^2) \quad (18b)$$

$$X_s = X_p \frac{Q_x^2}{1 + Q_x^2} \quad (19a) \qquad X_p = X_s \frac{1 + Q_x^2}{Q_x^2} \quad (19b)$$

$$L_s = L_p \frac{Q_x^2}{1 + Q_x^2} \quad (20a) \qquad L_p = L_s \frac{1 + Q_x^2}{Q_x^2} \quad (20b)$$

$$C_s = C_p \frac{1 + Q_x^2}{Q_x^2} \quad (21a) \qquad C_p = C_s \frac{Q_x^2}{1 + Q_x^2} \quad (21b)$$

It is apparent from the above relations that when the $Q$ of an impedance is greater than 10, $X_s$, $L_s$ and $C_s$ are equal to $X_p$, $L_p$ and $C_p$, respectively, with an error of less than 1%, but the values of $R_s$ and $R_p$ are quite different. This corresponds to the case of coils and condensers commonly used in resonant circuits which generally have $Q$'s considerably greater than 10. In this case, the difference between the effective series and parallel values of reactance, inductance, or capacitance is negligible while the difference between the effective series and parallel resistance is large.

It is also apparent that when the $Q$ of the impedance is less than 0.1, as may occur in resistors, $R_s$ and $R_p$ will be equal, with an error of less than 1%, while the difference between the effective series and parallel values of the reactive element will be large.

The Q and the effective series and parallel values of resistance, reactance, inductance or capacitance of a two-terminal impedance, as defined above, may be measured with the $Q$-Meter by connecting the unknown impedance, $Z$, either in series in the $Q$ circuit of the $Q$-Meter as represented in Fig. 2C or in parallel with the $Q$ circuit as in Fig. 2D. $L$ and $C$ in these circuits represent the inductance and resonant capacitance of the $Q$ circuit, and E represents the voltage inserted in series with the $Q$ circuit in the $Q$-Meter. The series connection is generally useful for measuring low impedances and the parallel connection for measuring high impedances.

When an unknown impedance is measured with the $Q$-Meter, the effective series values of resistance, reactance, etc., of the impedance are most simply determined from the series connection to the $Q$ circuit (Fig. 2C) whereas the effective parallel values are most simply determined from the parallel connection (Fig. 2D). For this reason the formulas for calculating the effective resistance, reactance, etc., given below have been arranged to give effective series values when the unknown impedance is measured in series in the $Q$ circuit, and to give effective parallel values when the impedance is measured in parallel with the $Q$ circuit.

The procedure in measuring an unknown impedance is as follows:

The $Q$ circuit is first resonated to the frequency of measurement, $f$, calling the values of resonant capacitance and the $Q$ of the $Q$ circuit, $C_1$ and $Q_1$, respectively. The unknown impedance is then connected to the $Q$ circuit, either in series or parallel, and the $Q$ circuit re-resonated to the same frequency of measurement, $f$, calling the new resonant capacitance and circuit $Q$, $C_2$ and $Q_2$, respectively. These values may be used directly in the following formulas to calculate effective series

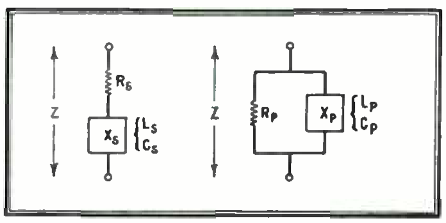



FIG. 2-A
CIRCUIT ELEMENTS IN SERIES

FIG. 2-B
CIRCUIT ELEMENTS IN PARALLEL

or parallel values of resistance, reactance, inductance or capacitance, and the $Q$ of the unknown impedance.

$$Q_x = \frac{(C_1 - C_2)\, Q_1 Q_2}{C_1 Q_1 - C_2 Q_2} \quad (22a) \qquad Q_x = \frac{(C_2 - C_1)\, Q_1 Q_2}{C_1 \; (Q_1 - Q_2)} \quad (22b)$$

$$R_s = \frac{1.59 \times 10^8 \left( \frac{C_1}{C_2} Q_1 - Q_2 \right)}{f\, C_1 \qquad Q_1 Q_2} \quad (23a) \qquad R_p = \frac{1.59 \times 10^8 \, Q_1 Q_2}{f C_1 \; (Q_1 - Q_2)} \quad (23b)$$

$$X_s = \frac{1.59 \times 10^8 \, (C_1 - C_2)}{f \qquad C_1 C_2} \quad (24a) \qquad X_p = \frac{1.59 \times 10^8}{f(C_2 - C_1)} \quad (24b)$$

$$L_s = \frac{2.53 \times 10^{10} \, (C_1 - C_2)}{f^2 \qquad C_1 C_2} \quad (25a) \qquad L_p = \frac{2.53 \times 10^{0}}{f^2 \, (C_2 - C_1)} \quad (25b)$$

$$C_s = \frac{C_1 C_2}{(C_2 - C_1)} \quad (26a) \qquad C_p = C_1 - C_2 \quad (26b)$$

When $C_1$ is:
Greater than $C_2$, $X_s$ is inductive (+).
Less than $C_2$, $X_s$ is capacitive (—).

**SERIES CONNECTION TO Q CIRCUIT. (FIG. 2C)**

When $C_1$ is:
Greater than $C_2$, $X_p$ is capacitive (—).
Less than $C_2$, $X_p$ is inductive (+).

**PARALLEL CONNECTION TO Q CIRCUIT. (FIG. 2D)**

**GENERAL FORMULAS FOR ANY IMPEDANCE**

In the formulas for $Q$, the quantities $(C_1 - C_2)$ and $(C_2 - C_1)$ are always considered positive.

The following symbols used in the above formulas refer to the $Q$-Meter readings:

$C_1$, $Q_1$ = Capacitance and $Q$ readings of $Q$ circuit alone.

$C_2$, $Q_2$ = Capacitance and $Q$ readings of $Q$ circuit with unknown impedance, $Z$, connected either in series or in parallel with the circuit.

$f$ = Frequency of measurement.

The following symbols refer to values of the unknown impedance, $Z$:

$Q_x$ = $Q$ of the unknown impedance.
$R_s$ = Effective series resistance.
$X_s$ = Effective series reactance.
$L_s$ = Effective series inductance.
$C_s$ = Effective series capacitance.
$R_p$ = Effective parallel resistance.
$X_p$ = Effective parallel reactance.
$L_p$ = Effective parallel inductance.
$C_p$ = Effective parallel capacitance.

The units used are:

$R$ = Resistance in ohms.
$X$ = Reactance in ohms.
$L$ = Inductance in microhenries.
$C$ = Capacitance in micro-microfarads.
$f$ = Frequency in kilocycles per second.

It is apparent that when an impedance is connected, for example, in parallel with the $Q$ circuit, the values obtained from the preceding formulas (23b) to (26b) are effective parallel values. If equivalent series values are desired, for example effective series resistance, it may be obtained by first calculating $Q_x$ by means of formula (22b) and the effective parallel resistance, $R_p$, from formula (23b), then substituting $Q_x$ and $R_p$ in formula (18a) to obtain the effective series resistance, $R_s$.

In a similar manner, effective parallel values may be calculated from measured series values by calculating first the series values of $R_s$, $X_s$, $L_s$ or $C_s$ and the $Q$ of the impedance, $Q_x$, from formulas (22a) to (26a) and making the necessary substitutions in formulas (18b) to (21b) to obtain parallel values.

### 1-C: Simplified Formulas for High Q Impedances ★

In some cases the calculation of desired quantities may be simplified. When the $Q$ of the impedance being measured is greater than 10 as will be the case in many components, the difference between the effective series and parallel values of reactance, inductance, or capacitance may be neglected and the values obtained from the preceding formulas (24) to (26) may be considered to be the effective reactance, inductance or capacitance of the impedance without regard to whether they are series or parallel values. The values of $R_s$ and $R_p$ in this case will be quite different as shown in the following group of formulas:

$$Q_x = \frac{(C'_1 - C'_2)\,Q_1Q_2}{C'_1Q_1 - C'_2Q_2} \qquad (22a)$$

$$R_s = \frac{1.59 \times 10^8 \left(\frac{C'_1}{C'_2}Q_1 - Q_2\right)}{f\,C'_1\,Q_1Q_2} \qquad (23a)$$

$$R_p = \frac{1.59 \times 10^8\,(C'_1 - C'_2)^2\,Q_1Q_2}{fC'_1C'_2(C'_1Q_1 - C'_2Q_2)} \qquad (27a)$$

$$X_s = X_p = \frac{1.59 \times 10^8\,(C'_1 - C'_2)}{f\;\;C'_1C'_2} \qquad (28a)$$

$$L_s = L_p = \frac{2.53 \times 10^{10}\,(C'_1 - C'_2)}{f^2\,C'_1C'_2} \qquad (29a)$$

$$C'_s = C'_p = \frac{C'_1C'_2}{(C'_2 - C'_1)} \qquad (30a)$$

SERIES CONNECTION TO Q METER. (FIG. 2C)

$$Q_x = \frac{(C'_2 - C'_1)\,Q_1Q_2}{C'_1\,(Q_1 - Q_2)} \qquad (22b)$$

$$R_p = \frac{1.59 \times 10^8\,Q_1Q_2}{fC'_1\,(Q_1 - Q_2)} \qquad (23b)$$

$$R_s = \frac{1.59 \times 10^8\,C'_1\,(Q_1 - Q_2)}{f\,(C'_2 - C'_1)^2\,Q_1Q_2} \qquad (27b)$$

$$X_s = X_p = \frac{1.59 \times 10^8}{f(C'_2 - C'_1)} \qquad (28)$$

$$L_s = L_p = \frac{2.53 \times 10^{10}}{f^2\,(C'_2 - C'_1)} \qquad (29b)$$

$$C'_s = C'_p = C'_1 - C'_2 \qquad (30b)$$

PARALLEL CONNECTION TO Q METER (FIG. 2D)

FORMULAS FOR IMPEDANCES HAVING A Q GREATER THAN 10

In the formulas above, the same units, symbols, and conditions previously stated apply, except that formulas (27) to (30) are accurate only for impedances having a $Q$ greater than 10. Formulas (22) and (23) are accurate for any impedance.

## GENERAL PRECAUTIONS

**2-A: Q Circuit Coils** ★ Measurements of components other than coils, such as condensers and resistors, require a coil in the $Q$ circuit of the $Q$-Meter for resonating to the frequency of measurement. The main requirements for this coil are (1) that its inductance is of such a value that it will resonate to the desired frequency of measurement with the total tuning capacitance desired, this being the sum of the capacitance used in the $Q$ tuning condensers and the capacitance of the component being measured, and (2) that its $Q$ is high enough to permit accurate measurements. Generally a $Q$ in the region of 200 to 250 will be most suitable. For some measurements, such as $Q$ or power factor of low loss condensers or insulating materials, a coil having a $Q$ of 400 to 500 is desirable.

The coil should preferably be shielded to avoid coupling to the test component and to prevent any nearby objects from changing the $Q$ circuit adjustment during measurement. Large unshielded coils are particularly subject to such changes because of the extent of their field and should not be used ordinarily for accurate measurement work. The coil shield should be grounded to the low potential coil terminal.

If measurements are to be made over a wide range of frequencies, a number of such coils are required, each of which can be used for a single or a narrow band of frequencies.

The Boonton Radio type 103-A inductors are suitable for this purpose, having been designed to plug into the coil terminals of the Q-Meter to facilitate rapid changing of inductance to correspond to the measurement frequency. They are completely shielded coils having a $Q$ in the region of 200 over the normal range of operation, when resonated with tuning capacitances between 40 and 400 $\mu\mu$f.

**2-B: Precautions** ★ In all measurements, unless otherwise stated, the $Q$ circuit is to be adjusted to resonance as indicated by a maximum deflection of the $Q$ voltmeter. The dial readings and $Q$ readings at resonance are the values to be used in the formulas in calculating quantities not directly indicated. Unless otherwise stated, the vernier condenser should be set at zero or its capacitance should be added to the main condenser dial reading.

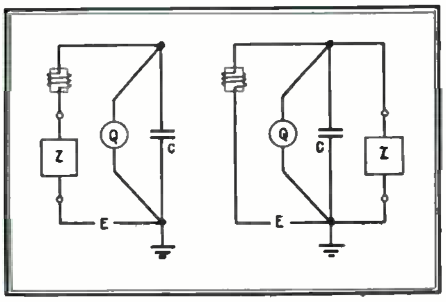



FIG. 2-C IMPEDANCE ELEMENTS IN SERIES

FIG. 2-D IMPEDANCE ELEMENTS IN PARALLEL

All ordinary precautions observed in making radio frequency measurements, such as placing the component being measured so that any field surrounding it is not appreciably affected by nearby conductors or by capacitance to the body of the operator, maintaining low resistance connections, etc., should be observed.

Leads between the $Q$-Meter and the component being measured should be heavy and as short as possible when making measurements at high frequencies.

Owing to the method of insertion of the voltage in the $Q$ circuit, the low potential coil terminal is not at ground potential. Care should be taken that components connected to the coil terminals are not grounded either to the $Q$-Meter cabinet or to ground since this will prevent correct operation of the $Q$ circuit. Components or circuits having a ground connection or large capacitance to ground can not be measured when connected to the coil terminals of the $Q$-Meter. Such components may in some cases be connected in parallel with the $Q$ circuit (to the condenser terminals) for measurement.

When measuring components other than coils, the determination of $Q$, resistance, or power factor generally depends on having losses in the component great enough to produce a measurable change in the $Q$ of the $Q$ circuit. That is, the $Q$ of the component must be comparable to the $Q$ of the $Q$ circuit. It is apparent that a condenser having a very high $Q$, for example, may lower the $Q$ of the $Q$ circuit by only a very small amount when it is connected across the circuit. If this change in $Q$ is too small to measure, the $Q$ or resistance of the test condenser can not be measured.

In measurements such as $Q$ or resistance of condensers in which the accuracy depends on the accuracy of the total tuning capacitance, the capacitance between any leads should be taken into account by disconnecting the condenser *at its terminals* and measuring the effect of the leads by noting the change in the resonant capacitance of the main tuning condenser when the leads are connected and disconnected. This also applies to any fixtures used in testing. Their capacitances should be determined and added to the readings of the main tuning condenser. This is particularly important in determining the distributed capacitance of a coil, which may be quite low. In general, testing fixtures should be made of low-loss insulating materials.

$Q$ voltmeter readings of less than about 100 are limited in accuracy by the meter calibration. Meters are generally rated in accuracy as a percentage of full scale so it is apparent that the accuracy of a reading expressed as a percentage of the reading decreases as the reading decreases.

## COILS

**3-A: General** ★ When a coil is measured with the $Q$-Meter, its inductance is the entire inductance of the $Q$ circuit except for the residual inductance of the circuit. The tuning capacitance at resonance is indicated directly by the tuning condenser dial and the $Q$ of the circuit is indicated directly by the $Q$ voltmeter. This $Q$ indication is the $Q$ of the entire resonant circuit, but this is equal to the $Q$ of the coil when the inductance and losses of the rest of the circuit are negligible compared to those in the coil.

When the coil being measured is unshielded, it should be mounted at sufficient distance from the metallic top of the Q-Meter so that the effect of this on the resistance or inductance of the coil is negligible. However, the leads should not be longer than necessary to secure this result.

When measuring shielded coils the shield should be grounded to the low potential coil terminal. In no case should the shield be grounded to *both* the low potential coil terminal and condenser terminal since the series voltage in the $Q$ circuit is inserted between these two terminals.

In measurements requiring two coils in the $Q$ circuit, care should be taken to avoid coupling between the coils. One of the coils, at least, should be shielded.

**3-B: Measurement of Q** ★ The $Q$ of a coil can be measured as follows: Connect the coil to the coil terminals of the Q-Meter, set the oscillator to the desired frequency, the oscillator output to the 250 or 500 line on the $Q$ range meter, and resonate the $Q$ circuit by means of the $Q$ tuning condenser. The $Q$ voltmeter reading at resonance indicates directly the $Q$ of the coil.

The $Q$ tuning condenser dial indicates the total tuning capacitance of the $Q$ circuit, except that added by the coil and its leads.

$Q$, as measured above, is the effective $Q$ of the coil and differs from true $Q$ which is defined as $\omega L/R$, by an amount which depends on the distributed capacitance of the coil as explained in the section on the Theory of the Method of Measurement. For most coils measured with the Q-Meter, this difference is negligible, since the minimum tuning capacitance is generally 10 to 20 times the distributed capacitance and the maximum difference between true $Q$ and effective $Q$ will generally be 5 to 10 per cent.

When coils having a high distributed capacitance are resonated with low tuning capacitances and it is desired to know true $Q$ with greater accuracy than the above measurement provides, true $Q$ may be obtained as follows:

Measure effective Q as described above and call this $Q_e$. Call the $Q$ tuning condenser dial reading $C_1$. Measure the distributed capacitance, $C_d$, of the coil by one of the methods described below, in sections 3-F or 3-G. True $Q$ is then:

$$Q = Q_e\left(\frac{C_1 + C_d}{C_1}\right) \qquad (31)$$

**3-C: Resistance** ★ The effective series resistance of a coil may be determined by first measuring its effective $Q$ as described above, recording the values of frequency, $f$, $Q$ condenser tuning capacitance $C_1$, and the $Q$ of the coil, $Q_1$. The resistance, $R_s$, of the coil is then:

$$R_s = \frac{1.59 \times 10^8}{f\,C_1 Q_1} \qquad (32)$$

The resistance $R_s$ thus obtained is the apparent resistance, or effective series resistance of the coil. For most coils this value will be practically the same as the true resistance when measured as described.

The true resistance, $R$, of a coil differs from the apparent resistance due to the distributed capacitance of the coil. For frequencies not too close to the resonant frequency of the coil the relation between true resistance, $R$, and apparent resistance, $R_s$, is given by:

$$R = R_s\left(\frac{C_1}{C_1 + C_d}\right)^2 \qquad (33)$$

in which $C_1$ is the tuning capacitance used when measuring the resistance (or Q) and $C_d$ is the distributed capacitance of the coil.

When a coil is measured with relatively low tuning capacitances and its distributed capacitance is sufficiently high so that there is an appreciable difference between true resistance and apparent resistance, the true resistance may be determined as follows:

Measure the apparent resistance, $R_s$, as described above. Measure the distributed capacitance of the coil, $C_d$, by one of the methods described below in sections 3-F and 3-G, and calculate the true resistance, $R$, using the above formula (33).

**3-D: Inductance** ★ The inductance of coils having inductances from a few tenths of a microhenry to a few tenths of a henry may be measured with an accuracy of about 3 per cent with the type 160-A Boonton Radio Q-Meter when used in conjunction with an external oscillator for operation between 50 kc. and the region of 1 kc. The range of inductance measurements with the type 170-A is much less.

The inductance of a coil may be measured as follows: Connect the coil to the coil terminals of the Q-Meter, set the $Q$ tuning condenser to about 400 μμf., and resonate the $Q$ circuit by adjusting the oscillator frequency. Record the frequency, $f$, and the tuning condenser reading, $C_1$. The inductance, $L_s$, is:

$$L_s = \frac{2.53 \times 10^{10}}{f^2\,C_1} \qquad (34)$$

If the $Q$ tuning condenser is set to exactly 400 μμf., this formula may be simplified to:

$$L_s = \frac{63.2 \times 10^6}{f^2} \qquad (35)$$

This measurement gives the apparent or effective series inductance, $L_s$, of the coil. For most coils measured as described above, this will differ from the true inductance, $L$, by an amount which is less than the accuracy of measurement.

True inductance is less than apparent inductance by an amount which depends on the distributed capacitance of the coil. Good small coils generally have a distributed capacitance in the region of 1 to 6 μμf. For these coils the maximum difference between true inductance and apparent inductance will be about 1.5 per cent when measured as described above.

The true inductance of coils having a high distributed capacitance or high capacitance between leads may be determined by measuring the apparent inductance, $L_s$, as described above, and measuring the distributed capacitance, $C_d$, of the coil by one of the methods described below in sections 3-F or 3-G. True inductance, $L$, is then:

$$L = L_s\left(\frac{C_1}{C_1 + C_d}\right) \qquad (36)$$

$C_1$ is the tuning capacitance used when measuring the apparent inductance. This formula applies for frequencies not too near the resonant frequency of the coil.

**3-E: Small Inductance in Series with Large Inductance** ★ A small inductance may be measured by connecting it in series with a coil having an inductance about the same or larger than the inductance to be measured. The accuracy of this measurement becomes less as the ratio of large to small inductance increases. Small inductances less than 0.01 microhenry have been measured at high frequencies in this way although the accuracy of measurement of such small values is not very great.

To determine the inductance of a small inductor:

Connect a suitable coil (see section 2-A) to the coil terminals of the Q-Meter, set the oscillator frequency to a value that will permit resonating the $Q$ circuit with the $Q$ tuning condenser set at about 400 μμf., and resonate the $Q$ circuit. Call the tuning capacitance $C_1$ and the frequency $f$. Connect the small inductor in series with the coil, taking care that no coupling exists between the coil and the small inductor, and re-resonate the $Q$ circuit, calling the new tuning capacitance $C_2$. The effective series inductance, $L_s$, of the small inductor is:

$$L_s = \frac{2.53 \times 10^{10}}{f_2}\,\frac{(C_1 - C_2)}{C_1 C_2} \qquad (25a)$$

Other values such as $Q$, resistance, etc., of the small inductor may be calculated from the formulas (22a) to (24a), which give the effective series values of an impedance measured in series in the $Q$ circuit.

**3-F: Distributed Capacitance** ★ A simple method of measuring the distributed capacitance of a coil which is fairly accurate for high distributed capacitances but is inaccurate for capacitances below about 10 μμf. is as follows:

Connect the coil to the coil terminals

(CONTINUED ON PAGE 29)

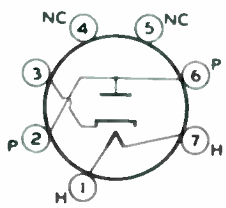
# VACUUM TUBE REVIEW

In future issues, the Vacuum Tube Review will carry a Reference Index of tubes listed previously in FM Radio-Electronic Engineering

## 1A3

### HF Diode
### Midget Type

1. Heater
2. Plate
3. Cathode
4. No connection
5. No connection
6. Plate
7. Heater




BOTTOM OF SOCKET 5AP

**1A3** is a heater-cathode type of Midget diode, particularly useful as a discriminator tube in portable FM receivers, and in portable high-frequency measuring equipment. Its interelectrode capacitances are very low, being in the order of 0.5 mmf. The resonant frequency of the 1A3 is approximately 1,000 mc. The glass button base provides for short leads and low lead inductance.

Heater Voltage AC or DC . . . . . 1.4 volts
Heater Current . . . . . . . . . . . . . . 0.15 amp.
Direct Interelectrode Capacitances, with no external shield:
Plate to Cathode, $C_{pk}$ . . . . . . . . . 0.4 mmf.
Plate to Heater, $C_{ph}$ . . . . . . . . . . 0.6 mmf.
Heater to Cathode, $C_{hk}$ . . . . . . . . 0.6 mmf.

Maximum Overall Length . . . 1 13/16 ins.
Maximum Seated Height . . . . . 1 9/16 ins.
Maximum Diameter . . . . . . . . . . . . 3/4 ins.
Bulb . . . . . . . . . . . . . . . . . . . . . . . . T-5-1/2
Base . . . . . . . . . . Miniature Button 7-Pin [1]
Mounting Position . . . . . . . . . . . . . . . . Any

[1] The center hole in sockets designed for this base provides for the possibility that this tube type may be manufactured with the exhaust-tube tip at the base end. For this reason, it is recommended that in equipment employing this tube type, no material be permitted to obstruct the socket hole.

**RECTIFIER**

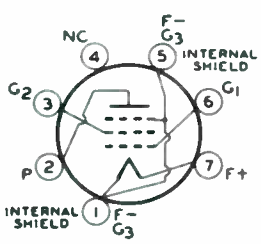
AC Plate Voltage, RMS . . 117 volts max.
DC Output Current . . . . . . . 0.5 ma. max.

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940, Rev. 11-40).

## 1L4

### RF Amp. Pentode
### Miniature Type

1. Filament—, Grid No 3, Int. Shield
2. Plate
3. Screen
4. No connection
5. Same as 1
6. Grid
7. Filament +




BOTTOM OF SOCKET 6AR

**1L4** is an RF pentode of the Miniature type with a sharp cut-off characteristic. It is recommended for use wherever a sharp cut-off pentode is required in compact, light-weight, portable receivers. The tube is, therefore, of interest in FM receivers and in other circuits not requiring AVC. The 1L4 features internal shielding which eliminates the need for an external bulb shield, but a socket with shielding is essential if minimum grid-plate capacitance is to be obtained.

Filament Voltage DC . . . . . . . . . 1.4 volts
Filament Current . . . . . . . . . . . . 0.05 amp.
Direct Interelectrode Capacitances, with no external shield:
Grid to Plate, $C_{g_1p}$ . . . . 0.008 max. mmf.
Input, $C_{g_1}(f + g_3 + \text{internal shield} + g_2)$ 3.6 mmf.
Output, $C_p(f + g_3 + \text{internal shield} + g_2)$ 7.5 mmf.
Maximum Overall Length . . . . . . 2 1/8 ins.
Maximum Seated Height . . . . . . . 1 7/8 ins.
Maximum Diameter . . . . . . . . . . . . 3/4 ins.
Bulb . . . . . . . . . . . . . . . . . . . . . . . . T-5-1/2
Base . . . . . . . . . . Miniature Button 7-Pin [1]
Mounting Position . . . . . . . . . . . . . . . . Any

[1] The center hole in sockets designed for this base provides for the possibility that this tube type may be manufactured with the exhaust-tube tip at the base end. For this reason, it is recommended that in equipment employing this tube type, no material be permitted to obstruct the socket hole.

**AMPLIFIER**

Plate Voltage . . . . . . . . . . . 110 volts max.
Screen Voltage, Grid No. 2 . 90 volts max.
Screen Supply Voltage . . . . 110 volts max.
Grid Voltage, Grid No. 1 . . . . 0 volts min.
Total Cathode Current . . . . 6.5 ma. max.

Typical Operating Conditions and Characteristics, Class $A_1$ Amplifier:

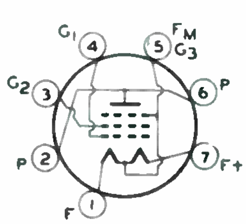
| | | | |
|---|---|---|---|
| Plate Voltage | 90 | 90 | volts |
| Screen Voltage No. | 67.5 | 90 | volts |
| Grid Voltage | 0 | 0 | volts |
| Plate Resistance | 0.6 | 0.35 | milamp. |
| Transconductance | 925 | 1,025 | micromhos |
| Grid Bias for Plate Current = 10 $\mu$amp. | −6 | −8 | volts |
| Plate Current | 2.9 | 4.5 | milamp. |
| Screen Current | 1.2 | 2.0 | milamp. |

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940, Rev. 11-40).

## 3A4

### Power Amp. Pentode
### Miniature Type

1. Filament, + for series operation
2. Plate
3. Screen
4. Grid
5. Fil. mid-tap. —for parallel operation
6. Plate
7. Filament +




7BB

BOTTOM OF SOCKET

**3A4** is a Miniature type of power amplifier pentode designed for use in compact, light-weight, portable equipment. The relatively large filament employed in the 3A4 enables it to supply the high peak currents required in RF power applications. In RF amplifier service, the 3A4 will deliver a power output of about 1.2 watts at 10 mc. The filament of the 3A4 can be operated either with series connection on 2.8 volts or parallel connection on 1.4 volts.

| | Series Filament [1] | Parallel Filament [2] |
|---|---|---|
| Filament Voltage DC | 2.8 | 1.4 volts |
| Filament Current | 0.1 | 0.2 amp. |

Direct Interelectrode Capacitances, with no external shield:
Grid to Plate, $C_{g_1p}$ . . . . . . 0.2 mmf. max.
Input, $C_{g_1}(f \& g_3 + g_2)$ . . . . . . . . 4.8 mmf.
Output, $C_p(f \& g_3 + g_2)$ . . . . . . 4.2 mmf.
Maximum Overall Length . . . . . . 2 1/8 ins.
Maximum Seated Height . . . . . . . 1 7/8 ins.
Maximum Diameter . . . . . . . . . . . . 3/4 ins.
Bulb . . . . . . . . . . . . . . . . . . . . . . . . T-5-1/2
Base . . . . . . . . . . Miniature Button 7-Pin [3]
Mounting Position . . . . . . . . . . . . . . . . Any

[1] Filament voltage applied across the two sections in series between pins No. 1 and No. 7. Grid voltage is referred to pin No. 1.
[2] Filament voltage applied across the two sections in parallel between pin No. 5 and pins No. 1 and No. 7 connected together. Grid voltage is referred to pin No. 5.
[3] The center hole in sockets designed for this base provides for the possibility that this tube type may be manufactured with the exhaust-tube tip at the base end. For this reason, it is recommended that in equipment employing this tube type, no material be permitted to obstruct the socket hole.

**AF POWER AMPLIFIER**

Plate Voltage . . . . . . . . . . . 150 volts max.
Screen Voltage . . . . . . . . . . . 90 volts max.
Plate Dissipation . . . . . . . . . 2 watts max.
Screen Dissipation . . . . . . . 0.4 watt max.

Total Zero-Signal Cathode Current [4] 18 ma. max.

Typical Operating Conditions and Characteristics — Class $A_1$ Amplifier: [5]

| | | Parallel Filament Arrangement [2] |
|---|---|---|
| Plate Voltage | 135 | 150 volts |
| Screen Voltage, Grid No. 2 | 90 | 90 volts |
| Grid Voltage, Grid 1 | −7.5 | −8.4 volts |
| Peak AF Grid Voltage | 7.5 | 8.4 volts |
| Zero Signal Plate Current | 14.8 | 13.3 milamp. |
| Max. Signal Plate Current | 14.9 | 14.1 milamp. |
| Zero Signal Screen Current | 2.6 | 2.2 milamp. |
| Max. Signal Screen Current | 3.5 | 3.5 milamp. |
| Plate resistance | 90,000 | 100,000 ohms |
| Transconductance | 1,900 | 1,900 μmhos |
| Load Resistance | 8,000 | 8,000 ohms |
| Total Harmonic Distortion | 5 | 6% |
| Max. Signal Power Output | 0.6 | 0.7 watt |

[4] For series-filament operation, as hunting resistor must be connected across the section between pins No. 1 and No. 5 to by-pass excess cathode current in this section. The value of the shunting resistor should be adjusted to make the voltage across the shunted section equal to the voltage across the section between pins No. 5 and No. 7. When other tubes in series-filament arrangement contribute to the filament current of the 3A4, an additional shunting resistor may be required between pins No. 1 and No. 7.

[5] Typical operating values for the 3A4 with filament sections in series will be approximately the same as those shown for parallel-filament operation.

**RF POWER AMPLIFIER**

DC Plate Voltage . . . . . . . 150 volts max.
DC Screen Voltage, Grid No. 2 . . . 135 volts max.
DC Grid Voltage, Grid No. 1 . . . −30 volts max.
DC Plate Current . . . . . 20 milamp. max.
DC Grid Current . . . . 0.25 milamp. max.
Total DC Cathode Current [5] . . . 25 milamp. max.
Plate Input . . . . . . . . . . . . . 3 watts max.
Screen Input . . . . . . . . . . . 0.9 watt max.
Plate Dissipation . . . . . . . . . 2 watts max.

Typical Operation: [5]

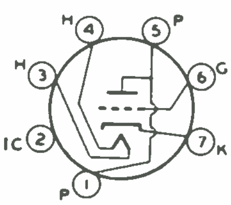
| | Parallel Filament Arrangement [2] |
|---|---|
| DC Plate Voltage | 150 volts |
| DC Screen Voltage | 135 volts |
| Grid Resistor | 0.2 megs. |
| DC Plate Current | 18.3 ma. |
| DC Screen Current | 6.5 ma. |
| DC Grid Current | 0.13 ma. |
| Power Output, Approx. | 1.2 watts |

**Ratings to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940, Rev. 11-40).**

# 6C4

## HF Power Pentode Miniature Type

1. Plate
2. Internal connection
3. Heater
4. Heater
5. Plate
6. Grid
7. Cathode




BOTTOM OF SOCKET 6BG

**6C4** is a heater-cathode type of miniature tube intended for use as class C amplifier and oscillator in compact, lightweight, portable equipment, but it is useful in other applications where a medium-mu miniature triode with high transconductance is desired. In class C service, the 6C4 will deliver a power output of about 5.5 watts at moderate frequencies, and 2.5 watts at 150 mc. The heater is designed to operate at 6.3 volts, 0.15 amp.

Heater Voltage, AC or DC [1] . . . . 6.3 volts
Heater Current . . . . . . . . . . . . . 0.15 amp.

Direct Interelectrode Capacitances, with no external shield:

Grid to Plate, $Cgp$ . . . . . . . . . . . 1.6 mmf.
Grid to Cathode, $Cg\ (h + k)$ . . . 1.8 mmf.
Plate to Cathode, $Cp\ (h + k)$ . . 1.3 mmf.
Max. Overall Length . . . . . . . . . . 2⅛ ins.
Max. Seated Height . . . . . . . . . . 1⅞ ins.
Max. Diameter . . . . . . . . . . . . . . . ¾ ins.
Bulb . . . . . . . . . . . . . . . . . . . . . . . T-5-½
Base . . . . . . . . . Miniature Button 7-Pin [2]
Mounting Position . . . . . . . . . . . . . . . Any

[1] In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

[2] The center hole in sockets designed for this base provides for the possibility that this tube type may be manufactured with the exhaust-tube tip at the base end. For this reason, it is recommended that in equipment employing this tube type, no material be permitted to obstruct the socket hole.

**AF AMPLIFIER**

Plate Voltage . . . . . . . . . . . 300 volts max.
Plate Dissipation . . . . . . . . 3.5 watts max.

Characteristics, Class $A_1$ Amplifier:

| | | |
|---|---|---|
| Plate Voltage | 100 | 250 volts |
| Grid Voltage [3] | 0 | −8.5 volts |
| Amplification Factor | 19.5 | 17 |
| Plate Resistance | 6,250 | 7,700 ohms |
| Transconductance | 3,100 | 2,200 micromhos |
| Plate Current | 11.8 | 10.5 milamp. |

[3] The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer or impedance coupling devices are recommended. Under maximum rated conditions, the resistance in the grid circuit should not exceed 0.25 meg. with fixed bias, or 1.0 meg. with cathode bias.

**RF POWER AMPLIFIER AND OSCILLATOR, CLASS C TELEGRAPHY**

DC Plate Voltage . . . . . . . 300 volts max.
DC Grid Voltage . . . . . . . −50 volts max.
DC Plate Current . . . . . 25 milamp. max.
DC Grid Current . . . . . . 8 milamp. max.
Plate Dissipation . . . . . . . . . 5 watts max.

Typical Operation [4]

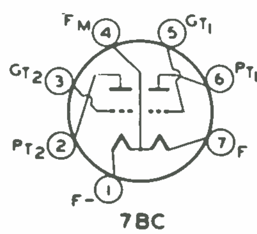
[4] Approximately 2.5 watts can be obtained when the 6C4 is used at 150 mc. as an oscillator with grid resistor of 10,000 ohms and maximum rated input.

DC Plate Voltage . . . . . . . . . . . . 300 volts
DC Grid Voltage . . . . . . . . . . . . −27 volts
DC Plate Current . . . . . . . . . . . . . . 25 ma.
DC Grid Current, Approx. . . . . . . . . 7 ma.
Driving Power, Approx. . . . . . . 0.35 watts
Power Output, Approx. . . . . . . . . 5.5 watts

# 3A5

## HF Twin Triode Miniature Type

1. Filament
2. Plate, $T_2$
3. Grid, $T_2$
4. Fil. mid-tap. + for parallel operation
5. Grid, $T_1$
6. Plate, $T_1$
7. Fil. + for series operation




7BC

BOTTOM OF SOCKET

**3A5** is a twin triode of the Miniature type intended for use in high-frequency applications. The relatively large filament employed in the 3A5 enables it to supply the high peak currents required in RF power applications. In Class C service, a 3A5 with its units in push-pull will deliver a power output of approximately 2 watts at 40 mc. It may be used at still higher frequencies with reduced efficiency. Each triode can be used independently of the other. The filament of the 3A5 can be operated either with series connection on 2.8 volts or parallel connection on 1.4 volts.

| | Series Filament [1] | Parallel Filament [2] |
|---|---|---|
| Filament Voltage DC | 2.8 | 1.4 volts |
| Filament Current | 0.11 | 0.22 amp. |

Direct Interelectrode Capacitances, with no external shield:

| | Triode Unit $T_1$ | Triode Unit $T_2$ |
|---|---|---|
| Grid to Plate, $Cgp$ | 3.2 | 3.2 mmf. |
| Grid to Filament, $Cgf$ | 0.9 | 0.9 mmf. |
| Plate to Filament, $Cpf$ | 1.0 | 1.0 mmf. |
| Plate to Plate, $C_{P_{T_1}P_{T_2}}$ | 0.32 | mmf. |

Max. Overall Length . . . . . . . . . . 2⅛ ins.
Max. Seated Height . . . . . . . . . . 1⅞ ins.
Max. Diameter . . . . . . . . . . . . . . . ¾ ins.
Bulb . . . . . . . . . . . . . . . . . . . . . . . T-5-½
Base . . . . . . . . . Miniature Button 7-Pin [3]
Mounting Position . . . . . . . . . . . . . . . Any

[1] Filament voltage applied across the two sections in series between pins No. 1 and No. 7. Grid voltage is referred to pin No. 1. For series-filament operation, a shunting resistor must be connected across the section between pins No. 1 and No. 4 to by-pass excess cathode current in this section. The value of the shunting resistor should be adjusted to make the voltage across the shunted section equal to the voltage across the section between pins No. 4 and

No. 7. When other tubes in series-filament arrangement contribute to the filament current of the 3A5, an additional shunting resistor may be required between pins No. 1 and No. 7.

[2] Filament voltage applied across the two sections in parallel between pin No. 4 and pins No. 1 and No. 7 connected together. Grid voltage is referred to pins No. 1 and No. 7 tied together.

[3] The center hole in sockets designed for this base provides for the possibility that this tube type may be manufactured with the exhaust-tube tip at the base end. For this reason, it is recommended that in equipment employing this tube type, no material be permitted to obstruct the socket hole.

#### AF AMPLIFIER, EACH UNIT

Plate Voltage . . . . . . . . . . 135 volts max.
Plate Current . . . . . . . . . . 5 milamp. max.
Plate Dissipation . . . . . . . . 0.5 watt max.
Characteristics, Class $A_1$ Amplifier:
Plate Voltage . . . . . . . . . . . . . . . . 90 volts
Grid Voltage . . . . . . . . . . . . . . . −2.5 volts
Amplification Factor . . . . . . . . . . . . . . . 15
Plate Resistance . . . . . . . . . . . 8,300 ohms
Transconductance . . . . . 1,800 micromhos
Plate Current . . . . . . . . . . . . . 3.7 milamp.

#### RF POWER AMPLIFIER AND OSCILLATOR, CLASS C TELEGRAPHY

DC Plate Voltage . . . . . . . 135 volts max.
DC Grid Voltage . . . . . . . −30 volts max.
DC Plate Current per unit
15 milamp. max.
DC Grid Current per unit
2.5 milamp. max.
Plate Input per unit . . . . . 2.0 watts max.
Plate Dissipation per unit
1.0 watts max.

Typical Operation at 40 mc. with both units:

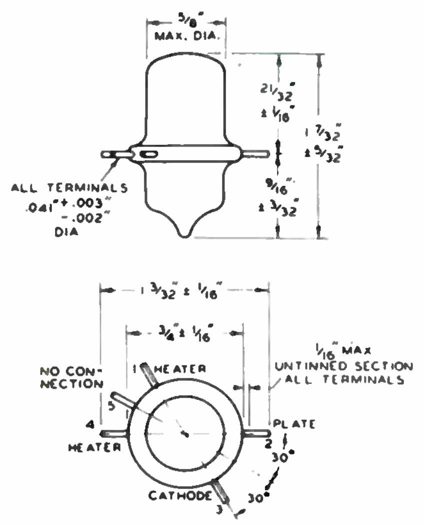
Push-Pull Power Amplifier & Oscillator (Key-down conditions per tube without modulation)

DC Plate Voltage . . . . . . . . . . . . 135 volts
DC Grid Voltage
From a fixed supply of . . . . . −20 volts
From a grid resistor of . . . . 4,000 ohms
From a cathode resistor of . . . 570 ohms
Peak RF Grid-to-Grid Voltage . . 90 volts
DC Plate Current . . . . . . . . . . 30 milamp.
DC Grid Current, approx. . . . . 5 milamp.
Driving Power, approx. . . . . . . . 0.2 watt
Power Output, approx. . . . . . . . . . 2 watts

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940, Rev. 11-40).

# 9004

## UHF Diode Acorn Type




**9004** is a heater-cathode type of Acorn diode suitable for use as a detector, mixer, or measuring device in UHF circuits. The resonant frequency of the 9004 is approximately 850 mc.

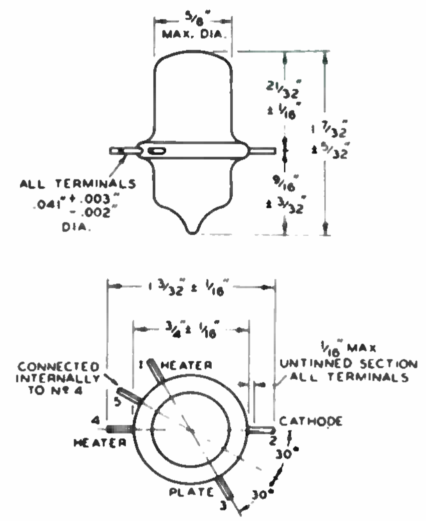
Heater Voltage, AC or DC . . . . . 6.3 volts
Heater Current . . . . . . . . . . . . . . 0.15 amp.
Direct Interelectrode capacitances, with no external shield:
Plate to Cathode . . . . . . . . . . . . 1.3 mmf.
Plate to Heater . . . . . . . 0.3 mmf. approx.
Heater to Cathode . . . . . 2.2 mmf. approx.
Overall Length . . . 1 7/32 ins. ± 5/32 ins.
Overall Diameter
1 3/32 ins. ± 1/16 ins.
Bulb . . . . . . . . . . . . . . . . . . . . . . . . . T-4-½
RCA Socket . . . . . . . . . . . Stock No. 9925
Mounting Position . . . . . . . . . . . . . . . . Any

#### RECTIFIER

Maximum Ratings are based on a line-voltage design center of 117 volts.
AC Plate Voltage, RMS . 117 volts max.
DC Output Current . . . . 5 milamp. max.

# 9005

## UHF Diode Acorn Type




**9005** is a heater-cathode type of Acorn diode, suitable for use as a detector, mixer, or measuring device in UHF circuits. The resonant frequency of the 9005 is about 1,500 mc.

Heater Voltage, AC or DC . . . . . 3.6 volts
Heater Current . . . . . . . . . . . . . 0.165 amp.
Direct Interelectrode Capacitances, with no external shield:
Plate to Cathode . . . . . . . . . . . . . 0.8 mmf.
Plate to Heater . . . . . . . 0.2 mmf. approx.
Heater to Cathode . . . . . 1.1 mmf. approx.
Overall Length . . . 1 7/32 ins. ± 5/32 ins.
Overall Diameter
1 3/32 ins. ± 1/16 ins.
Bulb . . . . . . . . . . . . . . . . . . . . . . . . T-4-½
RCA Socket . . . . . . . . . . . Stock No. 9925
Mounting Position . . . . . . . . . . . . . . . . Any

#### RECTIFIER

Maximum Ratings are based on a line-voltage design center of 117 volts
AC Plate Voltage (RMS) 117 volts max.
DC Output Current . . . . 1.0 milamp. max.

## RADIO TELEGRAPH STATIONS CLOSED

CHAIRMAN James Lawrence Fly of the Defense Communications Board has announced that the Board has directed the closure of all public domestic point-to-point radio circuits within the continental limits of the United States, effective midnight, June 30, 1942. Provision is made, however, that upon proper showing to the Federal Communications Commission, and a finding by the Commission that a particular circuit is necessary to meet a vital public need, the DCB will seek ways and means to meet that need.

Transmission of private messages over domestic radio circuits can be heard and easily monitored outside the United States. In many instances the nature of these private messages can give information of value to the enemy. The burden of possible censorship has been deemed insoluble within reasonable limits of available man power and funds.

Eighty stations operated by eleven companies will be affected by today's order. The chief carriers concerned are: R.C.A. Communications, Inc., Mackay Radio and Telegraph Co., Tropical Radio Telegraph Co., Globe Wireless, Ltd., Press Wireless, Inc., Radiomarine Corp. of America, Central Radio Telegraph Co., Michigan Wireless Telegraph Co., Wabash Radio Corp., Pere Marquette Radio Corp., and the Western Radio Telegraph Co. Their total traffic is considered quite small in comparison with all domestic message volume. Chairman Fly stated that adequate wire line communications facilities remain available to all users of these domestic radio circuits.

If upon recommendation of the Federal Communications Commission the DCB should permit any particular circuit or circuits to remain in business, it will follow as a matter of course that they will be effectively censored.

Not affected by the DCB order of today are the coastal and ship-to-shore radio stations, which are under the control of the Navy Department during the emergency period.

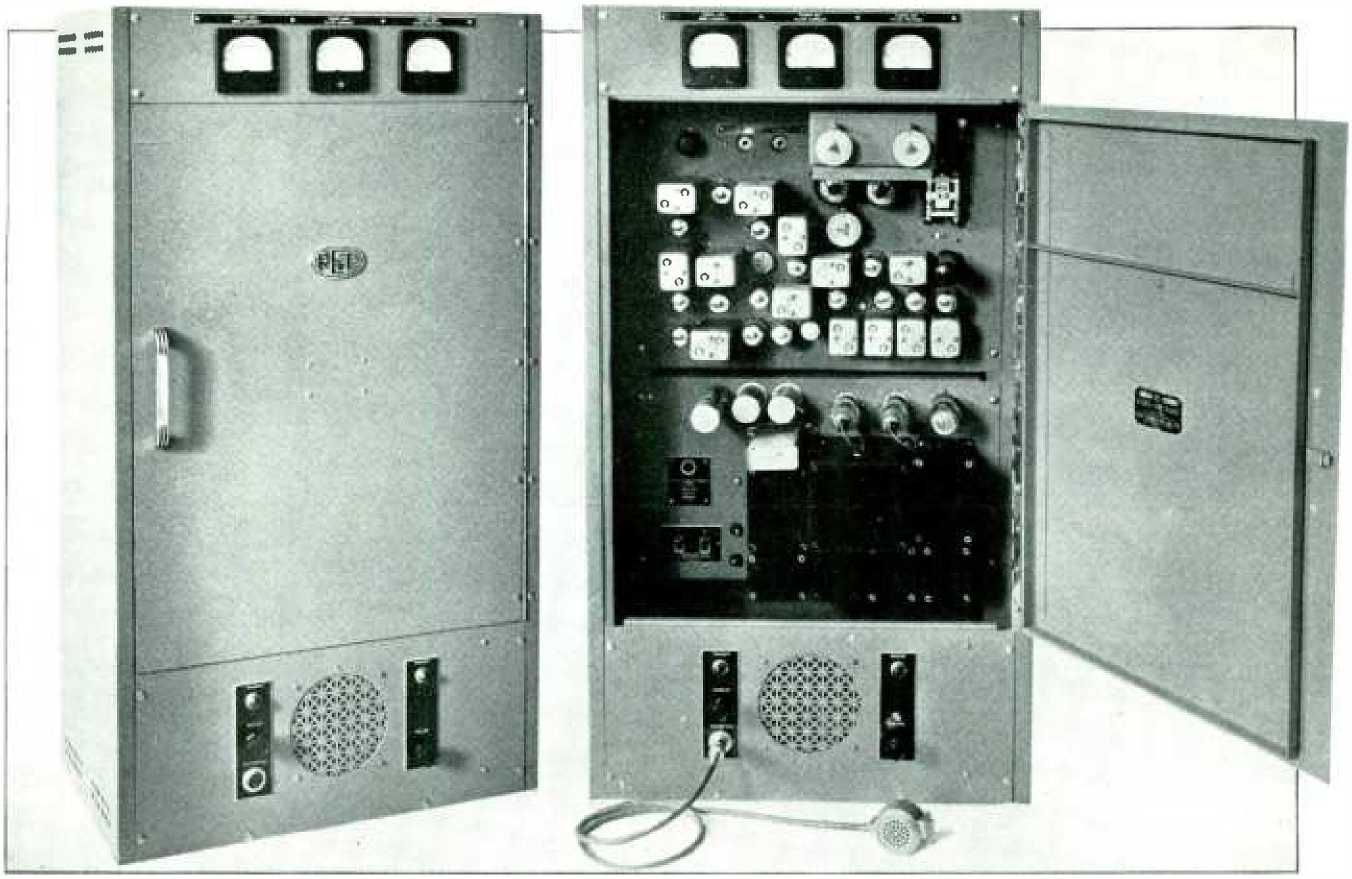


FIG. 1. REL TYPE 550A FM TRANSMITTER AND RECEIVER, DESIGNED TO OPERATE ON 60 CYCLE SUPPLY FOR FIXED INSTALLATIONS

# 50-WATT FM HEADQUARTERS UNIT

## Designed Particularly to Be Used with the REL Single-Chassis 2-Way Mobile Emergency Equipment

BY LESLE NOZDROVICZKY *

THE 50-watt FM equipment shown in the accompanying illustrations was designed for use at police, fire, or military headquarters. A minimum of time and effort is necessary to install it, since the entire transmitter, receiver, and power supply are contained in a steel cabinet 39½ ins. high by 22 ins. wide by 11½ ins. deep. The entire unit is light enough that two men can easily carry it.

The 550A unit is shown in Fig. 1 as it appears normally with the cabinet closed. It can be operated at any point within the 30- to 40-mc. band. The primary source of power is 105–125 volts, 50–60 cycles, single phase. The transmitter utilizes the Armstrong phase shift modulation principle. By using this system of modulation, the carrier frequency can be crystal controlled. RF power output is 50 watts. The primary power input is about 300 watts. The total band width necessary for full modulation is 30 kc.

Operation of the transmitter is simple. The output of a crystal-controlled oscillator is connected to an improved balanced phase-modulator stage. The output of the modulator is impressed on a series of frequency multipliers, resulting in a total multiplication of 32 times. The power amplifier consists of a pair of 807's connected in push-pull, driven by the output of the multipliers.

The receiver is a double superheterodyne, with a single crystal. One microvolt impressed on the antenna circuit of the receiver produces a 16 db. reduction of noise level in the loudspeaker. The limiter saturation begins at about 0.7-microvolt input.

The audio power output is 1.25 watts. A flexible squelch circuit is incorporated in the receiver. By arbitrarily setting the squelch control, the squelch circuit can be made to open for any signal from about 0.2 microvolts up.

The receiver utilizes a crystal oscillator and a frequency quadrupler or tripler, depending on the operating frequency of the receiver. The third or fourth harmonic of the crystal oscillator is heterodyned with the incoming frequency, resulting in a first intermediate frequency of about 9,000 kc. The fundamental frequency of the crystal is heterodyned with the first intermediate frequency, resulting in a second intermediate frequency of about 2,000 kc.

The output of the second intermediate amplifier is fed to a slope detector through a full wave, cascade limiter stage. The detector output is impressed on the audio amplifier and squelch stages.

The transmitter uses a total of seven tubes, comprising:

7A4 — Oscillator
7F7 — Modulator
7C5 — 1st quadrupler
7C5 — 2nd quadrupler
6L6 — Doubler
2-807 — Power amplifier

The receiver uses a total of eleven tubes, comprising:

7H7 — R.F. amplifier
7H7 — 1st mixer
7H7 — 1st IF amplifier
7H7 — 2nd mixer
7H7 — 2nd IF amplifier

* Engineering Department, Radio Engineering Laboratories, Long Island City, N. Y.

7C7 — 1st limiter
7C7 — 2nd limiter
7A6 — Detector
7F7 — Squelch & audio amplifier
7C5 — Audio output
7H7 — Oscillator multiplier

Referring to Fig. 1, the transmitter-receiver chassis is at the top, with the power supply chassis below. The meters, from left to right are: P.A. grid current, P.A. plate current, P.A. plate voltage.

The jacks for metering the oscillator plate and driver grid current and the receiver test plug can be seen in the top left corner.

The local speaker, squelch, and audio controls are located on the bottom panel, with the microphone input plug under the squelch control on the left.

Fig. 2 shows the back of the 550 with the cabinet cover removed. The bracket to which the antenna transmission line is fixed is located in the top left of the cabinet. This equipment can be supplied for either remote or direct control.

Several variations of the fundamental unit can be used, according to the requirements of the individual installation. That is:

Type 550A: All controls, speaker and microphone are at the transmitter cabinet. An airplane type push-to-talk carbon microphone is used. Speaker is 6-in. PM type. This is used when the unit is installed at the operating position.

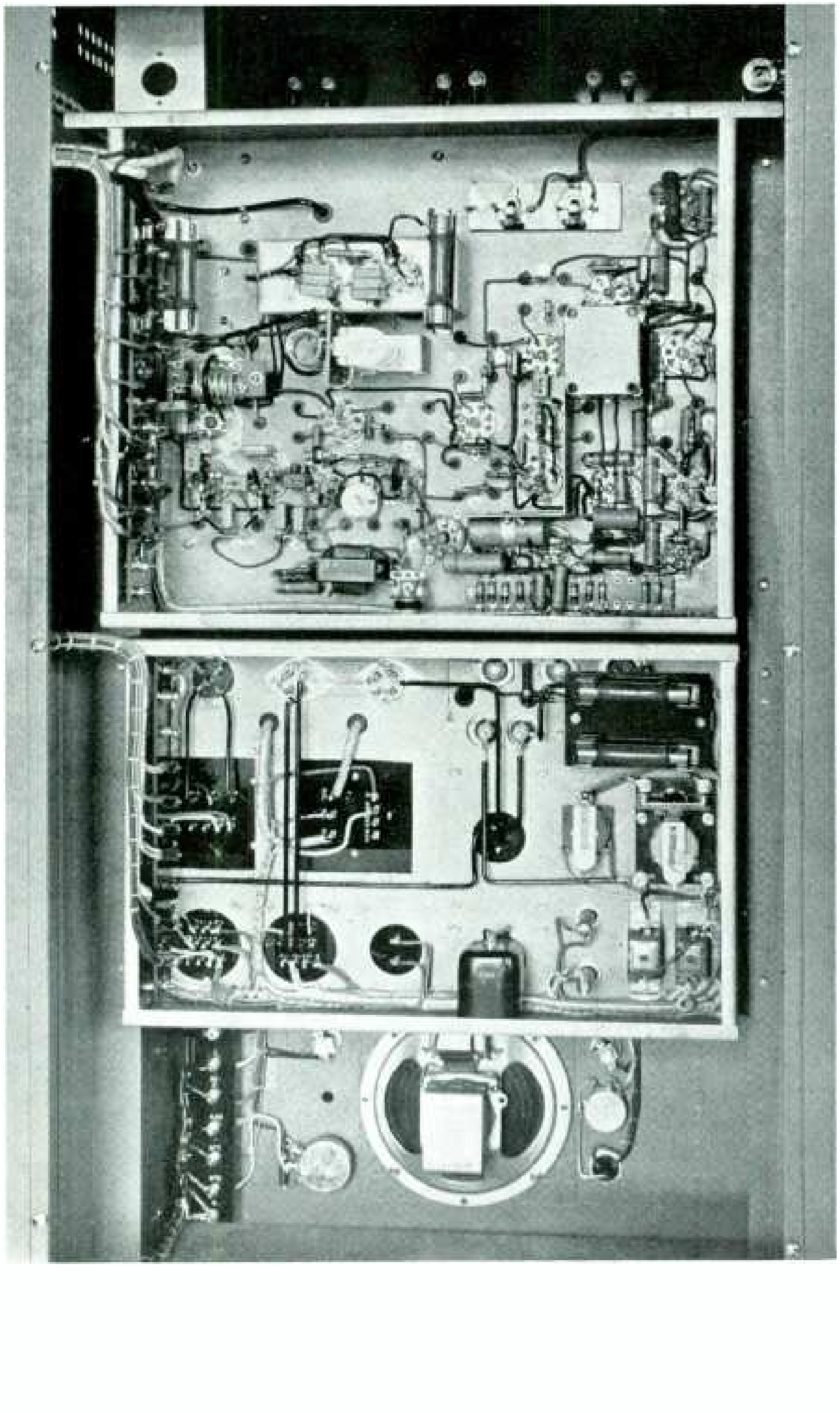
Type 550A-WE: Identical to the 550A except the microphone is replaced by a French type handset. Depending on a switch setting, the speaker may or may not operate when the handset is lifted from its hook. The speaker is always in operation when the handset is hung. This type is also used when the unit is installed at the operating position.

Type 550A-DC: The transmitter and receiver can be controlled from a desk type remote control station. The microphone is an airplane type push-to-talk carbon design. The remote control also houses the speaker, and the receiver volume and squelch controls. The maximum distance over which this arrangement is intended to operate is 100 ft.

Type 550A-DC-WE: The same as the 550A-DC, except the airplane type microphone is replaced by a French type handset. The handset and speaker operation are interconnected as in the 550A-WE model.

Type 550A-RL-WE: This unit can be controlled over one pair of telephone lines or at the transmitter by setting a switch at the transmitter either for local or remote control. There is a speaker and handset at the transmitter, also at the remote station. The remote control can be upward of 20 miles distant.

FIG. 2. CLOSE-UP OF THE TRANSMITTER AND RECEIVER CHASSIS, ABOVE, AND THE POWER SUPPLY CHASSIS, BELOW. THIS IS A HIGH-POWER, AC VERSION OF THE 565-A



## FROZEN ONLY ON THE SURFACE

(CONTINUED FROM PAGE 5)

partly successful in adhering to the practice of not starting a production release until every last item was on hand in the stock room. From the point of view of economical production, that is ideal.

Unfortunately, orders are running into such huge quantities on many contracts that there are increasing shortages on some of the materials and components that enter into practically all equipment. As a result, manufacturers have been forced to go ahead with partial assemblies, getting as much work done as possible while waiting for the missing items to come in. Otherwise, valuable time would be lost, and workers might have to be laid off.

With experienced workers becoming difficult to find and hard to keep because of the Draft, radio factories are loath to lay off any employees for fear they might not come back to work. This is another reason why stop-start methods of assembly have been adopted, in spite of the resulting increased production costs.

The loss of young men called out in the Draft is another problem related both to production volume and costs. A great deal of radio assembly work involves lifting and moving considerable weight. Women and older men cannot be employed for such work. The need is for young men. Those obtainable must go through a considerable period of training before they can turn out perfect work rapidly. This may require one or two months.

When they are called into the Draft,

(CONTINUED ON PAGE 30)

# RADIO-ELECTRONIC PRODUCTS DIRECTORY

## The Radio Engineers' & Purchasing Agents' Guide to Essential Materials, Components, and Equipment

### ANTENNAS, Transmitting

Blaw-Knox Co., Pittsburgh, Pa.
Lehigh Structural Steel Co., 17 Battery Pl., N. Y. C.
Lingo & Son, John E., Camden, N. J.
Truscon Steel Co., Youngstown, O.
Wincharger Corp., Sioux City, Iowa

### BEADS, Insulating

American Lava Corp., Chattanooga, Tenn.
Dunn, Inc., Struthers, 1321 Cherry, Phila., Pa.
Star Porcelain Co., Trenton, N. J.
Steward Mfg. Co., Chattanooga, Tenn.

### BOLTS, NUTS & SCREWS, Machine

American Screw Co., Providence, R. I.
Bristol Co., The, Waterbury, Conn.
Central Screw Co., 3519 Shields Av., Chicago
Chandler Prods. Corp., Cleveland, O.
Continental Screw Co., New Bedford, Mass.
Corbin Screw Corp., New Britain, Conn.
Harper Co., H. M., 2609 Fletcher, Chicago
International Screw Co., Detroit
Lamson & Sessions Co., Cleveland, O.
National Screw & Mfg. Co., Cleveland
New England Screw Co., Keene, N. H.
Ohio Nut & Bolt Co., Berea, Ohio
Parker Co., Charles, Meriden, Conn.
Parker-Kalon Corp., 198 Varick, N. Y. C.
Pawtucket Screw Co., Pawtucket, R. I.
Progressive Mfg. Co., Torrington, Conn.
Republic Steel Corp., Cleveland, O.
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Mfg. Co., Waterbury, Conn.
Shakeproof, Inc., 2501 N. Keeler, Chicago
Southington Hardware Mfg. Co., The, Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

### CABLE, Coaxial

American Phenolic Corp., 1830 S. 54 Av., Chicago
Anaconda Wire & Cable Co., 25 B'way, N. Y. C.
Belden Mfg. Co., 4673 W. Van Buren, Chicago
Boston Insulated Wire & Cable Co., Boston
Communications Prods. Co., Jersey City, N. J.
Cornish Wire Co., 15 Park Row, N. Y. C.
General Cable Corp., 420 Lexington, N. Y. C.
Doolittle Radio, Inc., 7521 S. Loomis Blvd., Chicago
General Insulated Wire Corp., 53 Park Pl., N. Y. C.
Simplex Wire & Cable Corp., Cambridge, Mass.

### CABLE, Microphone, Speaker & Battery

Alden Prods. Co., Brockton, Mass.
Anaconda Wire & Cable Co., 25 Broadway, N. Y. C.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
Boston Insulated Wire & Cable Co., Dorchester, Mass.
Holyoke Wire & Cable Corp., Holyoke, Mass.

### CASTINGS, Die

Aluminum Co. of America, Pittsburgh, Pa.
American Brass Co., Waterbury, Conn.
Dow Chemical Co., Dowmetal Div., Midland, Mich.

### CERAMICS, Bushings, Washers, Special Shapes

Akron Porcelain Co., Akron, O.
Louthan Mfg. Co., E. Liverpool, O.
Star Porcelain Co., Trenton, N. J.
Steward Mfg. Co., D. M., Chattanooga, Tenn.

### CHOKES, RF

Aladdin Radio Industries, 501 W. 35th, Chicago
Alden Prods. Co., Brockton, Mass.
American Communications Corp., 306 B'way, N. Y. C.
Barker & Williamson, Upper Darby, Pa.
Coto-Coil Co., Providence, R. I.
D-X Radio Prods. Co., 1575 Milwaukee, Chicago
General Winding Co., 254 W. 31 St., N. Y. C.
Guthman & Co., Edwin, 400 S. Peoria, Chicago
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Johnson Co., E. F., Waseca, Minn.
Meissner Mfg. Co., Mt. Carmel, Ill.
Miller Co., J. W., Los Angeles, Cal.
Muter Co., 1255 S. Michigan, Chicago
National Co., Malden, Mass.
Radex Corp., 1328 Elston Av., Chicago
Sickles Co., F. W., Chicopee, Mass.
Teleradio Eng. Corp., 484 Broome St., N. Y. C.
Triumph Mfg. Co., 4017 W. Lake St., Chicago

### CLIPS & MOUNTINGS, Fuse

Alden Prods. Co., Brockton, Mass.
Dante Elec. Mfg. Co., Bantam, Conn.
Ilsco Copper Tube & Prods., Inc., Station M, Cincinnati
Jefferson Elec. Co., Bellwood, Ill.
Jones, Howard B., 2300 Wabansia, Chicago
Littelfuse, Inc., 4753 Ravenswood, Chicago
Patton MacGuyer Co., Providence, R. I.
Sherman Mfg. Co., H. B., Battle Creek, Mich.

### CLOTH, Insulating

Acme Wire Co., New Haven, Conn.
Brand & Co., Wm., 276–4th Av., N. Y. C.
Endurette Corp. of Amer. Cliffwood, N. J.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Irvington Varnish & Insulating Co., Irvington, N. J.
Mica Insulator Co., 196 Varick, N. Y. C.

### CONDENSERS, Fixed

Aerovox Corp., New Bedford, Mass.
American Condenser Corp., 2508 S. Michigan, Chicago
Art Radio Corp., 115 Liberty, N. Y. C.
Atlas Condenser Prods. Co., 548 Westchester Av., N. Y. C.
Automatic Winding Co., East Newark, N. J.
Bud Radio, Inc., Cleveland, O.
Cardwell Mfg. Corp., Allen D., Brooklyn, N. Y.
Centralab, Milwaukee, Wis.
Condenser Corp. of America, South Plainfield, N. J.
Condenser Prods. Co., 1375 N. Branch, Chicago
Cornell-Dubilier Elec. Corp., S. Plainfield, N. J.
Cosmic Radio Co., 699 E. 135th St., N. Y. C.
Crowley & Co., Henry L., W. Orange, N. J.
Deutschmann Corp., Tobe, Canton, Mass.
Dumont Elec. Co., 34 Hubert St., N. Y. C.
Electro-Motive Mfg. Co., Willimantic, Conn.
Erie Resistor Corp., Erie, Pa.
Fast & Co., John E., 3123 N. Crawford, Chicago
General Radio Co., Cambridge, Mass.
Girard-Hopkins, Oakland, Calif.
H. R. S. Prods., 5707 W. Lake St., Chicago
Illinois Cond. Co., 3252 W. North Av., Chicago
Industrial Cond. Corp., 1725 W. North Av., Chicago
Insuline Corp. of America, Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Kellogg Switchb'd & Supply Co., 6650 Cicero, Chicago
Mallory & Co., P. R., Indianapolis, Ind.
Micamold Radio Corp., Brooklyn, N. Y.
Muter Co., 1255 S. Michigan, Chicago
Potter Co., 1950 Sheridan Rd., N. Chicago
RCA Mfg. Co., Camden, N. J.
Sangamo Elec. Co., Springfield, Ill.
Solar Mfg. Corp., Bayonne, N. J.
Sprague Specialties Co., N. Adams, Mass.
Teleradio Engineering Corp., 484 Broome St., N. Y. C.

### CONDENSERS, Variable Receiver Tuning

Alden Prods. Co., Brockton, Mass.
American Steel Package Co., Defiance, Ohio
Barker & Williamson, Ardmore, Pa.
Bud Radio, Inc., Cleveland, O.
Cardwell Mfg. Corp., Allen D., Brooklyn, N. Y.
General Instrument Corp., Elizabeth, N. J.
Hammarlund Mfg. Co., 424 W. 33d St., N. Y. C.
Insuline Corp. of America, Long Island City, N. Y.
Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., Malden, Mass.
National Co., Malden, Mass.
Radio Condenser Co., Camden, N. J.
Reliance Die & St'p'g Co., 1260 Clybourn Av., Chicago

### CONDENSERS, Variable Transmitter Tuning

Barker & Williamson, Upper Darby, Pa.
Bud Radio, Cleveland, O.
Cardwell Mfg. Corp., Allen D, Brooklyn, N. Y.
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Insuline Corp. of Amer., L. I. City, N. Y.
Johnson, E. F., Waseca, Minn.
Millen Mfg. Co., James, Malden, Mass.
National Co., Malden, Mass.

### CONDENSERS, Variable Trimmer

Aerovox Corp., New Bedford, Mass.
Alden Prods. Co., Brockton, Mass.
American Steel Package Co., Defiance, O.
Bud Radio, Inc., Cleveland, O.
Cardwell Mfg. Corp., Allen, Brooklyn, N. Y.
Centralab, Milwaukee, Wis.
General Radio Co., Cambridge, Mass.
Guthman, Inc., E. I., 400 S. Peoria, Chicago
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Insuline Corp. of America, Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., James, Malden, Mass.
Miller Co., J. W., Los Angeles, Cal.
Muter Co., 1255 S. Michigan Ave., Chicago
National Co., Malden, Mass.
Potter Co., 1950 Sheridan Rd., N. Chicago
Sickles Co., F. W., Chicopee, Mass.
Solar Mfg. Corp., Bayonne, N. J.
Teleradio Eng. Corp., 484 Broome, N. Y. C.

### CONNECTORS, Cable

Alden Prods., Brockton, Mass.
Amer. Microphone Co., 1915 S. Western Av., Los Angeles
Amer. Phenolic Corp., 1830 S. 54th St., Chicago
American Radio Hardware Co., 476 B'way, N. Y. C.
Andrew, Victor J., 6429 S. Lavergne Av., Chicago
Atlas Sound Corp., 1442 39th St., Brooklyn, N. Y.
Birnbach Radio, 145 Hudson St., N. Y. C.
Brush Development Co., Cleveland, O.
Bud Radio, Cleveland, Ohio
Cannon Elec. Development, 3209 Humboldt, Los Angeles
Eby, Inc., Hugh H., Philadelphia
Electro Voice Mfg. Co., South Bend, Indiana
General Radio Co., Cambridge, Mass.
Insuline Corp. of Amer., L. I. City, N. Y.
Jones, Howard B., 2300 Wabansia, Chicago
Mallory & Co., P. R., Indianapolis, Ind.

### CRYSTALS, Quartz

Bausch & Lomb Optical Co., Rochester, N. Y.
Bellefonte Eng. Labs., Bellefonte, Penna.
Bliley Elec. Co., Erie, Penna.
Burnett, Wm. W. I., San Diego, Cal.
Collins Radio Co., Cedar Rapids, Iowa
General Electric Co., Schenectady, N. Y.
General Radio Co., Cambridge, Mass.
Harvey-Wells Communications, Southbridge, Mass.
Hipower Crystal Co., 2035 W. Charleston, Chicago
Hollister Crystal Co., Merriam, Kan.
Hunt & Sons, G. C., Carlisle, Pa.
Kaar Engineering Co., Palo Alto, Cal.
Miller, August E., North Bergen, N. J.
Petersen Radio, Council Bluffs, Iowa
Precision Crystal Labs., Springfield, Mass.
Precision Piezo Service, Baton Rouge, La.
Premier Crystal Labs., 63 Park Row, N. Y. C.
RCA Mfg. Co., Camden, N. J.
Scientific Radio Service, Hyattsville, Md.
Standard Piezo Co., Carlisle, Pa.
Valpey Crystals, Holliston, Mass.
Zeiss, Inc., Carl, 485 Fifth Av., N. Y. C.

From month to month, new companies are entering the Radio-Electronic field. Older concerns are adding new products. Accordingly, this Directory will be revised each month, so as to assure engineers and purchasing agents of up-to-date information. We shall be pleased to receive suggestions as to company names which should be added, and hard-to-find items which should be listed in this Directory.

### FELT

American Felt Co., Inc., Glenville, Conn.
Western Felt Works, 4031 Ogden Av., Chicago

### FIBRE, Vulcanized

Brandywine Fibre Prods. Co., Wilmington, Del.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Mica Insulator Co., 196 Varick, N. Y. C.
Nat'l Vulcanized Fibre Co., Wilmington, Del.
Taylor Fibre Co., Norristown, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

### FINISHES, Metal

Airose Chemical Co., Providence, R. I.
Aluminum Co. of America, Pittsburgh, Pa.
Ault & Wiberg Corp., 75 Varick, N. Y. C.
Hilo Varnish Corp., Brooklyn, N. Y.
Maas & Waldstein Co., Newark, N. J.
New Wrinkle, Inc., Dayton, O.

### FUSES, Enclosed

Dante Elec. Mfg. Co., Bantam, Conn.
Jefferson Elec. Co., Bellwood, Ill.
Littelfuse, Inc., 4753 Ravenswood Av., Chicago

### GEARS & PINIONS, Metal

Gear Specialties, Inc., 2650 W. Medill, Chicago
Perkins Machine & Gear Co., Springfield, Mass.
Thompson Clock Co., H. C., Bristol, Conn.

### GEARS & PINIONS, Non-Metallic

Brandywine Fibre Prods. Co., Wilmington, Del.
Formica Insulation Co., Cincinnati, O.
Gear Specialties, Inc., 2650 W. Medill, Chicago
General Electric Co., Pittsfield, Mass.
Mica Insulator Co., 196 Varick St., N. Y. C.
National Vulcanized Fibre Co., Wilmington, Del.
Perkins Machine & Gear Co., Springfield, Mass.
Richardson Co., Melrose Park, Chicago
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

### HEADPHONES

Brush Development Co., Cleveland, O.
Conn. Tel. & Electric Co., Meriden, Conn.
Carrier Microphone Co., Inglewood, Cal.
Cannon Co., C. F., Springwater, N. Y.
Carron Mfg. Co., 415 S. Aberdeen, Chicago
Chicago Tel. Supply Co., Elkhart, Ind.
Connecticut Tel. & Elec. Co., Meriden, Conn.
Elec. Industries Mfg. Co., Red Bank, N. J.
General Electric Co., Pittsfield, Mass.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Av., Chicago
Murdock Mfg. Co., Chelsea, Mass.
Trimm Radio Mfg. Co., 1770 W. Berteau, Chicago
Universal Microphone Co., Inglewood, Cal.

### KNOBS, Radio & Instrument

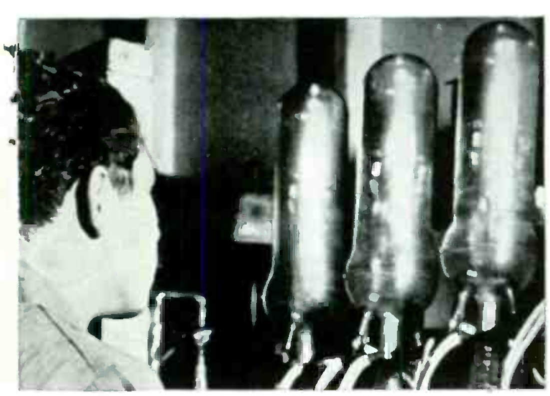
Alden Prods. Co., Brockton, Mass.
American Insulator Corp., New Freedom, Pa.
Chicago Molded Prods. Corp., 1025 N. Kolmar, Chicago
General Radio Co., Cambridge, Mass.
Imperial Molded Prods. Corp., 2921 W. Harrison, Chicago
Kurtz Kasch, Inc., Dayton, O.
Millen Mfg. Co., James, Malden, Mass.
Nat'l Co., Inc., Malden, Mass.
Rogan Bros., 2001 S. Michigan, Chicago

### LIGHTS, Pilot or Indicator

Alden Prods. Co., Brockton, Mass.
Dial Light Co. of America, 90 West, N. Y. C.
Drake Mfg. Co., 1713 W. Hubbard, Chicago
General Control Co., Cambridge, Mass.
General Elec. Co., Lamp Dept., Nela Specialty Div., Hoboken, N. J.
Herzog Miniature Lamp Works, 12–19 Jackson Av., Long Island City, N. Y.
Kirkland Co., H. R., Morristown, N. J.
Mallory & Co., P. R., Indianapolis, Ind.

# Filament Emission
# Makes the Modern World Go Around


*Close observation of the flow of electrons from a heated filament is made possible with this Electron Microscope. This instrument, designed and constructed in the Eimac laboratories, virtually gives a motion picture projection of the electron movement.*



*Before filaments are sealed into the triode they are placed in a temporary vacuum where they undergo their first emission test. Thus faulty filaments may be weeded out without further processing.*

THE life of radio communications hangs by a tiny thread of filament wire. If the steady flow of electrons from the vacuum tube filaments ceases, the transmitter is off the air no matter how excellent the other components may be performing. To assure peak emission under the most severe operation conditions, many exacting tests are conducted during the process of manufacture.

Above is an Eimac technician checking an Eimac tube on the Peak Emission Tester. This device, designed and constructed in the Eimac laboratories, measures the flow of electrons emitted from the completed tube. Of a long series of filament tests conducted at various stages of manufacture, this test is the final. Other important controls are illustrated at left.

From beginning to end, Eimac tubes are designed and constructed to give vastly superior performance. The proof that they do is made clear by the fact that Eimac tubes enjoy first choice in the minds of leading radio engineers throughout the world.

**EIMAC 304T**

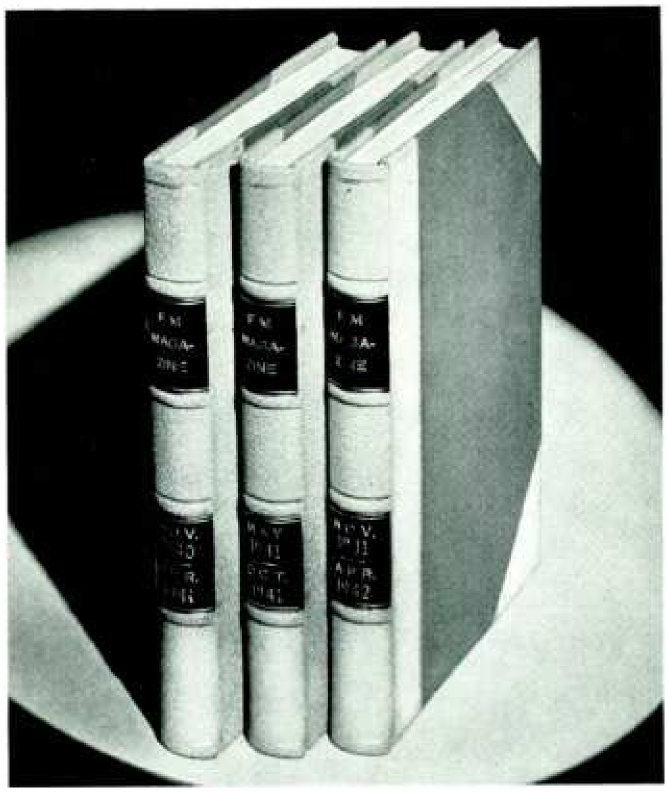
| | |
|---|---|
| Filament Voltage . | 5 or 10 volts |
| Plate Voltage (D.C.) . | 3000 volts |
| Plate Dissipation . . . | 300 watts |
| Power Output 3000 volts at 75% eff. . . . . | 900 watts |

*Follow the leaders to . . .*

**Eimac TUBES**

Eitel-McCullough, Inc. San Bruno, California

FOREIGN DIVISION: **FRAZAR & CO., LTD.** 301 CLAY ST., SAN FRANCISCO, CALIFORNIA, U. S. A.





**LUGS, Copper**
Burndy Engineering Co., 459 E. 133rd St., N. Y. C.
Dante Elec. Mfg. Co., Bantam, Conn.
Ideal Commutator Dresser Co., Sycamore, Ill.
Ilsco Copper Tube & Prods., Inc., Station M, Cincinnati
Krueger & Hudepohl, Third & Vine, Cincinnati, O.
Patton-MacGuyer Co., 17 Virginia Av., Providence, R. I.
Sherman Mfg. Co., H. B., Battle Creek, Mich.

**MACHINES, Impregnating**
Stokes Machine Co., F. J., Phila., Pa.

**MACHINES, Numbering**
Atlair Machinery Corp., 55 VanDam, N. Y. C.
Numberall Stamp & Tool Co., Huguenot Park, Staten Island, N. Y.

**MACHINES, Riveting**
Chicago Rivet & Machine Co., Bellwood, Illinois

**MACHINES, Screwdriving**
Detroit Power Screwdriver Co., Detroit, Mich.
Stanley Tool Div. of the Stanley Works, New Britain, Conn.

**MAGNETS, Permanent**
General Elec. Co., Schenectady, N. Y.
Mallory & Co., P. R., Indianapolis, Ind.

**METAL, Thermostatic**
Baker & Co., 113 Astor, Newark, N. J.
C. S. Brainin Co., 20 VanDam, N. Y. C.
Callite Tungsten Corp., Union City, N. J.
Chace Co., W. M., Detroit, Mich.
Metals & Controls Corp., Attleboro, Mass.
Wilson Co., H. A., 105 Chestnut, Newark, N. J.

**METALS, Pressed Powder**
Gibson Elec. Co., Pittsburgh, Pa.
Mallory & Co., P. R., Indianapolis, Ind.

**METERS, Ammeters, Voltmeters, Small Panel**
Burton-Rogers Co., Boston, Mass.
Cambridge Inst. Co., Grand Central Terminal, N. Y. C.
De Jur-Amsco Corp., Shelton, Conn.
General Electric Co., Bridgeport, Conn.
Hickok Elec. Instrument Co., Cleveland, O.
Hoyt Elec. Instrument Works, Boston, Mass.
Readrite Meter Works, Bluffton, O.
Reliance Inst. Co., 1135 W. Van Buren, Chicago
Roller-Smith Co., Bethlehem, Pa.
Simpson Elec. Co., 5218 W. Kinzie, Chicago
Triplett Elec. Instrument Co., Bluffton, O.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Weston Elec. Inst. Corp., Newark, N. J.

**MICA**
Brand & Co., Wm., 276 Fourth Av., N. Y. C.
Insulation Mfgrs. Corp., 565 W. Wash. Blvd., Chicago
Macallen Co., Boston, Mass.
Mica Insulator Corp., 196 Varick, N. Y. C.
New England Mica Co., Waltham, Mass.
Richardson Co., Melrose Park, Chicago

**MICROPHONES**
Amer. Microphone Co., 1015 Western Av., Los Angeles
Amperite Co., 561 B'way, N. Y. C.
Astatic Corp., Youngstown, O.
Brush Development Co., Cleveland, O.
Carrier Microphone Co., Inglewood, Cal.
Elect. Industries Mfg. Co., Red Bank, N. J.
Electro Voice Mfg. Co., South Bend, Ind.
Kellogg Switchboard & Supply Co., 6650 S. Cicero, Chicago
Radio Speakers, Inc., 221 E. Cullerton, Chicago
Philmore Mfg. Co., 113 University Pl., N. Y. C.
Permoflux Corp., 4916 W. Grand Av., Chicago
Rowe Industries, Inc., Toledo, O.
Shure Bros., 225 W. Huron St., Chicago
Universal Microphone Co., Inglewood, Cal.

**MOTOR-GENERATORS, Dynamotors, Rotary Converters**
Bodine Elec. Co., 2262 W. Ohio, Chicago
Carter Motor Co., 1608 Milwaukee, Chicago
Delco Appliance, Rochester, N. Y.
Diehl Mfg. Co., Elizabethport, N. J.
Eclipse Aviation, Bendix, N. J.
Eicor, Inc., 1060 W. Adams, Chicago
Electric Specialty Co., Stamford, Conn.
Janette Mfg. Co., 558 W. Monroe, Chicago
Pioneer Gen-E-Motor, 5841 W. Dickens Av., Chicago
Wincharger Corp., Sioux City, Iowa

**MOUNTINGS, Shock Absorbing**
Lord Mfg. Co., Erie, Pa.

**NUTS, Self-Locking**
Elastic Stop Nut Corp., Union, N. J.
Palnut Co., Inc., Irvington, N. J.
Standard Pressed Steel Co., Jenkintown, Pa.

**OVENS, Industrial & Laboratory**
General Elec. Co., Schenectady, N. Y.
Trent Co., Harold E., Philadelphia

**PHOSPHOR BRONZE**
American Brass Co., Waterbury, Conn.
Bunting Brass & Bronze Co., Toledo, O.
Driver-Harris Co., Harrison, N. J.
Phosphor Bronze Smelting Col, Philadelphia
Revere Copper & Brass, 230 Park Ave., N. Y. C.
Seymour Mfg. Co., Seymour, Conn.

**PLASTICS, Extruded**
Blum & Co., Inc., Julius, 532 W. 22 St., N. Y. C.
Brand & Co., Wm., 276 Fourth Av., N. Y. C.
Extruded Plastics, Inc., Norwalk, Conn.
Irvington Varnish & Insulator Co., Irvington, N. J.

**PLASTICS, Laminated or Molded**
Acadia Synthetic Prods., 4031 Ogden Av., Chicago
Alden Prods. Co., Brockton, Mass.
American Cyanamid Co., 30 Rockefeller Plaza, N. Y. C.
American Insulator Corp., New Freedom, Pa.
American Molded Prods. Co., 1753 N. Honore, Chicago
Auburn Button Works, Auburn, N. Y.
Barber-Colman Co., Rockford, Ill.
Brandywine Fibre Prods. Co., Wilmington, Del.
Catalin Corp., 1 Park Av., N. Y. C.
Celanese Celluloid Corp., 180 Madison Av., N. Y. C.
Chicago Molded Prods Corp., 1024 N. Kolmar, Chicago
Dow Chemical Co., Midland, Mich.
Durez Plastics & Chemicals, Inc., N. Tonawanda, N. Y.
Extruded Plastics, Inc., Norwalk, Conn.
Formica Insulation Co., Cincinnati, O.
General Electric Co. Plastics Dept., Pittsfield, Mass.
General Industries Co., Elyria, O.
Imperial Molded Prods Co., 2921 W. Harrison, Chicago
Industrial Molded Prods. Co., 2035 Charleston, Chicago
Kurz-Kasch, Inc., Dayton, O.
Macallen Co., Boston, Mass.
Mica Insulator Co., 196 Varick, N. Y. C.
Monsanto Chemical Co., Springfield, Mass.
National Vulcanized Fibre Co., Wilmington, Del.
Northern Industrial Chemical Co., Boston, Mass.
Richardson Co., Melrose Park, Chicago
Rogan Bros., 180 N. Wacker Dr., Chicago
Rohm & Haas Co., Philadelphia
Stokes Rubber Co., Joseph, Trenton, N. J.
Surprenant Elec. Ins. Co., Boston
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

**PLUGS & JACKS, Radio**
Alden Prods. Co., Brockton, Mass.
American Molded Prods. Co., 1753 N. Honore, Chicago
Guardian Elec. Mfg. Co., 1627 W. Walnut, Chicago
Jones, Howard, B., 2300 Wabansia Av., Chicago

**PRESSES, Plastic Molding**
Kux Machine Co., 3930 W. Harrison, Chicago

**PRESSES**
Stokes Macine Co., F. J., Philadelphia
Watson-Stillman Corp., The, Roselle Park, N. J.

**RECTIFIERS, Current**
Benwood Linze Co., St. Louis, Mo.
Continental Elec. Co., 903 Merchandise Mart, Chicago
Electronics Laboratories, Indianapolis, Ind.
Fansteel Metallurgical Corp., N. Chicago, Ill.
General Electric Co., Bridgeport, Conn.
International Tel. & Radio Mfg. Corp., E. Newark, N. J.
Mallory & Co., P. R., Indianapolis, Ind.
Nothelfer Winding Labs., Trenton, N. J.
United Cinephone Corp., Torrington, Conn.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

**REGULATORS, Temperature**
Allen-Bradley Co., Milwaukee, Wis.
Dunn, Inc., Struthers, 1321 Cherry, Philadelphia
Fenwal Inc., Ashland, Mass.
General Electric Co., Schenectady, N. Y.
Mercoid Corp., 4217 Belmont, Chicago
Minneapolis-Honeywell Regulator, Minneapolis, Minn.
Spencer Thermostat Co., Attleboro, Mass.

**REGULATORS, Voltage**
Acme Elec. & Mfg. Co., Cuba, N. Y.
Ferranti Elec., Inc., 30 Rockefeller Plaza, N. Y. C.
General Elec. Co., Schenectady, N. Y.
H-B Elec. Co., Philadelphia
Sola Electric Co., 2525 Clybourn Av., Chicago
United Transformer Corp., 150 Varick St., N. Y. C.

**RESISTORS, Fixed**
Acme Elec. Heating Co., Boston, Mass.
Aerovox Corp., New Bedford, Mass.
Allen-Bradley Co., Milwaukee, Wis.
Atlas Resistor Co., 423 Broome St., N. Y. C.
Centralab, Milwaukee, Wisconsin
Clarostat Mfg. Co., Brooklyn, N. Y.
Cont'l Carbon, Inc., Cleveland, O.
Daven Co., 158 Summit St., Newark, N. J.
Dixon Crucible Co., Jersey City, N. J.
Erie Resistor Corp., Erie, Pa.

WHAT ISSUES OF FM MAGAZINE ARE MISSING FROM YOUR FILES? COMPLETE YOUR BACK NUMBERS. SEE SPECIAL OFFER ON PAGE 28



## SYLVESTER THOMAS THOMPSON

JUST as this issue was closed, word was received that Sylvester Thomas Thompson had passed away after a month's illness at the West Suburban Hospital, Oak Park, Illinois.

As vice president in charge of production and export at Zenith Radio Corporation, the War had put a heavy extra load on his shoulders. He was a man of tremendous vitality, but in his devotion to carrying out with meticulous care the responsibilities which he assumed so willingly, he never thought to spare himself.

In addition to new activities in connection with Zenith's shift to all-out War production, he was one of the most useful members of the Radio Manufacturers' Association. He was special adviser to the Export Committee, vice chairman of the Priorities Committee, a member of the Executive Committee, and a director of the Association.

Mr. Thompson, for the past twenty years, has been one of the best known and most highly respected figures in the radio industry. He made his start in radio as a director and the executive vice president of Kolster Radio, Inc., and manager of the Federal Telegraph Company, owned by International Te'ephone & Telegraph Company.

Subsequently, he became vice president, general manager, and a director of Pilot Radio Corporation, in Long Island City, New York. This was at the time the Company was reorganized, and he contributed greatly to the success of the Company and the growth of its domestic and foreign trade.

After his resignation from Pilot Radio, he joined the Zenith Radio Corporation, where he had the direct supervision of this Company's tremendous production facilities, first for peace, and then for War. He was also charged with the direction and development of Zenith's foreign trade which, until hostilities broke out in Europe, covered nearly a hundred different countries.

Among the organizations to which he belonged were the Chicago Association of Commerce, where he was a member of the Foreign Commerce Committee, the Institute of Radio Engineers, the Radio Club of America, and the Society of Automotive Engineers.

Always generous with his time in the service of others, he will be remembered by his business associates as an organizer of tremendous driving power whose acts were always tempered with thoughts of kindness and consideration for all those who came in contact with him.

Sylvester Thomas Thompson was born in Suffern, Rockland County, New York, on December 9th, 1892. Until he went to Chicago to join Zenith Radio, he was a resident of New York City. He is survived by his widow, Mildred Eloise Thompson. Services were conducted at Postlewait Chapel, Oak Park, Illinois, on June 9th.

## IN THE NAVY

Mortimer Loewi, vice president of Allen B. DuMont Laboratories, has been commissioned as a Lieutenant Commander. At the present time, he is stationed at Washington, D. C.

Fred Millies, of the engineering staff at station WTMJ, Milwaukee, has joined the Navy, and is now stationed at Great Lakes, Ill.

Lieut. Morgan S. A. Reichner and Ensign Armand Deutsch are in charge of the newly opened Branch Radio Section, Office of Navy Public Relations, in New York City.

Rear Admiral A. J. Hepburn, USN (ret.) has announced that the purpose of this new branch is to service more effectively the network broadcasting companies and the agencies placing network programs. This is part of a plan to give wholehearted cooperation to those setting up Navy radio programs.

This new Navy office is located in Room 1904, at 580 Fifth Avenue, New York City. The telephone number is BRyant 9-1710.

Globar Div. Carborundum Co., Niagara Falls, N. Y.
Hardwick, Hindle, Inc., Newark, N. J.
Instrument Resistors Co., Little Falls, N. J.
Intern'l Resistance Co., Philadelphia
Ohmite Mfg. Co., 4835 W. Flournoy, Chicago
Precision Resistor Co., Newark, N. J.
Sensitive Research Inst. Corp., 4545 Bronx Blvd., N. Y. C.
Shallcross Mfg. Co., Collingdale, Pa.
Sprague Specialties Co., N. Adams, Mass.
Stackpole Carbon Co., St. Marys, Pa.
Ward Leonard Elec. Co., Mt. Vernon, N. Y.
White Dental Mfg. Co., 10 E. 40th St., N. Y. C.
Wirt Co., Germantown, Pa.

**RESISTORS, Variable**

Aerovox Corp., New Bedford, Mass.
Allen-Bradley Co., Milwaukee, Wis.
Amer. Instrument Co., Silver Spring, Md.
Atlas Resistor Co., N. Y. C.
Centralab, Milwaukee, Wis.
Cinema Eng. Co., Burbank, Cal.
Clarostat Mfg. Co., Brooklyn, N. Y.
Cutler-Hammer, Inc., Milwaukee, Wis.
DeJur Amsco Corp., Shelton, Conn.
Electro Motive Mfg. Co., Willimantic, Conn.
General Radio Co., Cambridge, Mass.
G-M Labs., Inc., Chicago, Ill.
Hardwick, Hindle, Inc., Newark, N. J.
Instrument Resistors, Inc., Little Falls, N. J.
Intern'l Resistance Co., Philadelphia
Mallory & Co., P. R., Indianapolis, Ind.
Ohio Carbon Co., Cleveland, Ohio
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago
Precision Resistor Co., Newark, N. J.
Shallcross Mfg. Co., Collingdale, Pa.
Stackpole Carbon Co., St. Marys, Pa.
Utah Radio Prods. Co., 820 Orleans St., Chicago
Ward Leonard Elec. Co., Mt. Vernon, N. Y.
Wirt Co., Germantown, Pa.

**RIVETS, Plain**

Central Screw Co., 3519 Shields Av., Chicago
Progressive Mfg. Co., Torrington, Conn.
Republic Steel Corp., Cleveland, O.

**SCREWS, Recessed Head**

American Screw Co., Providence, R. I.
Bristol Co., The, Waterbury, Conn.
Chandler Prods. Co., Cleveland, O.
Continental Screw Co., New Bedford, Mass.
Corbin Screw Corp., New Britain, Conn.
International Screw Co., Detroit, Mich.
Lamson & Sessions, Cleveland, O.
National Screw & Mfg. Co., Cleveland, O.
New England Screw Co., Keene, N. H.
Parker Co., Charles, The, Meriden, Conn.
Parker-Kalon Corp., 198 Varick, N. Y. C.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Mfg. Co., Chicago
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Mfg. Co., Waterbury, Conn.
Shakeproof, Inc., 2501 N. Keeler Av., Chicago
Southington Hardw. Mfg. Co., Southington, Conn.
Standard Pressed Steel Co., Jenkintown, Pa.
Whitney Screw Corp., Nashua, N. H.

**SCREWS, Self-Tapping**

American Screw Co., Providence, R. I.
Central Screw Co., 3519 Shields Av., Chicago
Continental Screw Co., New Bedford, Mass.
Parker-Kalon Corp., 198 Varick, N. Y. C.
Shakeproof, Inc., 2501 N. Keeler, Chicago

**SCREWS, Set and Cap**

Allen Mfg. Co., Hartford, Conn.
Parker-Kalon Corp., 198 Varick, N. Y. C.
Republic Steel Corp., Cleveland, O.
Shakeproof, Inc., 2501 N. Keeler Av., Chicago

**SCREWS, Hollow & Socket Head**

Allen Mfg. Co., Hartford, Conn.
Central Screw Co., 3519 Shields, Chicago
Parker-Kalon, 198 Varick, N. Y. C.
Standard Pressed Steel Co., Jenkintown, Pa.

**SHEETS, Electrical**

American Rolling Mill Co., Middletown, O.
Carnegie-Illinois Steel Corp., Pittsburgh, Pa.
Follansbee Steel Corp., Pittsburgh, Pa.
Granite City Steel Co., Granite City, Ill.
Newport Rolling Mill Co., Newport, Ky.
Republic Steel Corp., Cleveland, O.
Ryerson & Son, Inc., Jos. T., Chicago

**SOCKETS, Tube**

Aladdin Radio Industries, 501 W. 35th St., Chicago
Alden Prods. Co., Brockton, Mass.
Amer. Phenolic Corp., 1830 S. 54th Av., Chicago
Amer. Radio Hardware Co., 476 B'way, N. Y. C.
Birnbach Radio Co., 145 Hudson, N. Y. C.
Bud Radio, Inc., Cleveland, O.
Cinch Mfg. Co., 2335 W. Van Buren St., Chicago
Cont'l-Diamond Fibre Co., Newark, Del.
Eagle Elec. Mfg. Co., Brooklyn, N. Y.
Eby, Inc., H. H., Philadelphia
Federal Screw Prods. Co., 26 S. Jefferson, Chicago
Franklin Mfg. Corp., 175 Varick, N. Y. C.
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2300 Wabansia, Chicago
Micarta Fabricators, Inc., 4619 Ravenswood, Chicago
Millen Mfg. Co., James, Malden, Mass.
Miller Co., J. W., Los Angeles, Cal.
Nat'l Co., Malden, Mass.
Remler Co., San Francisco, Cal.
Smith Co., Maxwell, Hollywood, Cal.

**SOLDER, Self-fluxing**

Garden City Laboratory, 2744 W. 37th Pl., Chicago
General Elec. Co., Bridgeport, Conn.
Kester Solder Co., 4209 Wrightwood Av., Chicago
Ruby Chemical Co., Columbus, O.

**SPRINGS**

Accurate Spring Mfg. Co., 3817 W. Lake, Chicago
American Spring & Mfg. Corp., Holly, Mich.
American Steel & Wire Co., Rockefeller Bldg., Cleveland, O.
Barnes Co., Wallace, Bristol, Conn.
Cuyahoga Spring Co., Cleveland, O.
Gibson Co., Wm. D., 1800 Clybourn Av., Chicago
Hubbard Spring Co., M. D., Pontiac, Mich.
Hunter Pressed Steel Co., Lansdale, Pa.
Instrument Specialties Co., Little Falls, N. Y.
Muehlhausen Spring Corp., Logansport, Ind.
Peck Spring Co., Plainville, Conn.
Raymond Mfg. Co., Corry, Pa.

**TRANSFORMERS, IF**

Aladdin Radio Industries, 501 W. 35th St., Chicago
Amer. Transformer Co., Newark, N. J.
Automatic Windings Co., E. Passaic, N. J.
Carron Mfg. Co., 415 S. Aberdeen, Chicago
D-X Radio Prods. Co., 1575 Milwaukee, Chicago
General Winding Co., 254 W. 31 St., N. Y. C.
Guthman & Co., 400 S. Peoria St., Chicago
Hammarlund Mfg. Co., 424 W. 33 St., N. Y. C.
Meissner Mfg. Co., Mt. Carmel, Ill.
Millen Mfg. Co., James, Malden, Mass.
Miller Co., J. W., Los Angeles, Cal.
Nat'l Co., Malden, Mass.
Sickles Co., F. W., Springfield, Mass.
Teleradio Eng. Corp., 484 Broome St., N. Y. C.
Triumph Mfg. Co., 4017 W. Lake, Chicago

**TRANSFORMERS, Receiver Audio & Power**

Acme Elec. & Mfg. Co., Cuba, N. Y.
Amer. Transformer Co., Newark, N. J.
Amplifier Co. of Amer., 17 W. 20th St., N. Y. C.
Audio Devel. Co., N. Minneapolis, Minn.
Cinaudagraph Speakers, Inc., 3929 S. Michigan, Chicago
Electronic Trans. Co., 515 W. 29 St., N. Y. C.
Ferranti Elec., Inc., 30 Rockefeller Plaza, N. Y. C.
Freed Trans. Co., 72 Spring St., N. Y. C.
Gen'l Radio Co., Cambridge, Mass.
General Trans. Corp., 1250 W. Van Buren, Chicago
Halldorson Co., 4500 Ravenswood, Chicago
Jefferson Elec. Co., Bellwood, Ill.
Kenyon Transformer Co., 840 Barry St., N. Y. C.
Magnetic Windings Co., Easton, Pa.
New York Transformer Co., 51 W. 3rd, N. Y. C.
Norwalk Transformer Corp, S. Norwalk, Conn.
Raytheon Mfg. Co., Waltham, Mass.
Skaggs Transformer Co., Los Angeles, Cal.
Standard Transformer Corp., 1500 N. Halsted, Chicago
Superior Elec. Co., Bristol, Conn.
Thordarson Elec. Mfg. Co., 500 W. Huron, Chicago
Utah Radio Prods. Co., 820 Orleans St., Chicago

**TUBES, Cathode Ray**

Dumont Labs., Allen B., Passaic, N. J.
Farnsworth Tele. & Radio Corp., Ft. Wayne, Ind.
General Elec. Co., Schenectady, N. Y.
Hygrade Sylvania Corp., Salem, Mass.
Nat'l Union Radio Corp., Newark, N. J.
RCA Mfg. Co., Camden, N. J.

**TUBES, Current Regulating**

Amperite Co., 561 Broadway, N. Y. C.
Champion Radio Works, Danvers, Mass.
Hytron Corp. & Hytronic Labs., Salem, Mass.
RCA Mfg. Co., Camden, N. J.

**TUBES, Photo-Electric**

Bradley Labs., New Haven, Conn.
Cont'l Elec. Co., Geneva, Ill.
De Jur-Amsco Corp., Shelton, Conn.
De Vry, Herman A., 1111 W. Center, Chicago
Electronic Laboratory, Los Angeles, Cal.
Emby Prods. Co., Los Angeles, Cal.
General Elec. Co., Schenectady, N. Y.
General Scientific Corp., 4829 S. Kedzie Av., Chicago
G-M Labs., 4313 N. Knox Av., Chicago
Leeds & Northrup Co., Philadelphia
Nat'l Union Radio Corp., Newark, N. J.
Photobell Corp., 123 Liberty St., N. Y. C.
RCA Mfg. Co., Camden, N. J.
Rehtron Corp., 2159 Magnolia Av., Chicago
Rhamstine, J., Detroit, Mich.
Westinghouse Lamp Div., Bloomfield, N. J.
Weston Elec. Inst. Corp., Newark, N. J.

(CONTINUED FROM PAGE 18)

of the $Q$-Meter. Set the $Q$ circuit capacitance to about 50 μμf., calling this capacitance $C_1$, and resonate the $Q$ circuit by adjusting the oscillator frequency to exact resonance. Set the oscillator to a new frequency exactly one-half of the first resonant frequency. Retune the $Q$ circuit by means of the $Q$ tuning condenser and call the new condenser reading $C_2$. The distributed capacitance, $C_d$, is then:

$$C_d = \frac{C_2 - 4C_1}{3} \qquad (37)$$

This procedure may be repeated with different values of $C_1$ and the values of $C_d$ averaged to obtain somewhat greater accuracy. The best accuracy to be expected with this method is of the order of ± 2μμf.

**3-G: Resonant Frequency and Distributed Capacitance** ★ A more accurate method of determining the distributed capacitance of a coil when the capacitance is less than about 20 to 30 μμf., involves measuring the resonant frequency of the coil.

The resonant frequency of a coil may be determined with the $Q$-Meter by an indirect method which has the advantage of being quite accurate and is applicable to almost any type of coil, shielded or unshielded, within the range of the $Q$-Meter. This method depends on the fact that at the resonant frequency of a coil the impedance across its terminals is effectively a non-reactive resistance, and consists of making a number of settings of the $Q$-Meter frequency and resonating the $Q$ circuit at each frequency with the test coil first disconnected and then connected across the $Q$ circuit, until a frequency is found at which the connection of the test coil causes no change in the $Q$ circuit tuning. The following procedure is recommended to aid in locating the resonant frequency of a coil:

I. Connect the test coil to the *coil* terminals of the $Q$-Meter, set the $Q$ tuning condenser to about 400 μμf., and resonate the $Q$ circuit by adjusting the oscillator frequency. Call the frequency $f_1$ and tuning capacitance $C_1$.

II. Replace the test coil with a shielded coil having an inductance about 1/25 of that of the test coil, or a coil that will resonate in the $Q$ circuit to a frequency about 10 times the value of $f_1$. Set the $Q$-Meter to a frequency of about 10 times $f_1$ and resonate the $Q$ circuit to this new frequency. (This factor of 10 is based on the distributed capacitance of the coil being in the region of 4 μμf., which is common for small coils. Higher distributed capacitances will lower the resonant frequency of the coil and a smaller factor than 10 will obtain.)

III. Connect the test coil across the $Q$ circuit, to the condenser terminals, taking care to avoid coupling between the two coils, and re-resonate the $Q$ circuit by means of the $Q$ tuning condenser or vernier condenser, *observing whether the capacitance has to be increased or decreased* from its previous value to restore resonance.

If the capacitance has to be INCREASED, INCREASE the oscillator frequency by an appreciable amount (10 to 20%). If the capacitance has to be DECREASED, DECREASE the oscillator frequency.

IV. Disconnect the test coil and resonate the $Q$ circuit to the new frequency by means of the $Q$ tuning condenser. Repeat the above procedure III, changing the oscillator frequency by smaller increments as it approaches the resonant frequency of the test coil, until the frequency reaches a value at which the $Q$ circuit capacitance is unchanged when the test coil is connected or disconnected.

The oscillator frequency is then the resonant frequency of the test coil. Call this frequency $f_o$.

The distributed capacitance, $C_d$, of the coil may be calculated from the values of $f_1$ and $C_1$ obtained in paragraph I above, and the resonant frequency, $f_o$, of the coil, using the following formula:

$$C_d = \left(\frac{f_1}{f_o}\right)^2 C_1 \qquad (38)$$

The accuracy of this distributed capacitance measurement depends on the inductance of the coil being the same at the two measurement frequencies. This is reasonably accurate for commonly used coils, although it may not hold for coils having iron cores.

EDITOR'S NOTE: The second part of this article will appear in a forthcoming issue of FM RADIO-ELECTRONIC ENGINEERING.

## RADIO "OSCAR" TO KGO

For the second consecutive year, station KGO, at Oakland, California, has won the General Electric national merit award.

This award is presented each year to the broadcast station with the least air time lost through technical failure during the previous twelve months.

From this cause, KGO lost only 23½ seconds during 1941, setting a new record since the GE annual awards, which cover all stations of the NBC and Blue Network, were instituted.

The presentation was made to A. E. Evans, engineer in charge of the KGO transmitter, by Raymond M. Alvord, GE commercial vice president in charge of the Pacific district. W. B. Bryan, general manager of KGO, participated in the ceremony, which was put on the air.

This trophy, equivalent in broadcast engineering circles to Hollywood's "Oscar" awards, is a copper plaque mounted on mahogany. Copper in this year's plaque was taken from the world's first high-power broadcast transmitter, installed at station WGY, Schenectady, in 1925.

If the present restrictions on the use of copper are tightened further, it may be necessary to use gold for the next trophy.

### TUBES, Receiving

Hygrade Sylvania Corp., Salem, Mass.
Hytron Corp., Salem, Mass.
Ken-Rad Tube & Lamp Corp., Owensboro, Ky.
Nat'l Union Radio Corp., Newark, N. J.
Raytheon Prod. Corp., 420 Lexington Av., N. Y. C.
RCA Mfg. Co., Camden, N. J.
Tung-Sol Lamp Works, Newark, N. J.

### TUBES, Transmitting

Amperex Electronic Prods., Brooklyn, N. Y.
Eitel-McCullough, Inc., San Bruno, Cal.
Federal Telegraph Co., Newark, N. J.
General Elec. Co., Schenectady, N. Y.
Heintz & Kaufman, S. San Francisco, Cal.
Hytron Corp., Salem, Mass.
Nat'l Union Radio Corp., Newark, N. J.
Raytheon Prod. Corp., 420 Lexington Av., N. Y. C.
RCA Mfg. Co., Camden, N. J.
Taylor Tubes, Inc., 2341 Wabansia, Chicago
United Electronics Co., Newark, N. J.
Westinghouse Lamp Div., Bloomfield, N. J.

### TUBES, Voltage-Regulating

Amperite Co., 561 Broadway, N. Y. C.
Hygrade Sylvania Corp., Salem, Mass.
Hytron Corp., Salem, Mass.
RCA Mfg. Co., Camden, N. J.

### TUBING, Laminated Phenolic

Brandywine Fibre Prods Co., Wilmington, Del.
Formica Insulation Co., Cincinnati, O.
General Electric Co., Pittsfield, Mass.
Insulation Mfgrs. Corp., 565 W. Washington Blvd., Chicago
Mica Insulator Co., 196 Varick, N. Y. C.
Nat'l Vulcanized Fibre Co., Wilmington, Del.
Richardson Co., Melrose Park, Chicago
Synthane Corp., Oaks, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Wilmington Fibre Specialty Co., Wilmington, Del.

### TUBING & SLEEVING, Varnished Cambric, Glass-Fibre, Spaghetti

Bentley-Harris Mfg. Co., Conshohocken, Pa.
Brand & Co., Wm., 276 Fourth Av., N. Y. C.
Endurette Corp. of America, Cliffwood, N. J.
General Elec. Co., Bridgeport, Conn.
Insulation Mfgrs. Corp., 565 W. Washington Blvd., Chicago
Mica Insulator Co., 196 Varick St., N. Y. C.

### WIRE, Bare

American Steel & Wire Co., Cleveland, O.
Anaconda Wire & Cable Co., 25 Broadway, N. Y. C.
Ansonia Elec. Co., Ansonia, Conn.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
General Elec. Co., Bridgeport, Conn.
Phosphor Bronze Smelting Co., Philadelphia
Rea Magnet Wire Co., Fort Wayne, Ind.
Roebling's Sons Co., John, Trenton, N. J.

### WIRE, Magnet

Acme Wire Co., New Haven, Conn.
American Steel & Wire Co., Cleveland, O.
Anaconda Wire & Cable Co., 25 Broadway, N. Y. C.
Ansonia Elec. Co., Ansonia, Conn.
Belden Mfg. Co., 4633 W. Van Buren, Chicago
Electric Auto-Lite Co., The, Port Huron, Mich.
General Elec. Co., Bridgeport, Conn.
General Elec. Co., Schenectady, N. Y.
Holyoke Wire & Cable Corp., Holyoke, Mass.
Rea Magnet Wire Co., Fort Wayne, Indiana
Rockbestos Prods. Corp., New Haven, Conn.
Roebling's Sons, Co., John, Trenton, N. J.

## I.R.E. CONVENTION AT CLEVELAND

Following is a resumé of the papers to be given during the Summer Convention meetings of the Institute of Radio Engineers at Hotel Statler, Cleveland, Ohio:

MONDAY, June 29, 10:30 A.M. — 1:00 P.M.

Addresses of Welcome: A. F. Van Dyck, President of the Institute; P. L. Hoover, Chairman, Cleveland Section; C. E. Smith, Convention Committee Chairman

"Recording Standards"; I. P. Rodman, Columbia Recording Corp., New York City

"New Approach to the Problem of Phonograph Reproduction": G. L. Beers and C. M. Sinnott, RCA Manufacturing Company, Camden, N. J.

"Measuring Transcription Turntable Speed Variations": H. E. Roys, RCA Manufacturing Company, Indianapolis, Ind.

"New Type of Practical Distortion Meter": J. E. Hayes, Canadian Broadcasting Corp., Montreal, Que.

"Frequency Modulation Distortion in Loudspeakers": G. L. Beers and H. Belar, RCA Manufacturing Company, Camden, N. J.

2:30 P.M. — 5:00 P.M.

"Radio Frequency Oscillator Apparatus and Its Application to Industrial Process-Control Equipment": T. A. Cohen, Wheelco Instruments Company, Chicago, Ill.

"The Scanning Microscope": V. K. Zworykin, J. Hillier, and R. Snyder, RCA Manufacturing Company, Camden, N. J.

"Spectroscopic Analysis in the Manufacture of Radio Tubes": S. L. Parsons, Hygrade Sylvania Corp., Emporium, Pa.

"Minimizing Aberration of Electron Lenses": H. Poritsky, General Electric Company, Schenectady, N. Y.

TUESDAY, June 30, 10.00 A.M. — 1.00 P.M.

"Maintenance of Broadcasting Operations During Wartime": J. A. Ouimet, Canadian Broadcasting Corp., Montreal, Que.

"High-Power Television Transmitter": H. B. Fancher, General Electric Company, Schenectady, N. Y.

"Frequency Modulation Transmitter-Receiver for Studio Transmitter Relay": W. F. Goetter, General Electric Company, Schenectady, N. Y.

"Effect of Solar Activity on Radio Communication": H. W. Wells, Carnegie Institution of Washington, Washington, D. C.

2:30 P.M. — 4:30 P.M.

"Television Video Relay System": J. E. Keister, General Electric Company, Schenectady, N. Y.

"Mercury Lighting for Television Studios": C. A. Breeding, General Electric Company, Schenectady, N. Y.

"Focusing View-Finder Problem in Television Cameras": G. L. Beers, RCA Manufacturing Company, Camden, N. J.

WEDNESDAY, July 1, 10:00 A.M. — 1:00 P.M.

"Radio Strain Insulators for High Voltage and Low Capacitance": A. O. Austin, A. O. Austin, Barberton, Ohio.

"Improved Insulators for Self-Supporting or Sectionalized Towers": A. O. Austin, A. O. Austin, Barberton, Ohio.

"Brief Discussion of the Design of a 900-Foot Uniform Cross Section Guyed Radio Tower": A. C. Waller, Truscon Steel Company, Youngstown, Ohio.

"Circular Antenna": M. W. Scheldorf, General Electric Company, Schenectady, N. Y.

"Stub Feeder Calculations": H. A. Brown and W. J. Trijitzinsky, University of Illinois, Urbana, Ill.

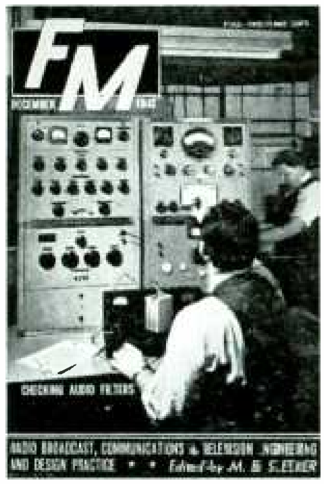
## FROZEN ONLY ON THE SURFACE

(CONTINUED FROM PAGE 23)

the local boards refuse to exempt them on the grounds that others can be trained quickly to take their places!

These are some of the elements which make up a situation seemingly full of contradictions, yet adding up to preparation for improved and added radio service to the public at lower costs when the War is over, but introducing limitations to civilian radio and increasing the cost of military equipment during this period of emergency.

LIEUT. GENERAL WILLIAM KNUDSEN INSPECTS GENERAL ELECTRIC RADIO PLANT WITH J. M. HOWELL, GE PLANT MANAGER AND J. J. FARRELL, RADIO DESIGN ENGINEER



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COL. CHARLES H. SCHOEFFEL
SUPERINTENDENT

May 13, 1942.

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We hope the quality and performance of the equipment presently installed will continue in future installations, and when the entire system is completed it is our further hope that we will have a police communication network that both you and we can be proud of.

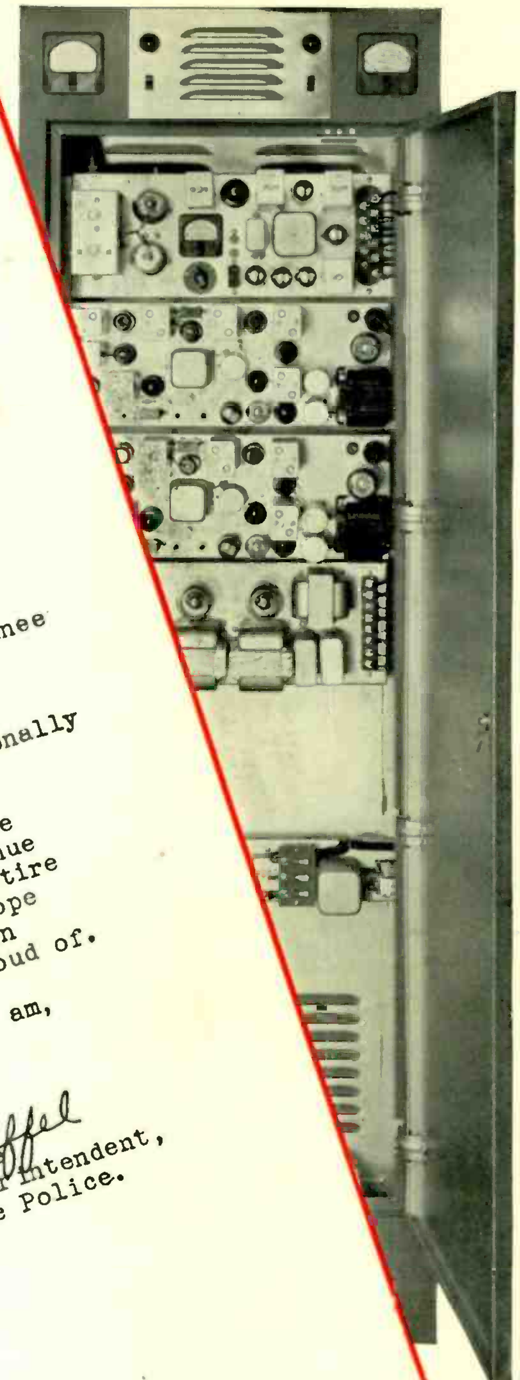
Appreciating your fine cooperation, I am,

Sincerely,

Chas. H. Schoeffel
Chas. H. Schoeffel
Colonel and Superintendent,
New Jersey State Police.

CHS:P

Mr. Fred M. Link,
125 W. 17th Street,
New York City.



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