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FM

RADIO-ELECTRONIC ENGINEERING & DESIGN

JUNE 1942

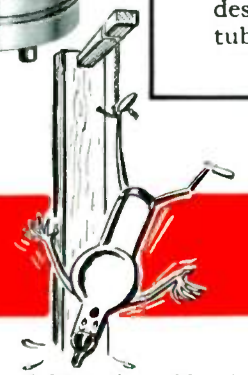
EMERGENCY EQUIPMENT
PRODUCTION METHODS

Radio-Electronic Products Directory

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

How to Get Longer Life from Your MERCURY-VAPOR TUBES

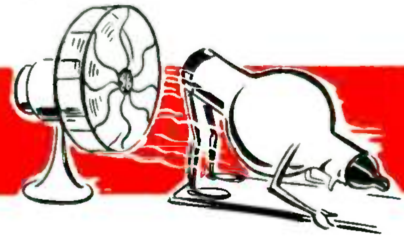
Here's a four-word formula to make your mercury-vapor tubes last longer—"Handle carefully; operate conservatively." Below are a few suggestions to help you put this formula into effect. They will help prevent many of the causes of tube failure, such as: loss of emission, high arc-drop, cathode bombardment, arc-backs, the liberation of gas, and cathode failure. These safeguards are applicable to such tubes as the following General Electric mercury-vapor rectifiers: GL-266B, GL-857B, GL-866A/866, GL-869B, GL-872, GL-872A. For more complete instructions on operation and handling, write for Bulletin GEH-977B. Also list the types of G-E mercury-vapor rectifiers you are now using. We shall be glad to send you complete service information designed to help you get the most out of your mercury-vapor tubes. *General Electric, Schenectady, N. Y.*



1
Keep tubes upright and avoid splashing mercury around. When tubes are first placed in operation, be sure to apply cathode voltage *alone* until mercury is properly distributed.

2
Keep condensed mercury temperature within limits recommended by tube manufacturer.

3
Be sure cathode base, not the anode end, is coolest part of tube. Don't let drafts blow on tubes. Never allow the mercury to condense at the anode end.



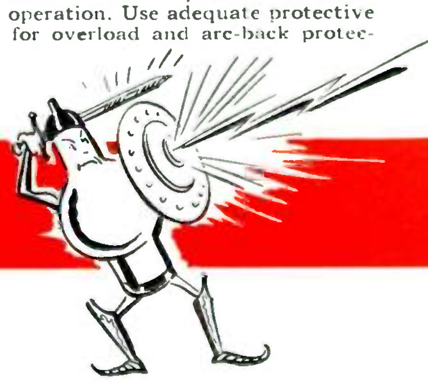
4
If you use forced air against the bottom of the tube, keep the blower on for a few minutes after shutting filaments down.

5
Allow plenty of filament warm-up time before applying anode voltage.

6
Keep peak inverse anode voltage and peak current as low as possible for satisfactory operation. Use adequate protective devices for overload and arc-back protection.

7
Do not allow the cathode voltage (measured at the pins) to deviate more than five per cent from the rated value.

8
Don't overload tubes, even for short periods. Maintain full cathode voltage during standby operation when tube is operated without load.



9
Protect the tubes adequately against the effects of r-f.

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

161-38-8860

CITED for VALUE

"performing distinguished service to those engaged in wartime radio-electronic work"

YES, WE ARE PROUD OF THE COMMENTS that are being made about RADIO-ELECTRONIC ENGINEERING in its new format. But we'd like to step back so that our contributors can take a bow.

These are the men who are responsible for the high standing of RADIO-ELECTRONIC ENGINEERING among radio publications.

Is a magazine leafed through hurriedly, set aside, and forgotten? Or is its appearance welcomed with interest and confidence, and appreciation for the usefulness of its contents? That depends chiefly upon the standing of the men who write the articles.

Those in RADIO-ELECTRONIC ENGINEERING are written by the men who conceived the ideas or did the work described. Thus they present first-hand knowledge and experience — rather than second-hand reporting by staff editors who can only write what they can remember.

We believe that this accounts for the exceptional reader-interest in RADIO-ELECTRONIC ENGINEERING. Who are these readers? A new analysis, just completed, shows them to be:

Engineers and executives of plants manufacturing radio and associated equipment	1,116
Civilian and military engineers and procurement officers in Government departments	300
Public utility engineers	337
Chief operators at airports and commercial stations	442
City, county, and state police radio officers	771
Broadcast station engineers and executives	1,308
Laboratories, patent lawyers, foreign purchasing commissions, and miscellaneous	144
Radio trade	295
Others	153

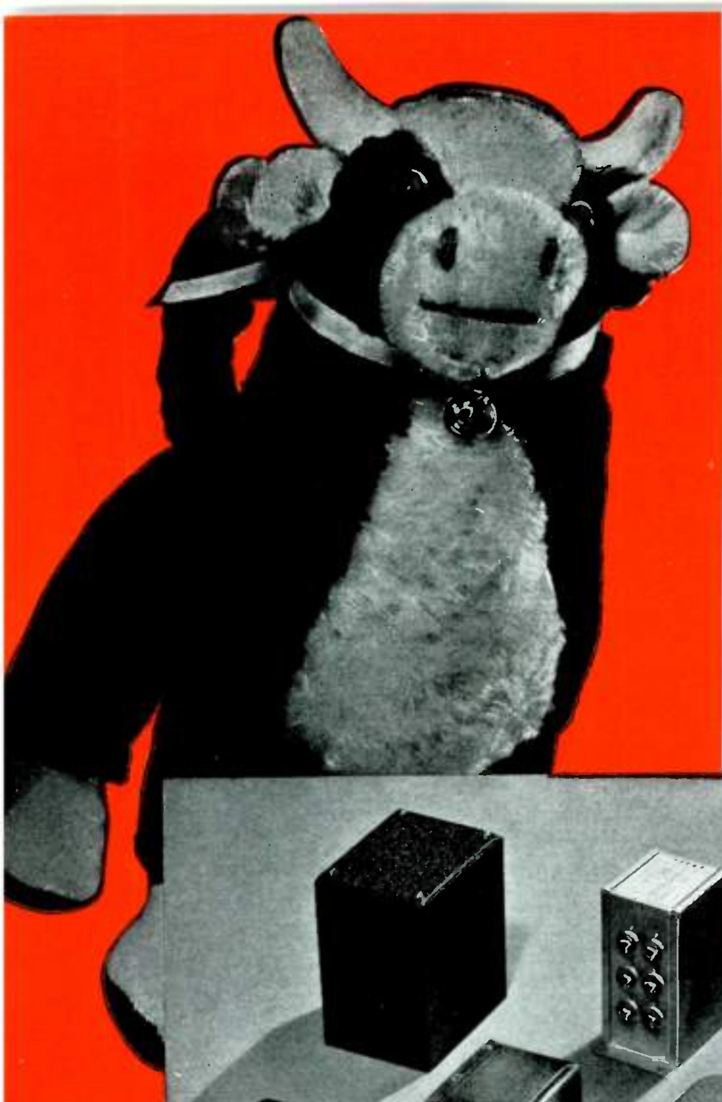
The names of the ranking civilian and military engineers and executives in all branches of wartime radio-electronic activity are to be found in these groups.

Many of these names appear again in our list of contributors.

Thus it has come about that Radio-Electronic Engineering is written by, as well as for, the men who occupy positions of leadership in the radio-electronic industry.

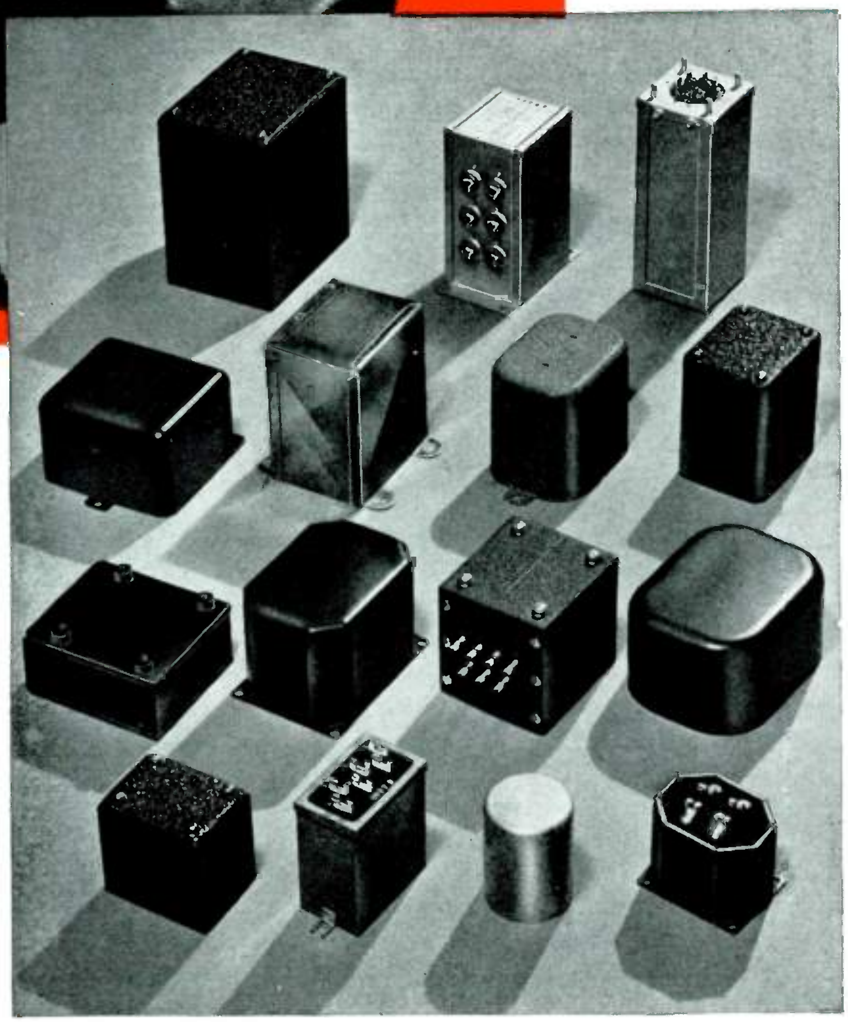
RADIO-ELECTRONIC ENGINEERING & DESIGN

FM



TOUGH?

Not when YOU'RE EQUIPPED TO HANDLE THEM



In addition to the electrical characteristics, many customers' application problems are related to the physical appearance and dimensions of their transformer components. Fortunately, the UTC sheet metal division supplies practically all the housings, laminations, brackets, and other devices which control the mechanical characteristics of UTC units. Instead of restricting designs to specific cases, the sheet metal division can run off a special case to more closely fit the final transformer dimensions, or to effect the particular mounting provisions required by the application.

The sheet metal division has drawing, forming, and other press facilities to cover the entire gamut of transformer housings from tiny transformer channels, to large oil tanks for broadcast and industrial service. Since these housings are produced at UTC, fast service can be given.

Illustrated are a few (just a very few) typical cases as supplied for some special applications

IF YOU HAVE A SPECIAL PROBLEM, MAY WE HAVE AN OPPORTUNITY TO COOPERATE?

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150 VARICK STREET ★ NEW YORK, N. Y.

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

FM RADIO-ELECTRONIC ENGINEERING & DESIGN

COMBINED WITH: APPLIED ELECTRONIC ENGINEERING

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CONTENTS

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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.

COVER PICTURE

This photograph, taken in the REL factory, symbolizes the part which skillful, ingenious young men are taking in the production of the superior radio apparatus with which our Armed Forces are being equipped. Theirs is a great responsibility, for the failure of a single part or connection during an engagement with the enemy might spell death to men whose lives depend upon maintaining communication with coöperating units.

SPEED PRODUCTION TESTS

...save engineering time in labs...

with R. C. P. ELECTRICAL and ELECTRONIC TEST INSTRUMENTS

RADIO CITY PRODUCTS *New line of up-to-the-minute electrical and electronic test instruments are specifically designed to meet today's war-time needs for speed, accuracy and flexibility.*

Special-purpose types meet the most exacting demands of laboratory and production line alike, while other models are designed "without frills" for wider-latitude applications. Several typical instruments in the Radio City Products' line are illustrated.

MODEL 670

ELECTRONIC LIMIT BRIDGE FOR PRECISION RESISTANCE TESTING

For rapid, precision resistance measurements. Direct reading, accurate to 0.1 of 1.%, in ±% deviations from predetermined standards. Internal standards to specifications. Instrument also provides for external standards. External and internal standards can be used in combination. Battery operated, self-contained with 4½" galvanometer...... **150.**

ELECTRONIC AC-DC VOLTMETER —OHMMETER—CAPACITYMETER

Vacuum tube voltmeter with 6 AC ranges and 7 DC ranges, 0-6000 V.—input resistance 16 and 160 megohms. Seven range direct reading vacuum tube ohmmeter to 1,000 megs. Seven range vacuum tube capacity meter to 2,000 mfd. In rugged welded crystalline finish case. **47.50**

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Meter sensitivity 2,500 ohms per volt. ±2% accurate. 5 DC ranges 0-1,000 volts. 4 AC ranges 0-1,000 volts. 4 DC ma. ranges 0-1,000. 4 Ohmmeter ranges 0-10 meg. db range from —10 to +55. Complete **23.50**

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A peak voltmeter designed for measurements covering the entire audio range. Meter 4½" 0-200 microammeter. Operates on 60 cycle 105-130 volt power supply. Provisions for battery operation. Complete.......... **35.50**

MODEL 666

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RADIO ENGINEERING PROBLEMS

As Reviewed at the Cleveland Convention of the Institute of Radio Engineers

BY ARTHUR VAN DYCK * and PAUL GALVIN **

EACH individual can learn from others something useful to his own war work concerning materials, precision manufacture, measurements, governmental procedure, or other things of vital interest at the moment.

The radio industry is doing a tremendous job in the war effort. It has become a billion dollar industry. It has converted from peace time production to war production rapidly.

In so doing it has changed from designs involving tolerances so crude that dials were arranged particularly to prevent the discovery thereof, to designs of high precision, both mechanically and electrically. From apparatus required to meet only the variable conditions between parlor and kitchen, it has turned to making apparatus to work reliably from the stratosphere to the equatorial desert.

The burden of this accomplishment has fallen most heavily upon the radio engineers. And well have they carried it — without adequate sleep, without furloughs, without rewards or medals they are doing the job.

Perhaps the training received by radio men during the past decade, in turning out a new line of forty-nine models every three months, has stood them in good stead. Even a war has perhaps been no worse than some of the past convulsions at new-model season.

We have done a good job so far. To continue that performance, and to better it, we should remember how basically vital is radio in this war.

The new mobility of attack, on land, sea and in the air, is possible only by use of radio communication. The companion mobility of successful defense is dependent likewise upon radio communication.

In addition to these, we have the applications of radio techniques to new instruments and weapons, thereby broadening the field of radio to limits not yet clearly seen.

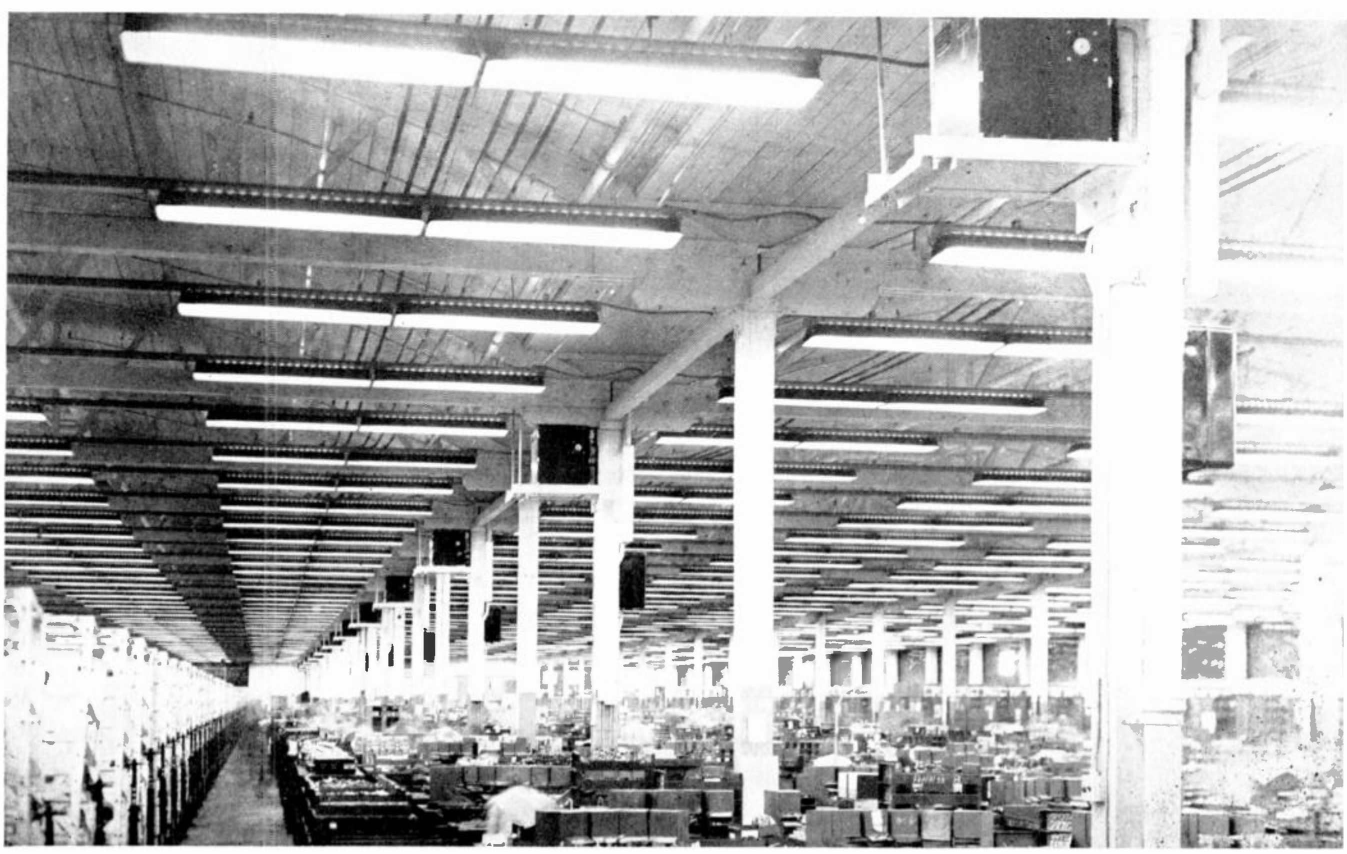
The world is in an age of miracles, and we in radio are among the favored few who are bringing them about. We should appreciate our responsibilities, but we can also take pride in what we are doing.

In connection with this matter of interchange of information, I might tell you at this time that the Board of Directors views with some concern the present situation in distribution of new technical information. While recognizing fully the need for the right kind and degree of secrecy, it is recognized also that under today's conditions of rapid advance in numerous new fields, too much secrecy is readily possible.

Complete isolation of workers, and too confined compartmentalization of knowledge, in radio science today, means duplication of work, and loss of contribution to work in each compartment from work in the others. Each and every laboratory thinks of itself as self-sufficient and wholly competent, and while all may be so for short periods of time, they cannot be so for longer periods. We do not realize,

* President, Institute of Radio Engineers and Manager, R.C.A. License Laboratory, 711 Fifth Avenue, New York City.

** President, Radio Manufacturers Association and President, Galvin Mfg. Corporation, Chicago, Ill.



THIS GENERAL ELECTRIC FACTORY, RECENTLY COMPLETED, IS AN EXAMPLE OF RADIO ENGINEERING GEARED TO ALL-OUT WAR EFFORT unless we study the matter specifically, how much of the knowledge existing in any one laboratory at any one time, comes from all the other laboratories of the world, made known by the free interchange of technical journals.

If that interchange is shut off, each laboratory is limited in new knowledge to its own contributions. Mere coördination through executive heads or committees is not importantly beneficial. Ideas come from the technical workers themselves, and each worker is fertilized only by technical detail from other workers.

Ideas in one field are more often sparked by work in other fields than by work in the same field. It seems quite certain that if this war continues much longer, as it gives every promise of doing, ways must be found of obtaining dissemination of information to loyal workers, with security from the enemy, or our performance will be dangerously handicapped.

Our enemies are excellent organizers in bringing all their abilities into well-focussed use. We must learn to do the same. The Board of Directors is making effort to find a way to assist.

I would like to report to you at this time on another war activity in which the Institute is participating. This is the standardization of radio material for the armed services. Radio designs for the Army and the Navy have been developed independently under different specifications and requirements, over past years in which their service conditions were different.

Now, however, radio technique and communication practices are so similar in the two armed services that a high degree of standardization between the two is possible. Such standardization is of course highly desirable from every standpoint, and the Government agencies concerned have initiated the coördination and simplification work involved.

The work has been in progress for several months, under the guidance of the American Standards Association and the sponsorship of the Institute of Radio Engineers. The work of the American Standards Association is of greater importance than is recognized generally in peacetime. In wartime, when advantage to production is urgently needed, such work comes into more prominent relief and is more readily accepted. This is obviously a work of great value to the war effort, but it involves much hard work without reward except that to the common good. It is being accomplished without fanfare and publicity, and will be reported through appropriate channels in due course. — *Arthur Van Dyck.*

WE MUST marshall real fighting ideas and turn our work and our habits of working into the groove that will best aid in our country winning the war. Those who have not negotiated this mental bottleneck haven't, as yet, made the proper adjustment to the point where they can make their very best war effort.

Engineers too often are inclined to view their jobs narrowly. The engineer too often prefers to resolve his problem within well defined limits and within a field whose structure is clearly defined. The engineer is too prone to want plenty of time to conclude a project with finality in the prescribed fashion.

That is out, positively, for the duration of this war. Your problems will never be finished. You will be constantly called upon to explore new horizons in the radio and electronic field. You will be called upon for better and quicker answers. Courageous enterprise on the part of the engineer will be a major contribution to our winning the war.

The text of this and the preceding page was taken from Arthur Van Dyck's address of welcome at the I.R.E. Convention at Cleveland, and from Paul Galvin's address during the symposium on wartime engineering, held during the Convention.

Ideas expressed by these men are of such significance to all those engaged in the development, design, and production of communications equipment for our Armed Forces that these excerpts are published here for the benefit of those who were not able to make the trip to Cleveland.

Because of restrictions on transportation, this Convention, marking the 30th anniversary of the Institute, may be the last until the War is over. However, activities of the local Chapters will continue without interruption.

Information about meetings of the I.R.E. Sections and membership can be obtained by writing to Harold P. Westman, Secretary, Institute of Radio Engineers, 330 West 42nd Street, New York City.

I might go so far as to say that without courageous enterprise on the part of our engineers, we might lose the war. We must have new and better models of everything, planes, tanks, boats, guns and radio equipment. If we don't, our smart enemy will have better equipment and apparatus and we shall be outclassed.

You are being called upon and will continue to be called upon throughout this entire war to strain to the breaking point to deliver energy, effort and brains, the like of which you have never done before. You may have thought you were very busy many times before, but this war effort calls for a personal and social readjustment and sacrifice of all engineers to where they must give complete devotion tenaciously to their task.

The engineers are being relied upon to come up with intelligent answers which the manufacturers can put into production in a hurry, and thus put into the hands of the Army and Navy large quantities of material for greater and more effective striking power.

In the war effort, radio engineers have to be ready and willing at all times to tackle the problem of substitution of materials when it comes up, regardless of how annoying it may be. It is part of the game.

One way to keep clear of the critical material problem as best you can is to design away from it. And in your design activity I caution you to watch this critical material problem very carefully. It will save you, your manufacturer, and the Army and Navy many headaches.

The mechanical engineer and the electrical engineer in this effort, more than ever before, must have a greater spirit of coöperation, one unto the other, in quickly working out design problems. The design engineer should be more conscious of the manufacturing and tooling problems. These can be serious bottlenecks in getting apparatus through the plant in quantities, and on time.

Today the radio development and design engineer has to be more cognizant of the other fellow's problems than ever before. The effectiveness of our industry's war effort depends upon the proper integration of all of our efforts — and those efforts can be so much more fruitful all along the line when broad thinking is applied to the development and design of the apparatus when it is still in the hands of the engineer.

Radio men are up against some clever engineers in the radio and electronic field in both Germany and Japan. An examination of the technical literature will show you that — and the Nazis have turned out apparatus which will command and challenge your attention.

I wonder sometimes, if you fellows thoroughly realize the importance radio is destined to play in the winning of this war. The whole pattern of war tactics and strategy has been altered by the use of radio communication and radio direction finders. The coördination of land, air and sea forces is accomplished by radio. Protection from the enemy and firing accuracy is accomplished by Radar. It has been said that in the aerial battle for Britain in the Fall of 1940, radio direction finding apparatus which we, in this country, call Radar, was a prime contributing factor in enabling the R.A.F. to maintain superiority in the air over the Nazis, with a much smaller aggregation of flying equipment.

You are alive, I am sure, to your war effort responsibilities but I implore you to do more. You must do more. We all must do more if we are to win this war. — *Paul Galvin.*

In Preparation: A forthcoming issue of Radio-Electronic Engineering will present a comprehensive article on the application and use of constant-voltage transformers, giving complete data on characteristics and mechanical design of standard types available for use in radio equipment.

FIG. 2, BELOW, SECOND STAGE OF ASSEMBLY LINE. PRE-WIRED SUB ASSEMBLIES ARE MOUNTED AT THIS STAGE, AS SHOWN BY SAMPLE SET AT LEFT. OPERATORS MEMORIZE THEIR WORK, USING SAMPLE ONLY FOR REFERENCE AND TO CHECK THEIR OPERATIONS

FIG. 1, ABOVE, THE FIRST ASSEMBLY STAGE. AT THE LEFT IS THE MODEL SET WITH ALL PARTS MOUNTED THAT ARE PUT ON BY THE OPERATOR AT THIS POSITION. MODEL SETS AT EACH STAGE SERVE TO MAINTAIN STANDARDS OF WORKMANSHIP

WARTIME PRODUCTION METHODS

How REL Has Stepped Up Production of 2-Way FM Emergency Equipment

BY LESLIE NOZDROVICZKY *

SINCE last December, a tremendous demand has sprung up for 2-way FM emergency equipment. What was a normal growth of police use for protective purposes suddenly expanded into a plan of offensive action to meet and forestall the development of any situation which may threaten the lives of our citizens, our industries, or our public service installations. In the latter group are power plants, substations, dams, reservoirs, railroads, bridges, and tunnels.

All this need for radio equipment, added to military requirements, has called for new designs correlated with new, fast production methods.

Correlated Planning ★ That is why the design of the REL Victory model and methods for its production were worked out simultaneously.

As soon as the parts list was available from the first laboratory model, consideration was given to combining items into such sub-assemblies as would permit advantageous pre-fabrication before bringing them to the production line.

At the same time, we went into the matter of pre-testing parts and sub-assemblies, both to catch defective components before they could be wired into the chassis, and to simplify final inspection and adjustment.

The pre-fabricated units in this equipment, some of which can be seen in Fig. 5, are:

1. The RF power amplifier plate transformer (not shown).
2. Power amplifier driver transformer.
3. Resistor strips.
4. Meter jack assemblies.
5. Dynamotor filters and terminal boards.
6. Cable harness.
7. In addition, all solid bus wires were laid out to be cut and bent in advance, and all coil leads were cut to length and stripped, ready for soldering.

Among the more important pre-assembly tests are:

1. Alignment of all low intermediate frequency transformers to approximate resonance.
2. Checking all other tuned circuits for frequency range and effective Q.
3. Adjusting and locking the power amplifier neutralizing condensers at their correct capacity.
4. Testing the dynamotors at their rated load.

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

dimensioned so that its capacitance does not exceed the ΔC available in the Q tuning condenser.

5-B: Dielectric Constant ★ To determine the dielectric constant, ϵ, of a sample of insulating material: Prepare it as described above, and measure its capacitance according to the method given in section 4-B, and call this value C. Measure the area of the active dielectric contained between the electrodes calling this value S, and measure the average thickness of the active dielectric calling this value t. When C is in micro-microfarads and S and t are in inches, the dielectric constant is:

$$\epsilon = \frac{4.45\ Ct}{S} \qquad (42)$$

When S and t are measured in centimeters, the dielectric constant is:

$$\epsilon = \frac{11.3\ Ct}{S} \qquad (43)$$

5-C: Power Factor and Q ★ To determine the power factor or Q of a sample of insulating material, the sample should be prepared as described above, and then measured as a small condenser as described in section 4-D. For convenience, the formulas are repeated here:

If C_1 and Q_1 are the capacitance and Q of the Q circuit at resonance with the sample not connected, and C_2 and Q_2 are the capacitance and Q of the circuit with the sample connected, then the Q of the insulating material is:

$$Q_x = \frac{(C_1 - C_2)\ Q_1 Q_2}{C_1\ (Q_1 - Q_2)} \qquad (39)$$

The power factor in per cent (for values less than about 10%) is:

$$\text{Power Factor} = \frac{100}{Q_x} = \frac{100 C_1 (Q_1 - Q_2)}{(C_1 - C_2)\ Q_1 Q_2} \qquad (40)$$

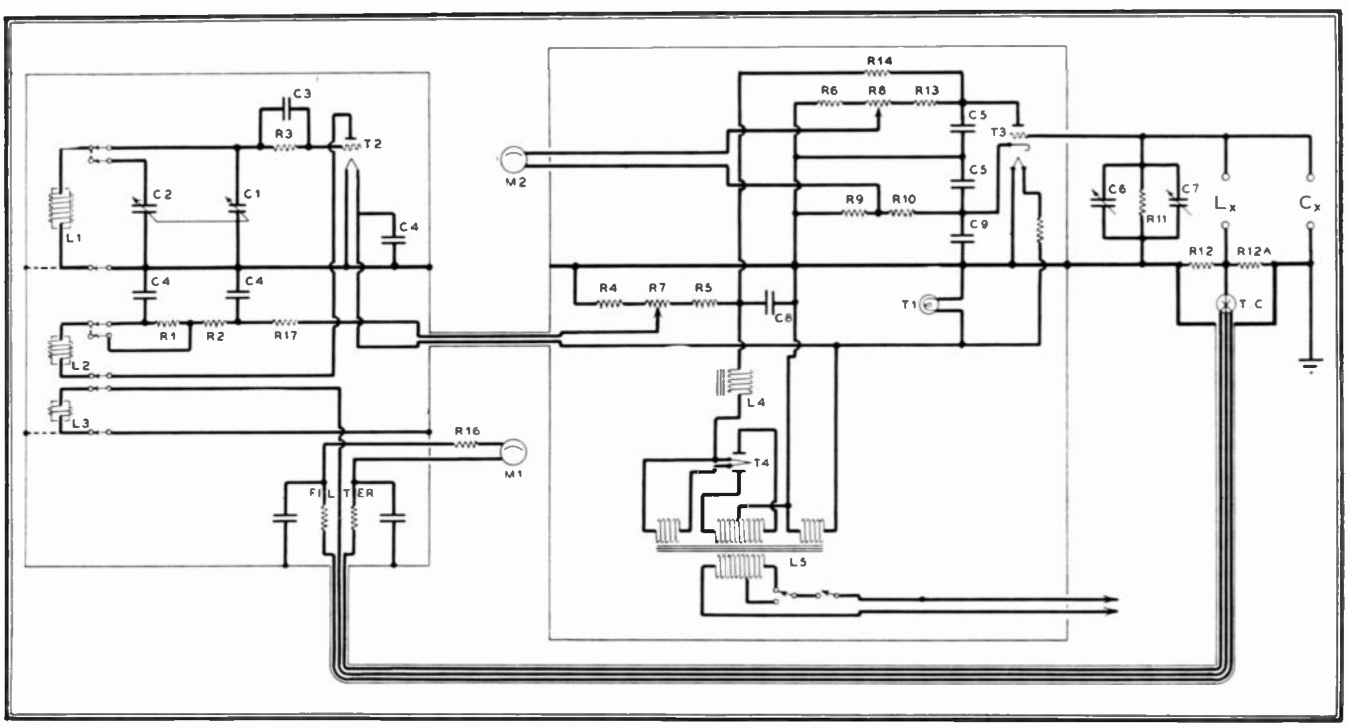
LARGE CONDENSERS

6-A: General ★ A large condenser can be measured by connecting it in series with a coil and connecting this combination to the coil terminals of the Q-Meter with the test condenser connected to the low potential side of the coil.

For this measurement a coil is required having an inductance which will resonate to the desired test frequency with the Q tuning condenser set to a high capacitance value, so that connecting and disconnecting the test condenser will produce a measurable change in the C and Q of the measuring circuit.

A resistor having a resistance of not over 10 megohms is also required which must be connected across the test condenser when it is in the Q circuit to provide a DC path for the grid bias of the vacuum tube voltmeter.

It is important when measuring large condensers to observe the precaution of including as little inductance as possible in the condenser leads during the measurements, as the internal inductance of the condenser will usually be small and even an inch or two of lead may cause a serious error. It is generally desirable to leave the condenser in the circuit and short it out at the condenser terminals



CIRCUIT CONSTANTS OF TYPE 160-A

R1	Fixed resistor	1,000 ohms
R2	Fixed resistor	200 ohms
R3	Fixed resistor	40,000 ohms
R4	Fixed resistor	3,000 ohms
R5	Fixed resistor	750 ohms
R6	Fixed resistor	200 ohms
R7	Potentiometer	8,000 ohms
R8	Potentiometer	200 ohms
R9	Fixed resistor	25,000 ohms
R10	Fixed resistor (1%)	25,000 ohms
R11	Fixed resistor	100 meg.
R12, R12A	Fixed resistor (1 unit)	.04 ohm
R13	Fixed resistor	50,000 ohms
R14	Fixed resistor	1,000 ohms
R15	Fixed resistor	.3 ohm
R16	Thermocouple calibrating resistor	
R17	Fixed resistor	100 ohms
C1	Osc. tuning condenser (small)	
C2	Osc. tuning condenser (large)	
C3	Fixed condenser	100 mmf.
C4	Fixed condenser	3,000 mmf.
C5	Fixed condenser	5,000 mmf.
C6	Q tuning condenser (main)	
C7	Q tuning condenser (vernier)	
C8	Power filter condenser	8 mfd.
C9	Fixed condenser	.1 mfd.
L1	Oscillator grid coil	
L2	Oscillator plate coil	
L3	Oscillator coupling coil	
L4	Power filter choke	
L5	Power transformer	
T1	Mazda 41, 2.5 volts	
T2	Oscillator tube	102-A
T3	Q voltmeter tube	101-A
T4	Rectifier tube	5W4
M1	Oscillator output voltmeter	
M2	Q voltmeter	
TC	Thermocouple	

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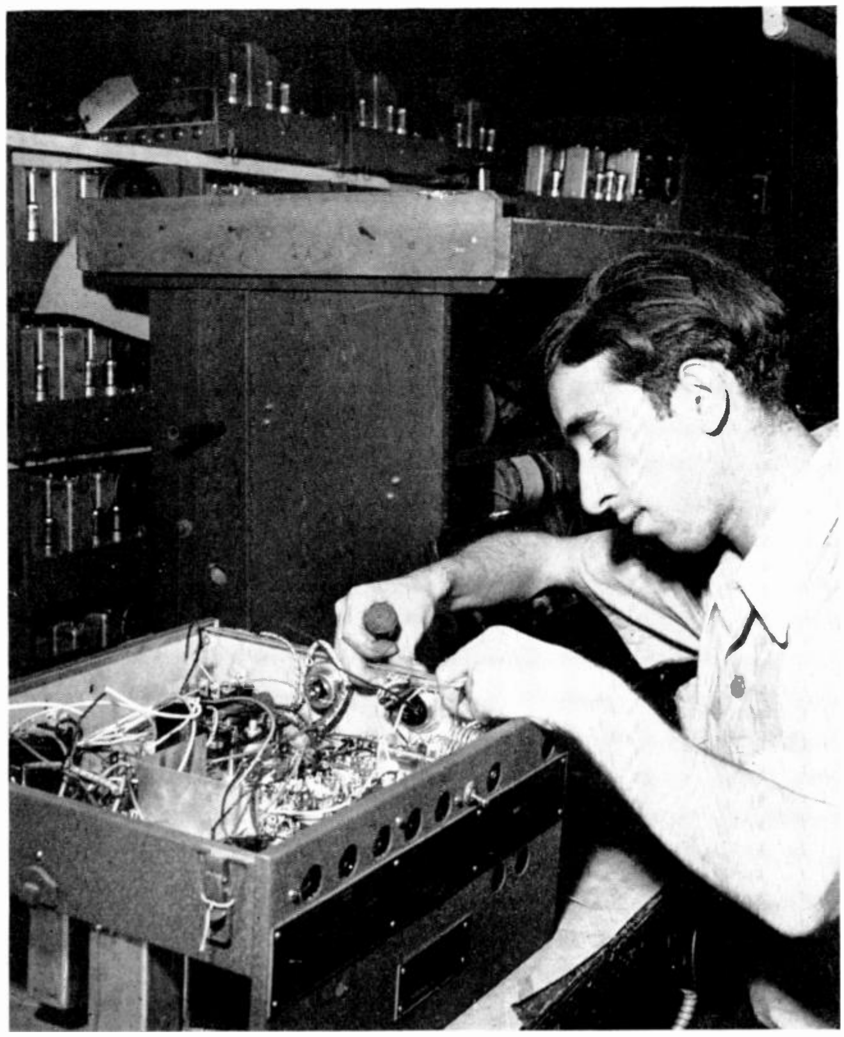


FIG. 3, LEFT, 3RD AND 4TH STAGES. FIG. 4, RIGHT, PRE-FORMED WIRING HARNESS SIMPLIFIES WIRING AT THE 5TH ASSEMBLY STAGE

The Assembly Line ★ The production line for wiring and assembling the single-unit transmitter and receiver were divided into 10 stages or positions. Each stage requires approximately one hour at our present rate of production.

The training of the men on the line required two to three weeks before they had mastered their operations completely. From the start, each man had before him a chassis finished up to the point required at his position.

For example, Fig. 1 shows the operator at the first stage, with his sample chassis on which are mounted all the parts he is required to install. Similarly, the second stage is shown in Fig. 2, and the third and fourth stages in Fig. 3.

Fig. 4 illustrates the fifth stage. Some of the finished sets can be seen in the background of this picture. The ninth stage, and the corresponding sample, are shown in Fig. 5.

The men memorized their work during the training period, so that the samples are now used only for reference, and to maintain the original standard methods and practices. Wiring or assembly mistakes are rarely found, for the men on the production line have become highly skilled.

However, to bring the errors to a still lower minimum, each man checks the work done at the preceding stage. Also, he inspects every part and sub-assembly he handles for mechanical defects.

One man, trained to do every operation required at each stage, works outside the production line. He is able to step in at any position in case one of the operators is absent.

Another man supplies parts to the line, removes finished sets, and keeps the soldering iron tips clean.

The production supervisor inspects the tools, and checks the sets on the line at random intervals, so that the men know that their work is subject to inspection at all times.

Good light, the first requisite of favorable working conditions, is supplied by fluorescent illumination. To relieve monotony, which can be so detrimental to working efficiency, music is supplied by high-fidelity FM reception. It is interesting to note that the men show a decided preference for popular selections played by well-known orchestras and for light symphonic music.

A bonus system was established shortly after production was started. This provides the advantages of piecework, without attendant evils. Each man working on the Victory model receives a bonus every payday. The amount for each man is computed from his salary and the number of sets finished during the pay week.

Testing Methods ★ As the sets reach the end of the production line, the inspector checks them carefully for mechanical faults before they are moved on to final testing.

The testing operations are divided into three stages, as follows:

1. Preliminary test.
2. Receiver, modulator, and driver performance tests.
3. Final measurements of overall performance.

When the sets reach final inspection, they have reached the stage where:

1. They are completely assembled, they have been mechanically inspected, and they are all wired except for
2. The dynamotors which are mounted but not connected, and
3. The power amplifier screen grid wiring which has not been put on.

FIG. 5, THE 9TH STAGE BRINGS THE SETS ALMOST TO COMPLETION. DESPITE COMPLICATED CIRCUITS, WIRING ERRORS ARE VERY RARE

4. The low intermediate frequency amplifiers are roughly tuned to resonance.

One man carries out the first stage of final testing, while another handles the second and third stages. The first test position is shown in the foreground of Fig. 6, with the second in the background. Fig. 7 illustrates the third and last position.

First Test Stage ★ The first tester, putting the sets through stage one, inserts all the tubes and the transmitter and receiving crystals, and connects the metering equipment. Current for the filaments and control circuits is obtained from a storage battery. High voltage is furnished by an AC-operated DC power supply.

At the right of the first test position is a sloping-top control box, at which the tester can turn the high voltage on or off, independently of the filament current.

First, the tester tunes all circuits not previously adjusted to approximate resonance by setting the slots of the trimmer condensers at their working positions. This is possible because large numbers of sets are aligned at the same frequency.

After this is done, if the set is good, the tester will have about 50% drive in the transmitter, and enough sensitivity in the receiver to proceed with the alignment from a frequency standard.

The following circuits are metered at the first test position:

1. Current and voltage output of the high-voltage power supply.
2. Receiver first limiter grid current.
3. Receiver detector current.
4. Transmitter oscillator plate current.
5. Transmitter power amplifier grid current.

With the set aligned roughly, the frequency standard is turned on. This radiates enough power at the working frequency of the receiver to enable the tester to adjust the discriminator to zero detector current. This fixes the resonant frequency of the receiver within 1,000 cycles.

The frequency standard is then turned off, and a signal generator is used for the complete alignment process.

A specially designed signal generator is connected to the second mixer grid, and its frequency is adjusted for zero detector current. The low intermediate frequency amplifiers are peaked accurately.

The signal generator frequency can be shifted by a switch to the limits of the amplifier band-pass, to check the band width of the receiver.

The final operation is to peak the transmitter multipliers accurately for maximum drive. Then the set is passed on to the second position.

Second Test Stage ★ Again, primary power is furnished by a storage battery and an AC-operated DC supply, wired through a control box. At this stage, meters are connected to the set to show:

1. Receiver first limiter grid current.
2. Receiver detector current.
3. Receiver audio output voltage.

(This is measured across the speaker voice coil. The output meter also measures the noise-suppressing ability of the set.)

4. Transmitter oscillator plate current.
5. Transmitter power amplifier grid current, at no load.

In addition, by the use of a special receiver, oscilloscope, and a beat frequency oscillator, the Armstrong phase-shift modulator in the transmitter is aligned.

The tester at the second position starts

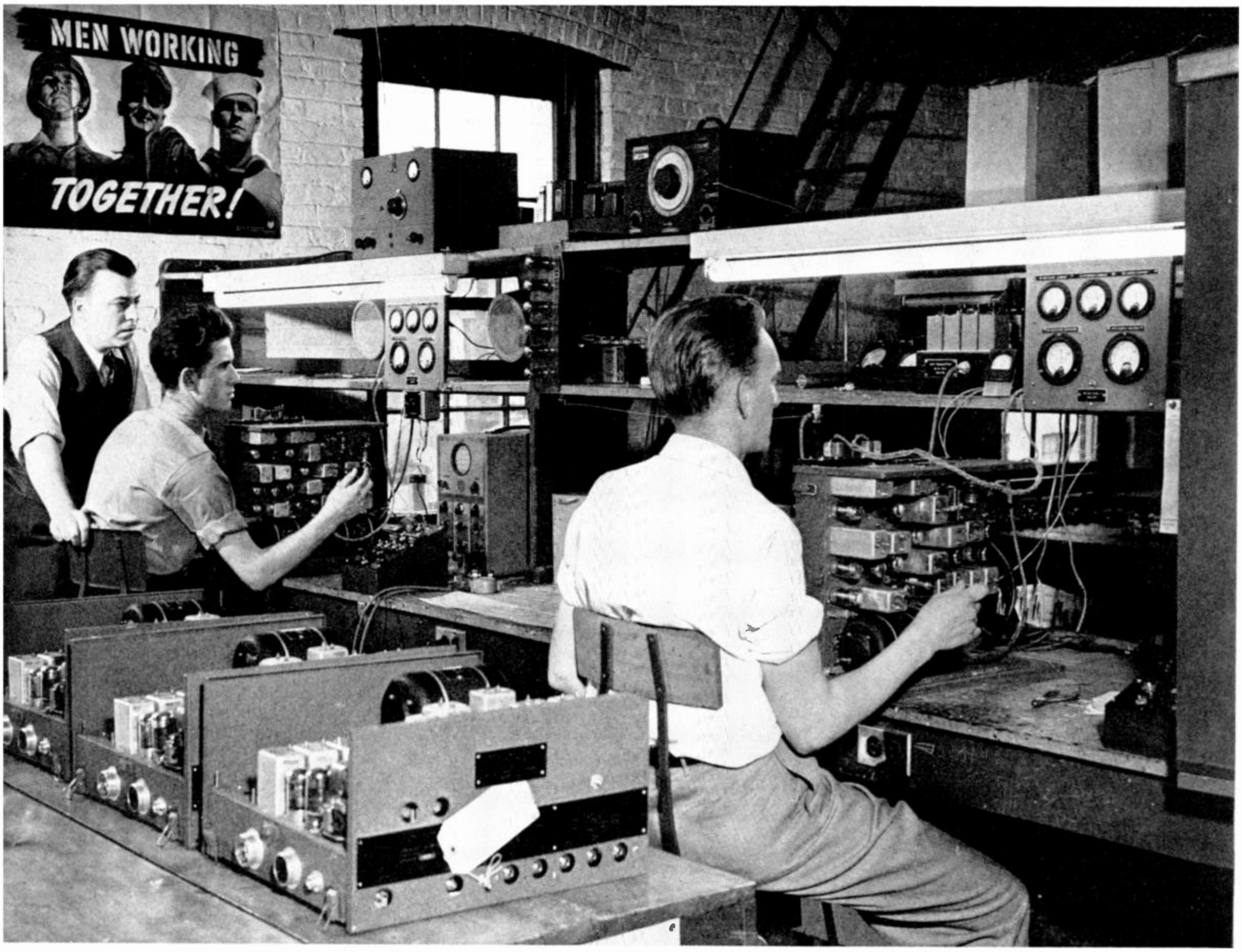


FIG. 6, RIGHT, 1ST POSITION AND, LEFT, 2ND POSITION OF FINAL TEST, WHERE CIRCUITS ARE CHECKED AND CONDENSERS ARE ALIGNED

out by connecting a signal generator to the antenna jack of the set, adjusts the generator for zero detector current, and peaks the high-frequency receiver circuits accurately.

He checks the receiver sensitivity and noise suppression by noting the zero signal first limiter current, and noise voltage across the speaker when 1 microvolt input to the receiver. The 1 microvolt signal level is established from a General Radio type 804-B signal generator.

Audio output of the receiver is measured by applying a strong phase-modulate signal to the set. The frequency swing corresponds to 100% modulation of the associated transmitter. The voltage measured across the receiver voice coil shows if the audio output of the set is up to the rated value. The final test is to check the Armstrong phase-shift modulator. A known voltage is applied to the modulator, and a receiver whose audio output is proportional to the frequency swing is used to pick up the radiated signal.

Output voltage from the receiver is applied to the vertical deflecting plates of an oscilloscope. The transmitter phasing network is adjusted to the proper wave shape, as indicated on the oscilloscope. Both wave shape and amplitude must be correct in order for a set to pass this test.

Upon completion of these tests, both the transmitter and receiver are known to be working properly, except for the transmitter RF power amplifier. At this point, the dynamotors are connected to their respective terminal boards, and the transmitter power amplifier screen grid is connected to its high-voltage source. Then it is moved to the last position, shown in Fig. 7.

Third Test Stage ★ At the third test stage, the set is clamped on a shake-table, all meters are connected, and the circuits are switched to the "receive" position. The following circuits are metered.

1. Low-voltage dynamotor current.
2. High-voltage dynamotor current.
3. Receiver first limiter current.
4. Receiver detector current.
5. Receiver audio output.
6. Transmitter oscillator plate current.
7. Transmitter power amplifier grid current. (The power amplifier plate current on this set is the high-voltage dynamotor current.)
8. High-voltage dynamotor output voltage.
9. RF power output.

A dummy antenna is used to absorb the transmitter output. It consists of a non-inductive resistance, across which a diode vacuum tube voltmeter is connected. The diode current was established at several power levels by a photometric method of direct power measurement. This dummy antenna and the control box can be seen in the foreground of Fig. 7.

While observations are being made on the meter readings, the set is being vi-

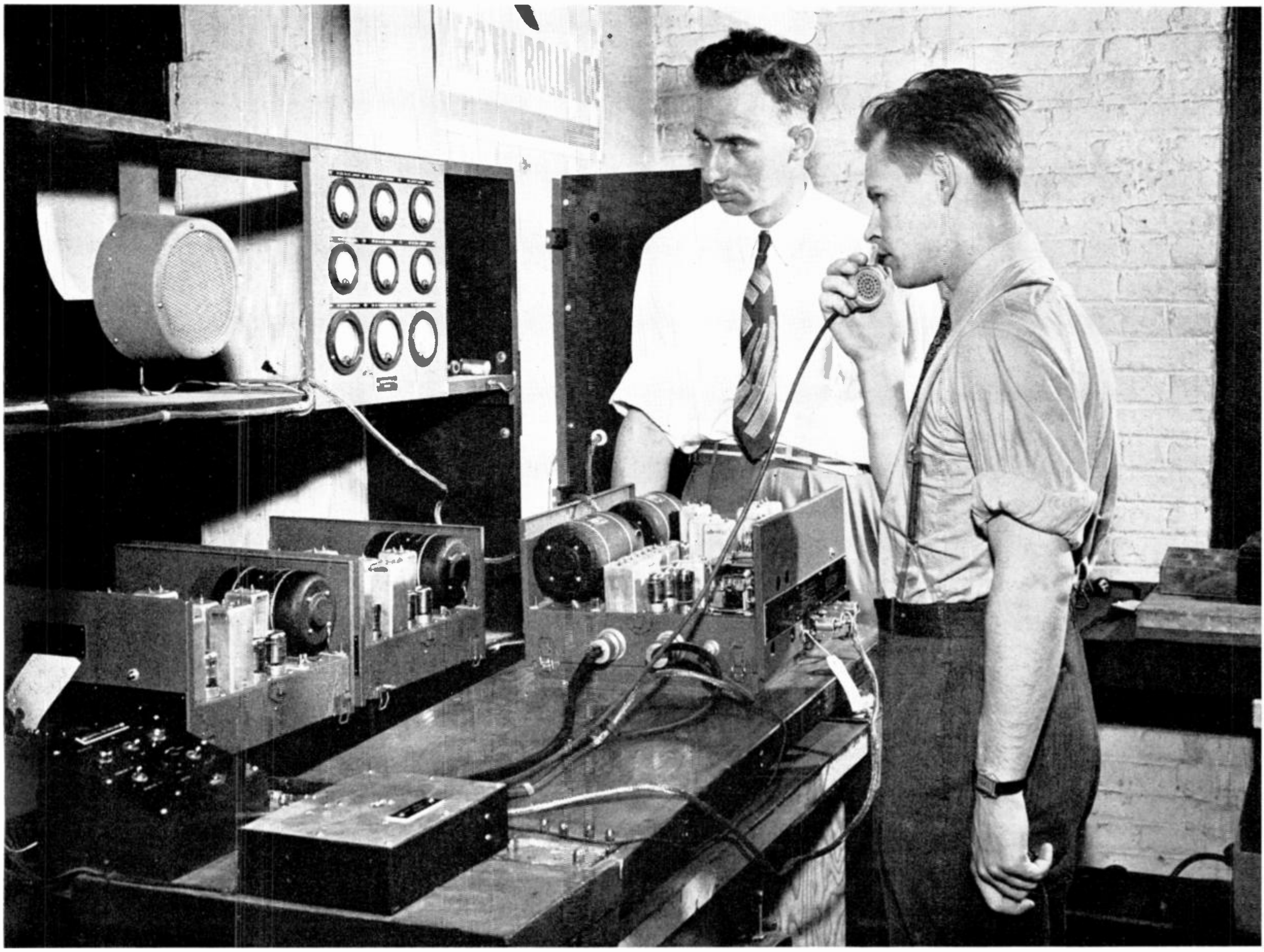


FIG. 7, CHIEF ENGINEER FRANK GUNTHER, LEFT, AND AUTHOR LESLIE NOZDROVICZKY SPOT CHECK FINISHED SET ON SHAKE-TABLE

brated on the shake-table. No variation of any of the readings is tolerated during the vibration test, and during actual operation of the transmitter and receiver the performance must be the same as if the set were at rest. Furthermore, the circuit measurements must be the same as during the second stage tests.

During this final check under vibration, which lasts about three minutes, the set is operated from a 6-volt DC supply, as it would be under service conditions.

Causes of Rejections ★ It is remarkable to see how uniformly these single-unit transmitters and receivers perform under test. Most of the rejections occur during the second and third test stages. Sets are rarely rejected for wiring errors. The recurring faults are chiefly:

1. Defective tubes.
2. Defective transmitter or receiver crystals.
3. Defective dynamotors.
4. Defective relays.
5. Failure of sockets when tubes are inserted.

About once in two weeks, a transmitter or receiver turns up that refuses to behave properly. These are given special attention by our engineering department. In every case so far, defective operation was caused by such simple faults as poor connections to the tube sockets, high resistance ground, or a coil opened up under vibration or mechanical strain.

For all tests, close limits of minimum performance have been set. The standards have been made high to allow a large factor of safety under service conditions.

A set rejected at any one of the test stages is turned over to a trained troubleshooter. After correction, the set is returned to the test stage where it was rejected, and it is checked just as if it came right off the line.

Rate of Production ★ Irregularities in the flow of materials and components are still something of a limitation on the weekly average of production. At present, a fourteen-man line, including two testers, turns out one complete unit per hour. It is estimated, however, that we shall be able to double this rate of production as time goes on.

EDITOR'S NOTE: *Complete data and circuits of the REL single-unit emergency equipment were published in the March and April, 1942, issues.*

FABRICATING MYCALEX

Mycalex is a non-critical material which can be substituted for ceramics in a very large number of applications. Although Mycalex is now used extensively, lack of knowledge concerning its fabrication is responsible for the failure of radio designers to specify it in place of ceramic materials, particularly for RF insulation. A comprehensive article on cutting, drilling, machining, and engraving Mycalex is now in preparation, and will appear in an early issue of RADIO-ELECTRONIC ENGINEERING.

SPOT NEWS NOTES

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

"FM": will probably be the nickname of Frank Madden Gunther, born June 16th. His father is Frank A. Gunther, vice president in charge of engineering at REL, and squadron leader in the Civil Air Patrol. Mrs. Gunther is also a CAP pilot, and both have commercial flying tickets. Before Pearl Harbor, they operated W2FQD.

Hotels Stevens & Congress: Break all radio convention records, and will continue to do so for the duration of the War. They have been taken over by the Navy as radio school barracks.

Expansion: Benwood-Linze Company, of St. Louis, engineers and manufacturers of rectifiers and associated equipment, have bought the Fore Electric Company, including their equipment, inventory, assets, and name. Fore Electric, founded in 1917, produced battery chargers, magnetizers, transformers, and electric meters. Albert Wehmeier, Fore president, will retire. Benwood-Linze will continue to produce Fore products and replacement parts.

Benay Venuta: Is more succinct than Chairman Fly. In "By Jupiter," starring as Queen of the Amazons, she cries out at her opposition: "Your attitude stinks."

Soldering Irons: Complete series for all kinds of radio production work is shown in new catalog from Hexacon Electric Company, Roselle Park, N. J.

Television: Construction permit has been issued to Balaban & Katz for a new commercial station on channel 3 (66 to 72 mc.) to be completed August 15, 1942.

David Grimes: Veteran of World War I, radio pioneer, and chief engineer at Philco since 1939 has been elected a vice-president of the Philco Corporation.

Concentric Cable: Now approved for war equipment, Copolene cable is demonstrating advantages over stranded-wire-and-bead construction, chiefly because it uses a continuous tube of insulation which does not introduce increase of electrical loss. It is manufactured by Amphenol and Simplex Wire.

New FM Station: W49BN, Rochester, N. Y., is now on the air with a 3-kw. REL transmitter bought BF. Single vertical coaxial antenna is carried by a 107-ft. wooden mast erected on a hill 1,700 ft. above sea level. An important gap in the FM network is filled by W49BN, since it is 120 miles from Alpine and the same distance from W51R, at Rochester, N. Y.

Leo Freed: One of the busiest representatives in the radio industry looked like this back in the days when the business was like what it isn't going to be for quite a long time to come.

James Lawrence Fly: His nomination to the FCC has been approved by the Senate. This will be his first full term of 7 years. He was first sworn in as a member of the Commission on September 4, 1939, to finish the uncompleted term of Frank R. McNinch, who retired because of illness.

Ignition Noise Suppression: Army's problem of suppressing ignition interference may lead to compulsory suppressor equipment on all cars after the War. Delmar G. Roos, chief engineer of Willys-Overland, directing interference research project in coöperation with the Signal Corps, announces that standard devices have now been developed for all motorized units. Test booths now in use make it possible to install and check suppressor equipment in 3 minutes.

Microphones: Of all types for communications and broadcast studio use are shown in a new catalog issued by Shure Brothers, 225 West Huron Street, Chicago. Also illustrated are stands, fittings, pickups, and recording heads.

Amateur Transmitters: All must be registered with the FCC by August 25th. Forms can be obtained from the Commission's headquarters at Washington, or from FCC field offices. This action has been taken at request of the Board of War Communications. Order applies not only to holders of amateur licenses but to any person or organization in possession of an amateur transmitter. In addition, FCC requests every licensed amateur who neither owns nor possesses a transmitter to notify the Commission of the fact, and to give his present address, as well as any subsequent change of address within five days.

In the Armed Forces: Check-up shows that 894 men and one woman have left NBC and 85 outlets to go into the Service. From NBC headquarters alone, 226 employees have gone since December 7th. The one woman, from WROL, was probably the first in radio to enlist in the WAAC.

Norman Guimond: Resigned as radio engineer of Massachusetts State Police to become chief engineer of WOCB, West Yarmouth, Mass.

Suspicion Confirmed: Ever since the advent of all-wave receivers, short-wave tuning has been an important point-of-sale factor in broadcast sets. Unknown factor was actual use of the short-wave bands by radio listeners in the USA. An investigation made recently shows that, while one-third of sets in use can tune in foreign broadcasts, less than one per cent of listeners ever listen on the short-wave bands. Most of these are probably foreign-language speaking residents in the USA who prefer to hear their native tongues.

Harry Houck: Now vice president and general manager of Measurements Corporation, Booton, N. J.

Spokane: Morris H. Willis, president of Spokane Radio Company, Inc., celebrated the 15th anniversary of his concern by holding open house at the new quarters on West Sprague Street where his jobbing and manufacturing activities are combined under one roof. This company, serving broadcast stations, Government agencies and industrial laboratories from California to Alaska, has now spread out into the electronic field to a considerable extent.

Dynamotors: Among the additions to the Radio-Electronic Products Directory in this issue is a complete list of companies manufacturing dynamotors for mobile and aircraft radio equipment. Some of the names, including three vacuum cleaner concerns, are entirely new among radio manufacturers.

FM Reception: Carl H. Wesser, chief engineer of W45D, reports that on June 10th he logged FM stations on 19 channels, including New York and New England transmitters, between 7:00 P.M. and 8:45 P.M. On that day, W47NV came in steadily from noon until evening. His station was snowed under with calls from local listeners who wanted to know why they were hearing stations outside the local area.

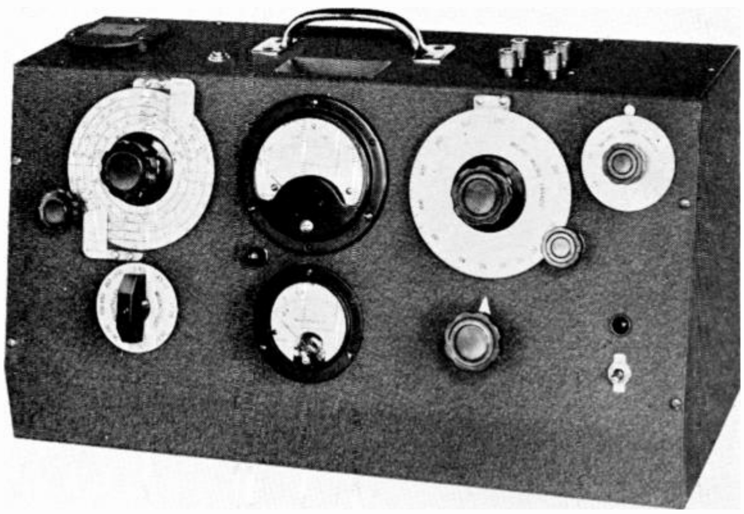
Tube Data: A very comprehensive technical manual on radio receiving tubes has been issued by General Electric Company, and is now available through the Renewal Tube Sales Section at Bridgeport, Conn. Twenty-four pages of illustrations and data are planned to assist engineers and experimenters engaged in the design of vacuum tube circuits. At first glance, the number of tube types seems bewildering, but the arrangement is clear and easy to understand.

PHOTO BY U. S. ARMY SIGNAL CORPS

NEWS PICTURE

Men in Training: In cities and towns throughout the nation, more and more radio and service shops are displaying signs which read: "Closed for Duration of War." Still, if every radio dealer, serviceman, and amateur volunteered and was accepted, the needs of our Armed Forces would not be met entirely.

Our Army, Navy, Marine Corps, Coast Guard, and Merchant Marine are operating splendid radio schools, staffed by able instructors. This training will be of great advantage and will lend much prestige when peace comes, for the men who take advantage of this opportunity will be prepared to take part in radio and television activities which will dwarf the growth of the industry after the last War. — Photo above was taken at one of the U. S. Signal Corps Radio Schools.



TYPE 160-A BOONTON Q METER HAS 8 RANGES, COVERING 50 KC. TO 75 MC.

THE FACTOR Q

Part 2: Additional Data on Q Measurements, and Details of the Types 160-A and 170-A Q Meters*

SMALL CONDENSERS

4-A: General ★ Measurements of the capacitance and Q, or power factor, of small condensers can be made with the Q-Meter if the capacitance of the test condenser is within the ΔC range of the Q tuning condenser of the Q-Meter. The accuracy with which such measurements can be made is dependent on the capacitance, inductance, and Q of the test condenser, the frequency of measurement, and the technique employed. In general, the accuracy of capacitance measurements is within $\pm 2\%$, and the accuracy of Q measurements is within $\pm 10\%$. Under certain conditions greater accuracies can be obtained. In the higher frequency region (above 30–40 mc. with the type 160-A) the accuracy of the Q and C measurement will decrease.

Above a few megacycles, the inductance and resistance of leads connecting the condenser posts of the Q-Meter and the test condenser proper become increasingly important and accordingly should be made of short, wide conducting strip.

If the capacitance of the condenser is small, i.e., a few micro-microfarads, the capacitance of the leads may become comparable to that of the test condenser, and may require correction.

The internal inductance of condensers and their leads becomes more and more important with increasing frequency. This is indicated by an increase in the apparent capacitance of the condenser. A 1,000 $\mu\mu$f condenser will resonate at 50 mc. with an inductance of .01 μhy, a 100 $\mu\mu$f condenser will resonate at 160 mc. with .01 μhy. The increase in apparent capacitance of the condenser will be evident at frequencies considerably below the resonant frequency.

The accuracy of measuring the Q of a component such as a condenser when it is connected in parallel with the Q circuit is also related to its effect on the Q of the Q circuit. A consideration of the equations from which the Q or resistance of the component is calculated indicates that the accuracy of this measurement will increase as the ΔQ (i.e., $Q_1 - Q_2$) increases. However, since the accuracy of the Q Voltmeter calibration is a function of full scale reading, it is obvious that very low Q_2 readings may be inaccurately indicated and that an optimum operating region will exist which is determined by the values involved. From a practical viewpoint, it will be found that most condensers can be measured with greater accuracy when they are closely coupled to the measuring circuit, i.e., when their capacitance is a large percentage of the total circuit capacitance. Condensers with very poor dielectric are the exception and the measuring technique must be modified to fit the conditions. With such condensers, the C_2 setting of the Q condenser should be increased until the Q_2 value can be read accurately.

Measuring Technique ★ Experience has shown that, in general, the most accurate method of determining the capacitance, the Q, the series and the parallel resistance of a condenser is as follows:

1. Connect the test condenser to the Q-Meter observing the precautions previously mentioned.
2. Set the Q tuning condenser to some convenient low capacitance value, such as 30 $\mu\mu$f. Record this as C_2.
3. Select a coil which will resonate with the capacitance of the test condenser, plus the capacitance setting of the Q tuning condenser to the desired frequency of measurement.
4. Adjust the oscillator frequency to resonate the Q circuit. Fine adjustment may be made with the vernier Q condenser, changing this by perhaps a few tenths of a micro-microfarad.
5. Record the circuit Q reading as Q_2.
6. Remove the test condenser.
7. Retune the Q circuit, noting the circuit Q at resonance. Record the Q condenser setting as C_1 and the circuit Q reading as Q_1. An average curve drawn through a number of measurements, especially if fairly closely spaced over a frequency range will further increase the accuracy of this measurement.

4-B: Capacitance ★ The capacitance of the test condenser is:

$$C_p = C_1 - C_2 \qquad (26b)$$

The value of C_p thus obtained is the effective parallel capacitance of the test condenser. The difference between this value and effective series capacitance is negligible for condensers having a Q greater than about 10, which will be the case for most small condensers used in radio circuits. When the Q of a condenser or an impedance is 10 or less, the effective series capacitance may be determined as described in section 1-B, Part 1.

It is important, especially when measuring very small capacitances, that the measurement excludes the capacitance of leads to the test condenser. This may readily be accomplished by connecting suitable leads to the Q-Meter before making the initial resonance setting of the Q circuit, and connecting the test condenser at the end of the leads, taking care not to change the position of the leads during the measurement.

One very useful feature of the above method is that it provides a relative indication of losses in the test condenser simultaneously with the capacitance measurement, as indicated by the drop in Q of the Q circuit when the test condenser is connected.

For capacitance measurements of greater accuracy than this method provides, the following method should be used.

* Part 1 of this article appeared in RADIO-ELECTRONIC ENGINEERING for May, 1942. This data was prepared by the Engineering Department of the Boonton Radio Corporation, Boonton, N. J.

4-C: Accurate Capacitance Measurements Using External Condenser ★ By the use of a calibrated standard precision condenser in conjunction with the *Q*-Meter, the capacitance of small condensers can be measured with a high degree of accuracy which is limited generally only by the accuracy of calibration of the standard condenser, since the accuracy of setting the condenser is generally greater than the accuracy of calibration.

To measure capacitances using an external condenser, this condenser should be connected to the condenser terminals of the *Q*-Meter, and the same general procedure described above in section 4-B should be followed except that all capacitance settings and observations should be made with the external condenser instead of the *Q* tuning condenser. The following additional precautions should be taken:

The length of leads required to connect a large condenser to the *Q*-Meter, together with the internal inductance of such a condenser, limit the maximum frequency of accurate measurement to the region of 500 kc. It is advisable to set the frequency of measurement in the neighborhood of 200 kc. to permit using leads up to about a foot in length. This frequency requires a coil for use in the *Q* circuit having an inductance in the region of 1 or 2 millihenries (see section 2-A, Part 1).

All leads used should be fairly rigid and well supported to avoid accidental changes in circuit capacitance, especially when measuring small capacitances. Connections to the test condenser should be made at the condenser terminals to exclude lead capacitances from the measurement. The test condenser should be connected directly to the standard condenser.

4-D: Power Factor and Q ★ The power factor, *Q*, and resistance of small condensers having *Q*'s of less than about 2,000 to 6,000 (power factors greater than about 0.015 to 0.05 per cent) can be measured with the *Q*-Meter.

The maximum *Q* that can be measured depends on the capacitance of the test condenser and the *Q* of the *Q* circuit. The measurement of *Q* requires measuring the drop in *Q* of the *Q* circuit when the condenser is connected across the circuit and this decrease in *Q* becomes smaller as the *Q* of the test condenser becomes large compared to the *Q* of the *Q* circuit and also as the capacitance of the test condenser becomes smaller. It is apparent, therefore, that when the *Q* of the test condenser is high enough it will not produce a measurable difference in the *Q* of the *Q* circuit and therefore its *Q* or resistance cannot be measured.

In general, the *Q* of commonly used mica or other solid dielectric condensers, air dielectric condensers with poor insulation, etc., may be measured. However, good air dielectric condensers usually have a *Q* too high to be measured.

The general precautions described in sections 4-A and 4-B should be observed in measuring power factor or *Q*. The *Q* of the test condenser, Q_x, is

$$Q_x = \frac{(C_1 - C_2)\, Q_1 Q_2}{C_1\,(Q_1 - Q_2)} \qquad (39)$$

The power factor of the test condenser in per cent (for values less than about 10%) is:

$$\text{Power Factor} = \frac{100}{Q_x} = \frac{100\, C_1 (Q_1 - Q_2)}{(C_1 - C_2)\, Q_1 Q_2} \qquad (40)$$

4-E: Resistance ★ The resistance of a small condenser having a *Q* of less than about 2,000 to 6,000 may be determined by following the procedure described in the preceding section 4-D, i.e., obtaining the values of *Q* circuit tuning capacitance and *Q*, C_1 and Q_1 without the test condenser connected, and C_2 and Q_2 with the test condenser connected and the frequency of measurement, *f*.

The effective parallel resistance, R_p, of the test condenser is:

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

This formula is accurate for condensers or impedances having any *Q*.

The effective series resistance, R_s, for condensers having a *Q* of more than about 10 is:

$$R_s = \frac{1.59 \times 10^8\, C_1\,(Q_1 - Q_2)}{f\,(C_1 - C_2)^2\, Q_1 Q_2} \qquad (27b)$$

The effective series or parallel resistance of condensers or impedances having a *Q* of 10 or less may be determined by the method described in section 1, Part 1.

If the effective series capacitance, C_s, and the *Q*, Q_x, of the test condenser are known the effective series resistance, R_s, is:

$$R_s = \frac{1.59 \times 10^8}{f C_s\, Q_x} \qquad (41)$$

INSULATING MATERIALS

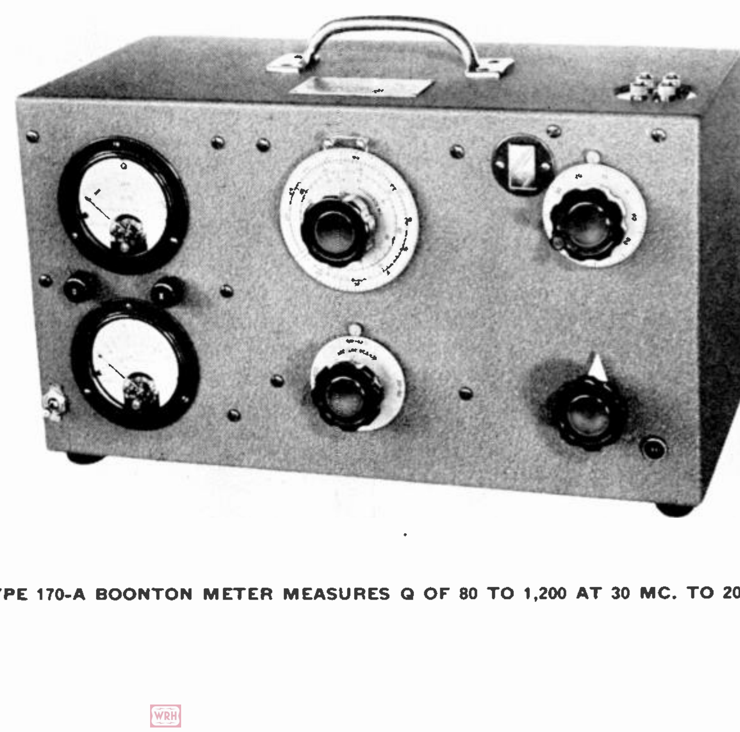
5-A: General ★ The fundamental properties of interest in connection with insulating materials are the dielectric constant ϵ and the losses as expressed by *Q* or power factor. These quantities may be determined for most insulating materials by making a condenser out of a sample of the material and measuring this condenser as described in the preceding section 4.

Thin sheets of insulating material are most convenient for this purpose and may be provided with tin foil conducting surfaces by applying a thin film of vaseline (or similar material having low losses) to the sample of insulating material and pressing and rubbing the tin foil into close contact with the sample, excluding all air pockets. Connections to the tin foil surfaces may be made by means of two copper or brass strips or heavy wires attached to the *Q*-Meter condenser terminals, and shaped so that they make contact with the tin foil when the prepared sample is placed between these connecting leads. The contact surfaces should be kept clean.

Mercury electrodes can be used by means of the conventional method of floating the sample on the surface of mercury contained in a suitable dish, placing a metal ring (or rectangle) on top of the sample and filling inside the ring with mercury. Suitable leads should be provided for connecting the mercury electrodes to the *Q*-Meter.

Oils or other fluids require a cell or container with suitable electrodes between which the fluid to be measured can be placed.

In any case, in order to reduce edge effects, the area of the active dielectric between the electrodes should be large compared to the thickness of the dielectric. The sample condenser should be



TYPE 170-A BOONTON METER MEASURES Q OF 80 TO 1,200 AT 30 MC. TO 200 MC.

dimensioned so that its capacitance does not exceed the ΔC available in the Q tuning condenser.

5-B: Dielectric Constant ★ To determine the dielectric constant, ϵ, of a sample of insulating material: Prepare it as described above, and measure its capacitance according to the method given in section 4-B, and call this value C. Measure the area of the active dielectric contained between the electrodes calling this value S, and measure the average thickness of the active dielectric calling this value t. When C is in micro-microfarads and S and t are in inches, the dielectric constant is:

$$\epsilon = \frac{4.45\,Ct}{S} \qquad (42)$$

When S and t are measured in centimeters, the dielectric constant is:

$$\epsilon = \frac{11.3\,Ct}{S} \qquad (43)$$

5-C: Power Factor and Q ★ To determine the power factor or Q of a sample of insulating material, the sample should be prepared as described above, and then measured as a small condenser as described in section 4-D. For convenience, the formulas are repeated here:

If C_1 and Q_1 are the capacitance and Q of the Q circuit at resonance with the sample not connected, and C_2 and Q_2 are the capacitance and Q of the circuit with the sample connected, then the Q of the insulating material is:

$$Q_x = \frac{(C_1 - C_2)\,Q_1 Q_2}{C_1\,(Q_1 - Q_2)} \qquad (39)$$

The power factor in per cent (for values less than about 10%) is:

$$\text{Power Factor} = \frac{100}{Q_x} = \frac{100\,C_1\,(Q_1 - Q_2)}{(C_1 - C_2)\,Q_1 Q_2} \qquad (40)$$

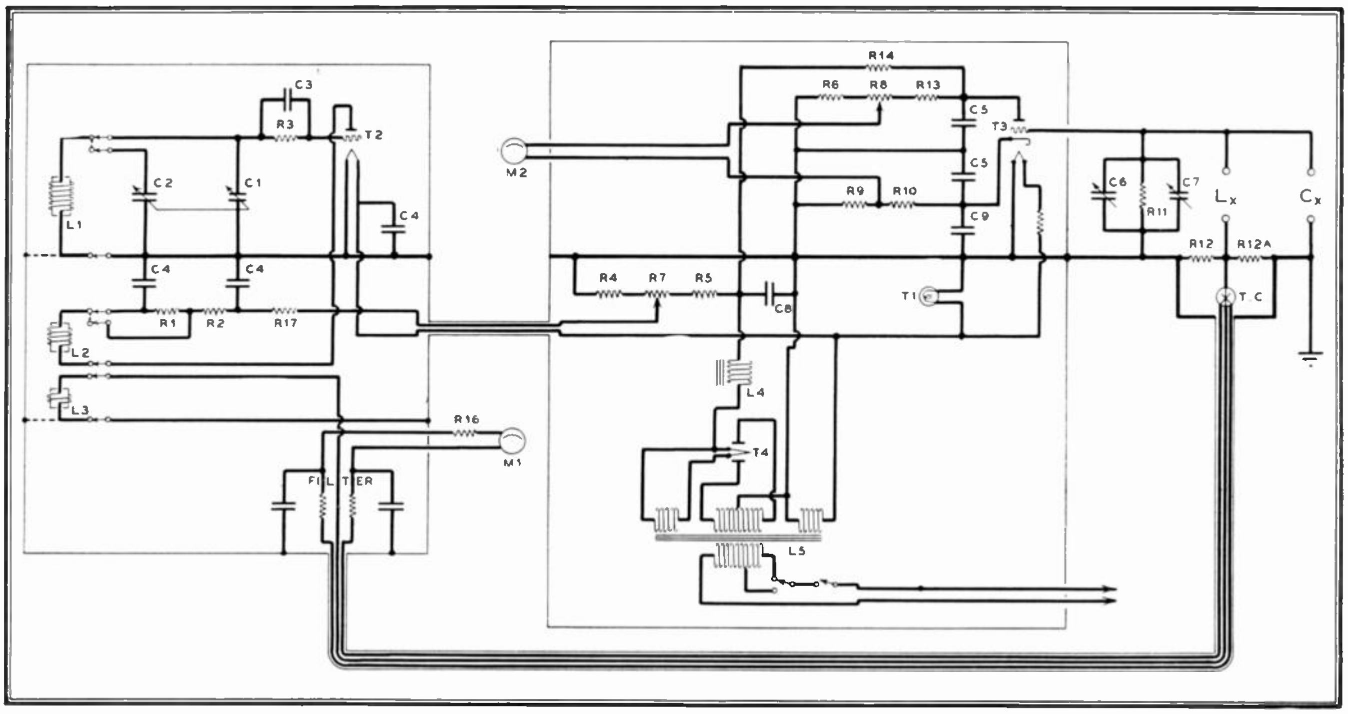
LARGE CONDENSERS

6-A: General ★ A large condenser can be measured by connecting it in series with a coil and connecting this combination to the coil terminals of the Q-Meter with the test condenser connected to the low potential side of the coil.

For this measurement a coil is required having an inductance which will resonate to the desired test frequency with the Q tuning condenser set to a high capacitance value, so that connecting and disconnecting the test condenser will produce a measurable change in the C and Q of the measuring circuit.

A resistor having a resistance of not over 10 megohms is also required which must be connected across the test condenser when it is in the Q circuit to provide a DC path for the grid bias of the vacuum tube voltmeter.

It is important when measuring large condensers to observe the precaution of including as little inductance as possible in the condenser leads during the measurements, as the internal inductance of the condenser will usually be small and even an inch or two of lead may cause a serious error. It is generally desirable to leave the condenser in the circuit and short it out at the condenser terminals



CIRCUIT CONSTANTS OF TYPE 160-A

R1 Fixed resistor . . . . 1,000 ohms
R2 Fixed resistor . . . . 200 ohms
R3 Fixed resistor . . . . 40,000 ohms
R4 Fixed resistor . . . . 3,000 ohms
R5 Fixed resistor . . . . 750 ohms
R6 Fixed resistor . . . . 200 ohms
R7 Potentiometer . . . . 8,000 ohms
R8 Potentiometer . . . . 200 ohms
R9 Fixed resistor . . . . 25,000 ohms
R10 Fixed resistor (1%) . . . . 25,000 ohms
R11 Fixed resistor . . . . 100 meg.
R12, R12A Fixed resistor (1 unit) . . . . .04 ohm
R13 Fixed resistor . . . . 50,000 ohms
R14 Fixed resistor . . . . 1,000 ohms
R15 Fixed resistor . . . . .3 ohm
R16 Thermocouple calibrating resistor
R17 Fixed resistor . . . . 100 ohms
C1 Osc. tuning condenser (small)
C2 Osc. tuning condenser (large)
C3 Fixed condenser . . . . 100 mmf.
C4 Fixed condenser . . . . 3,000 mmf.
C5 Fixed condenser . . . . 5,000 mmf.
C6 Q tuning condenser (main)
C7 Q tuning condenser (vernier)
C8 Power filter condenser . . . . . . 8 mfd.
C9 Fixed condenser . . . . .1 mfd.
L1 Oscillator grid coil
L2 Oscillator plate coil
L3 Oscillator coupling coil
L4 Power filter choke
L5 Power transformer
T1 Mazda 41, 2.5 volts
T2 Oscillator tube 102-A
T3 Q voltmeter tube 101-A
T4 Rectifier tube 5W4
M1 Oscillator output voltmeter
M2 Q voltmeter
TC Thermocouple

with a heavy copper jumper without changing the position of any leads when measuring the circuit without the condenser. This will reduce errors due to lead inductance to a minimum.

6-B: Capacitance and Inductance ★ The effective capacitance of condensers up to about 0.1 or 0.2 μf can be measured by resonating the Q circuit by means of the Q tuning condenser, first without the test condenser (or with the test condenser shorted out), then with the test condenser in series with the low potential side of the coil. Small changes in tuning capacitance may be read on the vernier condenser dial. The two readings of tuning capacitance of the Q circuit should be recorded.

Let C_1 represent the tuning capacitance setting without the test condenser, and C_2 the tuning capacitance with the test condenser connected in series with the coil. Then the effective series capacitance, C_s, of the test condenser is:

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

If C_1 is larger than C_2, the effective reactance of the test condenser is inductive and its effective series inductance, L_s, is

$$L_s = \frac{2.53 \times 10^{10}}{f^2} \; \frac{(C_1 - C_2)}{C_1 C_2} \qquad (25a)$$

or if the effective inductance, L_1, of the coil used in the Q circuit is known, the effective series inductance, L_s, of the test condenser is:

$$L_s = L_1 \frac{(C_1 - C_2)}{C_2} \qquad (44)$$

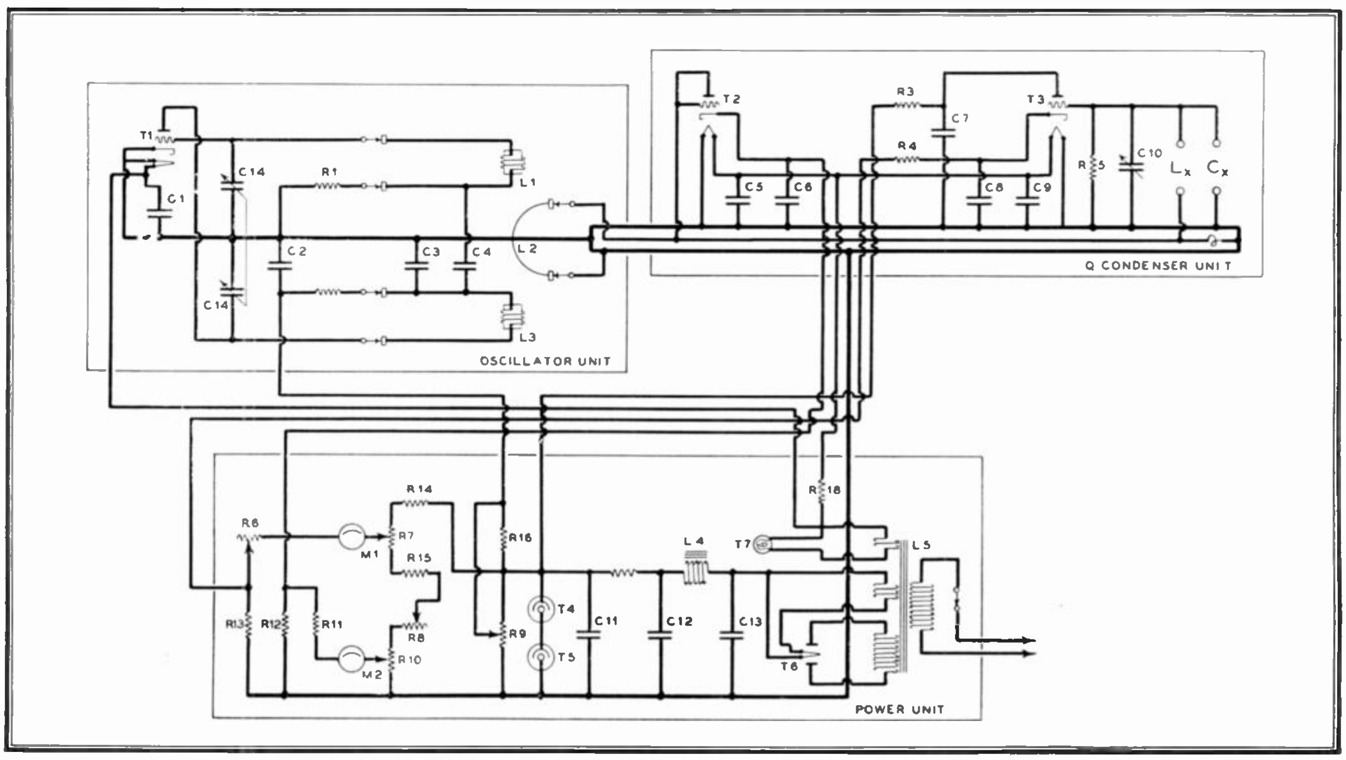
At the resonant frequency of the condenser $C_1 = C_2$ and the condenser is effectively a non-reactive resistance. The effective resistance can be determined as described below.

6-C: Resistance, Power Factor and Q ★ The effective resistance, power factor and Q of a limited range of large condensers can be measured with the Q-Meter by connecting the condensers in series in the Q circuit when such condensers have losses great enough to lower the Q of the Q circuit appreciably. For example, the Q of a test condenser having a capacitance of about 400 $\mu\mu$f may be measured when the Q of the test condenser is less than about 2,000. If the test condenser capacitance is about 4,000 $\mu\mu$f, its Q may be measured when it is not over about 300, and for larger condensers the maximum Q that can be measured is correspondingly lower.

The Q of the test condenser, Q_x, is:

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

The power factor of the test condenser in per cent for values less than about 10 per cent is the reciprocal of Q times 100, or:



CIRCUIT CONSTANTS OF TYPE 170-A

R1 Fixed resistor, 2 watts . . . 5,000 ohms
R2 Fixed resistor, ½ watt . . 1,000 ohms
R3 Fixed resistor, ½ watt . . 1,000 ohms
R4 Fixed resistor, ½ watt . . 1,000 ohms
R5 Fixed resistor, ⅓ watt . . . . 3 meg.
R6 Potentiometer, 3 watts . 7,500 ohms
R7 Potentiometer, 3 watts . . . 200 ohms
R8 Potentiometer, 3 watts . 1,000 ohms
R9 Potentiometer, 50 watts . 8,000 ohms
R10 Potentiometer, 3 watts . . . 200 ohms
R11 Fixed resistor, ½ watt . 25,000 ohms
R12 Fixed resistor, ½ watt . 25,000 ohms
R13 Fixed resistor, ½ watt . 25,000 ohms
R14 Fixed resistor, 10 watts . 40,000 ohms
R15 Fixed resistor, ½ watt . . 1,200 ohms
R16 Fixed resistor, 10 watts . 15,000 ohms
R17 Fixed resistor, 10 watts . . 1,500 ohms
R18 Fixed resistor, 2 watts . . . . 8 ohm
C1 Fixed mica condenser . . . . . 250 mmf.
C2 Fixed mica condenser . . . . . 250 mmf.
C3 Fixed mica condenser . . . 1,000 mmf.
C4 Fixed mica condenser . . . 1,000 mmf.
C5 Fixed mica condenser . . . . . 250 mmf.
C6 Fixed mica condenser . . . . . 250 mmf.
C7 Fixed mica condenser . . . . . 500 mmf.
C8 Fixed mica condenser . . . . . 500 mmf.
C9 Fixed mica condenser . . . . . 250 mmf.
C10 Q tuning condenser
C11, C12, C13 Electrolytic, each section . . . . 4 mfd.
C14 Oscillator tuning condenser
T1 Oscillator tube (calibrated) HY-615
T2 Q unit tube (calibrated) 955
T3 Q unit tube (calibrated) 955
T4 Voltage regulator tube . . VR-105 30
T5 Voltage regulator tube . . VR-105 30
T6 Rectifier tube 5W4
T7 Mazda 46, 6 volts
L1 Oscillator grid coil
L2 Oscillator coupling coil
L3 Oscillator plate coil
L4 Power filter choke
L5 Power transformer

Power Factor =

$$\frac{100}{Q_x} = \frac{100\,(C_1Q_1 - C_2Q_2)}{(C_2 - C_1)\,Q_1Q_2} \qquad (45)$$

The effective series resistance, R_s, of the test condenser is:

$$R_s = \frac{1.59 \times 10^8 \left(\frac{C_1}{C_2} Q_1 - Q_2\right)}{fC_1 \qquad Q_1Q_2} \qquad (23a)$$

6-D: Impedance ★ To determine the impedance of a large condenser, first measure its effective series resistance, R_s, as described in the preceding section 6-C. Then calculate the effective series reactance, X_s, of the test condenser from the values of C_1, C_2, and f obtained in the resistance measurement, as follows:

$$X_s = \frac{1.59 \times 10^8\,(C_2 - C_1)}{f \qquad C_1C_2} \qquad (24a)$$

If the reactance of the condenser is inductive use $C_1 - C_2$ in place of $C_2 - C_1$. If the effective series capacitance, C_s, or inductance, L_s, of the test condenser has already been determined, its reactance can be calculated by means of one of the following formulas:

$$X_s = \frac{1.59 \times 10^8}{fC_s} \qquad (46)$$

$$X_s = 6.28 \times 10^{-3}\,fL_s \qquad (47)$$

The impedance, Z_x, of the test condenser may then be calculated from the values of resistance, R_s, and reactance X_s, just determined as follows:

$$Z_x = \sqrt{R_s^2 + X_s^2} \qquad (48)$$

6-E: Bypass Condensers ★ Bypass condensers having capacitances not too high can be measured according to the preceding sections 6-A to 6-D. In many cases, however, it may be unnecessary to measure the constants of a condenser. When a bypass condenser is used in series in a tuned circuit, the effect of its resistance on the Q of the circuit and its reactance on the tuning of the circuit can be observed directly by connecting an equivalent circuit to the Q-Meter with the bypass condenser in series with the coil, and observing the change in circuit Q and tuning capacitance when the bypass condenser is shorted out. The bypass condenser should be shunted by a resistance of not over 10 megohms for this test.

The difference in Q tuning condenser settings indicates the relative reactance of the test condenser and whether its reactance is capacitive or inductive. (See section 6-B.) The change in circuit Q shows directly the lossing effect of the bypass condenser on the circuit.

The same general precautions for measuring large condensers described in the preceding sections 6-A and 6-B should be observed.

RESISTORS

7-A: General ★ The effective resistance of resistors that are comparable to either the series or the anti-resonant resistance of a tuned circuit resonated to the frequency of measurement, may be measured with the Q-Meter at frequencies up to about 30–40 mc. by connecting the resistors in series or parallel with the Q circuit of the Q-Meter. In general, two ranges of resistance can be measured; a range of low values comparable to the series resistance of the tuned circuit and a range of high values comparable to the anti-resonant resistance of the circuit. Both ranges decrease in value with increasing frequency.

For example, at 1,000 kc., a resonant circuit having a Q of about 200 and C of about 100 $\mu\mu$f, has a series resistance of about 8 ohms, and an anti-resonant resistance of about 300,000 ohms. Using this circuit, resistors connected in series with the tuned circuit having values from about 1 to 30 ohms, and resistors connected in parallel with the circuit having values from about 100,000 ohms to 3 megohms may be measured.

At 10 mc., a similar circuit would have 1/10 these values of resistance and the corresponding ranges of resistances that can be measured are about 0.1 to 3 ohms and 10,000 to 300,000 ohms.

Within these limitations the effective resistance of resistors can be determined as follows:

7-B: Low Resistance in Series with Q Circuit ★ Connect to the coil terminals of the Q-Meter a suitable coil having an inductance that will resonate to the desired frequency of measurement with a convenient tuning capacitance. (See section 2-A, Part 1.) Set the oscillator frequency to the desired value and the oscillator output to the 250 line on the Q range meter, and resonate the Q circuit by means of the Q tuning condenser. Call the condenser setting C_1 and the circuit Q, indicated on the Q voltmeter, Q_1. Call the oscillator frequency f.

Connect the resistor to be measured in series with the coil in the Q circuit at the low potential coil terminal, and re-resonate the Q circuit, calling the new Q reading Q_2 and the condenser reading C_2.

The effective series resistance, R_s, of the resistor is:

$$R_s = \frac{1.59 \times 10^8 \left(\frac{C_1}{C_2} Q_1 - Q_2\right)}{fC_1 \qquad Q_1Q_2} \qquad (23a)$$

If C_1 is greater than C_2 the effective reactance of the resistor is inductive and its effective series inductance, L_s, is:

$$L_s = \frac{2.53 \times 10^{10}\,(C_1 - C_2)}{f^2 \qquad C_1C_2} \qquad (25a)$$

or if the inductance, L_1, of the coil used in the Q circuit is known, the effective series inductance of the resistor may be calculated from:

$$L_s = L_1\left(\frac{C_1 - C_2}{C_2}\right) \qquad (49)$$

If C_2 is greater than C_1, the effective reactance of the resistor is capacitive and its effective series capacitance, C_s, is:

$$C_s = \frac{C_1C_2}{(C_2 - C_1)} \qquad (26a)$$

When the effective reactance of a resistor is capacitive, it may often be more accurate to represent the resistor as a shunt or parallel combination of resistance and capacitance. If the effective parallel values of resistance and capacitance are desired, the Q of the resistor, Q_x, may be calculated from:

$$Q_x = \frac{(C_1 - C_2)\,Q_1Q_2}{C_1Q_1 - C_2Q_2} \qquad (22a)$$

and the effective series resistance and capacitance calculated from formulas (23a) and (26a) above, and these values used in formulas (18b) and (21b), Part 1, to determine the effective parallel resistance, R_p, and capacitance, C_p. The general relations between series and parallel values are discussed in section 1, Part 1.

7-C: High Resistance in Parallel with Q Circuit ★ The same general procedure described in the preceding section 7-B should be followed when measuring resistors having a resistance value high enough to connect across the Q circuit, except that the resistor being measured should be connected to the condenser terminals of the Q-Meter instead of in series with the coil.

If Q_1 and C_1 are the Q and condenser readings at resonance without the resistor, and Q_2 and C_2 the readings with the resistor connected across the Q circuit, the effective parallel resistance, R_p, of the resistor is:

$$R_p = \frac{1.59 \times 10^8\,Q_1Q_2}{fC_1\,(Q_1 - Q_2)} \qquad (23b)$$

If the reactance of the resistor is capacitive, C_1 will be larger than C_2 and the effective parallel capacitance, C_p, of the resistor is:

$$C_p = C_1 - C_2 \qquad (26b)$$

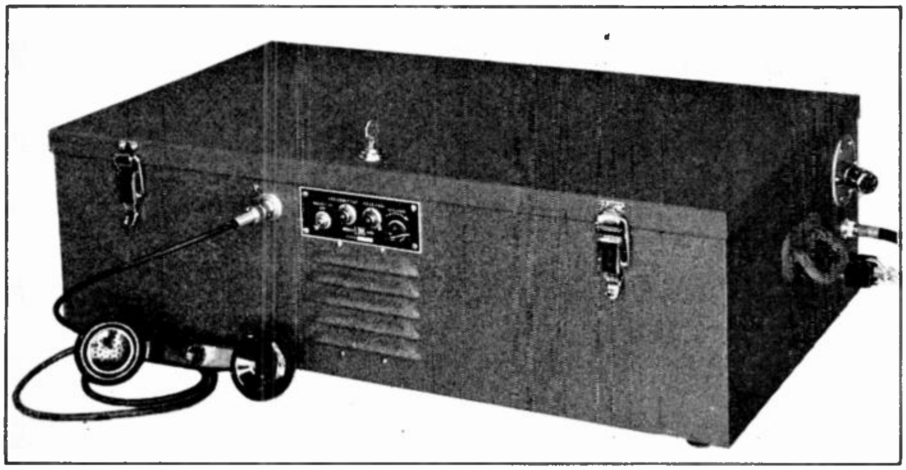
If C_2 is larger than C_1 the reactance is inductive and the effective parallel inductance, L_p, may be calculated from:

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

When the effective reactance of a resistor is inductive, it is sometimes more convenient to represent the resistor as a series combination of inductance and resistance, in which case the values of effective series resistance and inductance may be desired instead of the parallel values obtained from formulas (23b), (25b), and (26b) above.

If values of effective series resistance, inductance, or capacitance are desired, the corresponding parallel values can be measured as described above, and the Q of the resistor, Q_x, can be calculated from:

(CONTINUED ON PAGE 30)



SPECIAL SERVICE 2-WAY FM UNIT IS PROTECTED FROM DUST AND DAMPNESS

FM FOR NEW SERVICES

2-Way Design for Use Wherever 6-Volt Supply is Available

BY DONALD G. BEACHLER*

ONE after another come new uses for 2-way FM communication. In many instances, types of equipment already in production can be used, but others require new designs or special features.

For example, the need has developed in recent months for a compact communications unit of very rugged construction that can be set up quickly, anywhere on land, on small boats or large vessels, or in airplanes, if necessary.

Such a unit, illustrated in the accompanying photographs, is now being produced by FM Link. Except for the 6-volt supply, it is entirely self-contained, even to the handset and standby speaker, and a vertical rod antenna mounted rigidly or with a spring fixture on the side of the metal case.

The case measures 20 ins. long, 16 ins. wide, and stands 8½ ins. high. Heavy handles are provided at the ends. The weight is approximately 100 lbs.

Looking at the illustration below, the receiver is mounted at the left, the transmitter, of 25 or 35 watts output, is at the right, and the vibrator power supply for the receiver is at the right, close to the front of the case. Standard controls and pilot lights are provided on the front panel, with louvres for the standby speaker just below.

When not in use, the handset is clipped inside the cover. During operation, the handset can be plugged in at the front, and the cover put in place so as to protect the equipment from dust or dampness. It is not necessary to raise the cover while the unit is in use.

If a fixed antenna is available, its use is generally recommended instead of the vertical rod, if extra transmitting range is required. A concentric connector is located directly below the antenna rod mounting.

The connector for the battery cable is also mounted under the antenna fittings. Four prongs are used on the plug, with two connected to each of the 6-volt leads, in order to handle the current drawn during transmission.

The transmit-receive switch is relay-operated, controlled by a button on the handset.

Current drain, at 6 volts, is 6.5 amperes for the receiver and 2.25 amperes for the transmitter in the standby position, with the filaments heated and ready for instant use. This is a total battery drain of 8.75 amperes or 52.5 watts. The 25-watt transmitter, while in use, draws 23 amperes at 138 watts, or 30 amperes at 180 watts for the 35-watt transmitter.

Tubes in the receiver are:

6AC7 or 6SH7	RF amplifier
6K8	1st detector
6V6	Crystal oscillator, multiplier
6SH7 or 6SG7	IF amplifier
6K8	2nd detector, crystal oscillator
6SJ7 or 6AC7	1st limiter
6AC7	2nd limiter
6H6	Discriminator
6H6	AVC, squelch filter
6SL7GT	1st audio squelch
6K6GT	Audio output

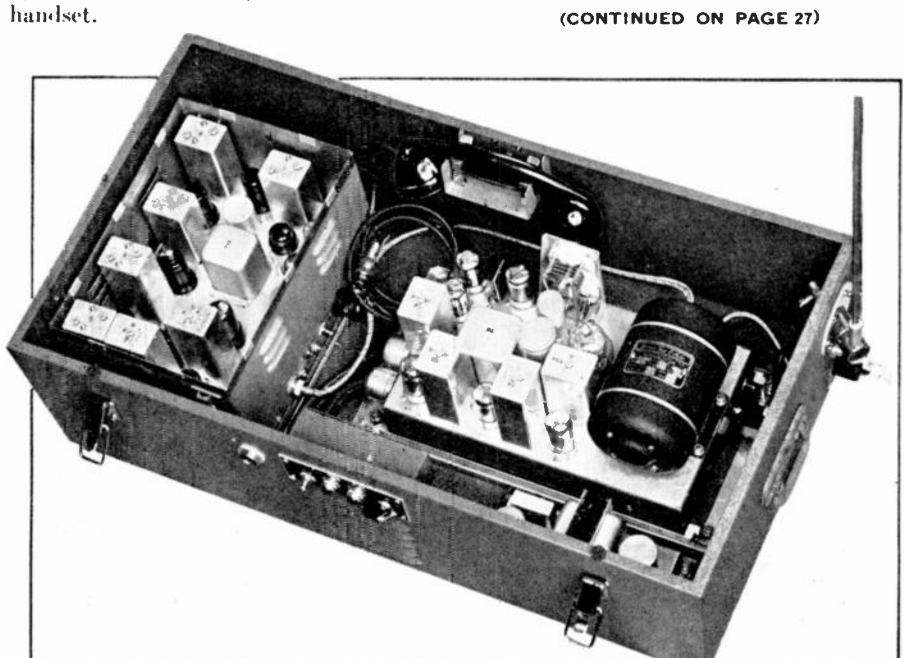
Tubes in the 25- and 35-watt transmitters are:

7C7	Crystal oscillator
2-7A8	Balanced modulators
7C7	1st Frequency quadrupler
7C7	2nd Frequency quadrupler
7C5	Frequency doubler
807	Power amplifier

Crystal control is provided for both the transmitter and receiver. The nominal operating frequency is within the 30-40 mc. band. Since this equipment is intended for speech only, the frequency deviation is ±15 kc., and the audio range is 300–3,000 cycles with high-frequency pre-emphasis.

Although 6 volts is the standard operating voltage for this unit, it can be supplied for use on 12, 24, or other common DC voltages. The transmitter output values given above are nominal ratings. Actual output of the two transmitters are

(CONTINUED ON PAGE 27)



VIBRATOR POWER SUPPLY FOR RECEIVER AND TRANSMITTER DYNAMOTOR ARE BUILT IN

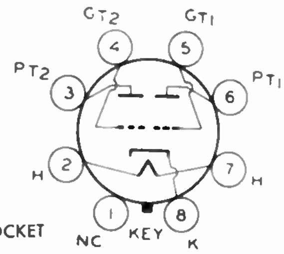
* F. M. Link, 125 W. 17th St., New York City.

VACUUM TUBE REVIEW

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

1635
Class B
Twin Amplifier

1. No connection
2. Heater
3. Plate, T_2
4. Grid, T_2
5. Grid, T_1
6. Plate, T_1
7. Heater
8. Cathode



BOTTOM OF SOCKET

1635 is a class B twin amplifier of GT construction, and a heater rating of 6.3 volts, 0.6 amp. It is designed with a variable-mu grid so as to reduce distortion in the output at low signal levels. It has been given two ratings, i.e., one for use on sustained signals, and the other on variable signals only. In applications involving sustained signals, the 1635 is operated with not more than 300 volts on the plate. At that voltage, it can handle a power output of about 10 watts. When it is not used on sustained signals, it can be operated with a plate voltage as high as 400 volts, and at this voltage it will handle a power output of about 17 watts.

Heater voltage, AC or DC			6.3 volts
Heater current			0.6 amps.
Plate volts[1]	300 max.[2]	400 max.[3]	volts
Peak plate current per plate	90 max.	90 max.	milamp.
Average plate dissipation per plate	3 max.	4.5 max.	watts

Following values are for the two units, unless otherwise specified

Plate supply impedance	0	1000[4]	0	ohms
Effective grid circuit impedance per unit	0	516[5]	0	ohms
Plate voltage	300	300	400	volts
DC grid voltage	0	0	0	volts
Peak AF grid-to-grid voltage	70	108[6]	76	volts
Zero-signal DC plate current	6.6	6.6	10	milamp.
Maximum-signal DC plate current	54	54	63	milamp.
Peak grid current per unit	38	39	41	milamp.
Eff. load resistance plate to plate	12000	12000	14000	ohms
Total distortion	4	5	—	%
Maximum signal power output	10.4	10.4	17	watts

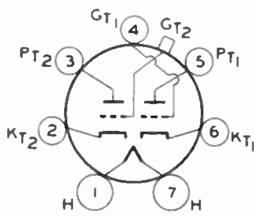
Maximum overall length	3 5/16 ins.
Maximum seated height	2¾ ins.
Maximum diameter	1 5/16 ins.
Bulb	T-9
Base	Intermediate shell octal 8-pin
Mounting position	Any

[1] Maximum ratings are based on a line voltage design center of 117 volts.
[2] For sustained signal operation as, for example, on key-down operation.
[3] For other than sustained operation as, for example, on broadcast operation.
[4] Practical design value.
[5] At 400 cycles for class B stage in which the effective resistance per grid circuit is 500 ohms, and the leakage reactance of the coupling transformer is 50 millihenries. The driver stage should be capable of supplying the grids of the class B stage with the specified values at low distortion.
[6] Includes peak voltage drop through the grid circuit impedance.

1642
Twin Triode
Amplifier

1. Heater
2. Cathode, T_2
3. Plate, T_2
4. Grid, T_1
5. Plate, T_1
6. Cathode, T_1
7. Heater

Cap Grid, T_2



BOTTOM OF SOCKET

1642 is a multi-unit tube containing in one envelope two medium-mu triodes with a mu of 10.4. Each triode unit has separate terminals for all electrodes except the heater which is common to both units. Therefore, each unit operates independently of the other. This tube has a small shell 7-pin micanol base.

Heater voltage, AC or DC	6.3 volts
Heater current	0.6 amp.

Direct Interelectrode capacitances: [1]

	Triode T_1	Triode T_2
Grid to plate	2.4	1.8 mmf.
Grid to cathode	2.6	1.6 mmf.
Plate to cathode	1.4	2.0 mmf.

Amplifier — each unit [2]

Plate voltage	250 max. volts
Plate dissipation	2.1 max. watts

Class A_1 amplifier characteristics:

Plate voltage	250 volts
Grid voltage	−16.5 volts
Amplification factor	10.4
Plate resistance	7600 ohms
Transconductance	1375 micromhos
Plate current	8.3 milamp.

Maximum overall length	4 17/32 ins.
Maximum seated height	3 29/32 ins.
Maximum diameter	1 9/16 ins.
Bulb	ST-12
Cap	Small metal
Base	Small shell 7-pin Micanol
Mounting position	Any

[1] With no external shield.
[2] Maximum ratings are based on a line voltage design center of 117 volts.

9JP1/1809P1
High Vacuum
Cathode Ray Tube

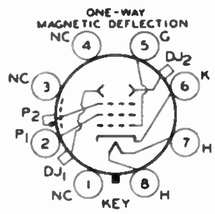
9JP1/1809-P1 is a high-vacuum cathode-ray tube having a viewing screen 9 ins. in diameter. The tube uses a combination of magnetic and electrostatic fields for deflection of the electron beam. It features short overall length and close-spaced electrostatic electrodes to provide good deflection sensitivity. With this close spacing, the maximum spot travel caused by these electrodes is approximately 2 ins. The 9JP1/1809-P1 produces a luminous spot having a greenish hue, and is suitable for the observation and photography of transient and recurrent phenomena.

The indirectly-heated cathode, the control electrode (grid), the first anode, and the second anode constitute an electron gun for projecting a beam of electrons upon the fluorescent screen. The resultant luminous spot can be regulated as to spot size and intensity by suitable choice of electrode voltages.

Deflection of the electron beam is ordinarily accomplished by the use of an electromagnetic field and an electrostatic field. The electromagnetic field is usually placed so that its axis coincides with that of the electrostatic field in order that the deflection produced by one field will be at right angles to that produced by the other field. One field is controlled by the voltage under observation; the other is used for the time sweep.

The 9JP1/1809-P1 is recommended for use in oscillographic applications where the inertialess characteristic of the electron beam, the provision for two methods

1. No connection
2. Anode 1
3. No connection
4. No connection
5. Control Electrode
6. Cathode
7. Heater
8. Heater
DJ_1. Def. Electrode
DJ_2. Def. Electrode
P_2. Anode 2



BOTTOM OF SOCKET

of beam control, the brilliant image, and the short overall length all contribute to the general utility of this type.

CHARACTERISTICS AND RATINGS

Heater voltage, AC or DC . . . . 2.5 volts
Heater current . . . . 2.1 amp.
Focusing method . . . . Electrostatic
Deflection method Magnetic and Electrostatic: Electrode DJ_1 is on same side of tube as base pin 2.
Electrode DJ_2 is on same side of tube as base pin 6.
Phosphor . . . . No. 1
Fluorescence . . . . Green
Persistence . . . . Medium
Direct interelectrode capacitances:
Control electrode to all other electrodes 8 mmf.
Deflecting electrode DJ_1 to DJ_2 . 1 mmf.
Either DJ_1 or DJ_2 to all other electrodes . . . . 3.6 mmf.
Cathode to all other electrodes . . 8 mmf.
Overall length . . . . 15 11/16 $\pm 3/8$ ins.
Greatest bulb diam. . . . . $9 \pm 3/8$ ins.
Minimum diam of screen . . . . 8 ins.
Bulb side terminals . . . . Snap connectors
Base . . . . . Small wafer octal 8-pin, sleeve
Deflection yoke:
Position on tube neck: Lip flush with bulb reference line (see drawing)
Working length for 55° angle deflection 2 ins. max.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS [1]

Anode No. 2 (high voltage electrode) 5000 max. volts
Anode No. 1 (focusing electrode) 2000 max. volts
Grid (control electrode) . . . Never positive
Peak voltage between No. 2 and either deflecting electrode . . . . . 3000 max. volts
DC heater to cathode . . . 125 max. volts
Grid circuit resistance . . . 1.5 max. meg.
Typical operation:
Anode No. 2[2] . . . . . 2500 5000 volts
Anode No. 1 for focus at 75% of grid voltage for cutoff[3] . . . 785 1570 volts
Grid voltage for cutoff[4] −45 −90 volts
Deflection sensitivity, DJ_1 & DJ_2 .272 .136 mm/v DC
Deflection factor, DJ_1 & DJ_2 93.8 187 v. DC/in.

[1] Maximum ratings are based on a line voltage design center of 117 volts.
[2] Brilliance and definition decrease with decreasing voltage on anode No. 2. In general, anode No 2 voltage should not be less than 2500 volts.

INSTALLATION

The base pins of the 9JP1 fit the standard octal socket which may be installed to hold the tube in any position. The socket should be made of good insulating material; a type having insulating baffles between contacts provides an additional factor of safety.

The bulb of this type, except for the screen surface, should be enclosed in a grounded metal case. If an iron or steel case is used to minimize the effect of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized.

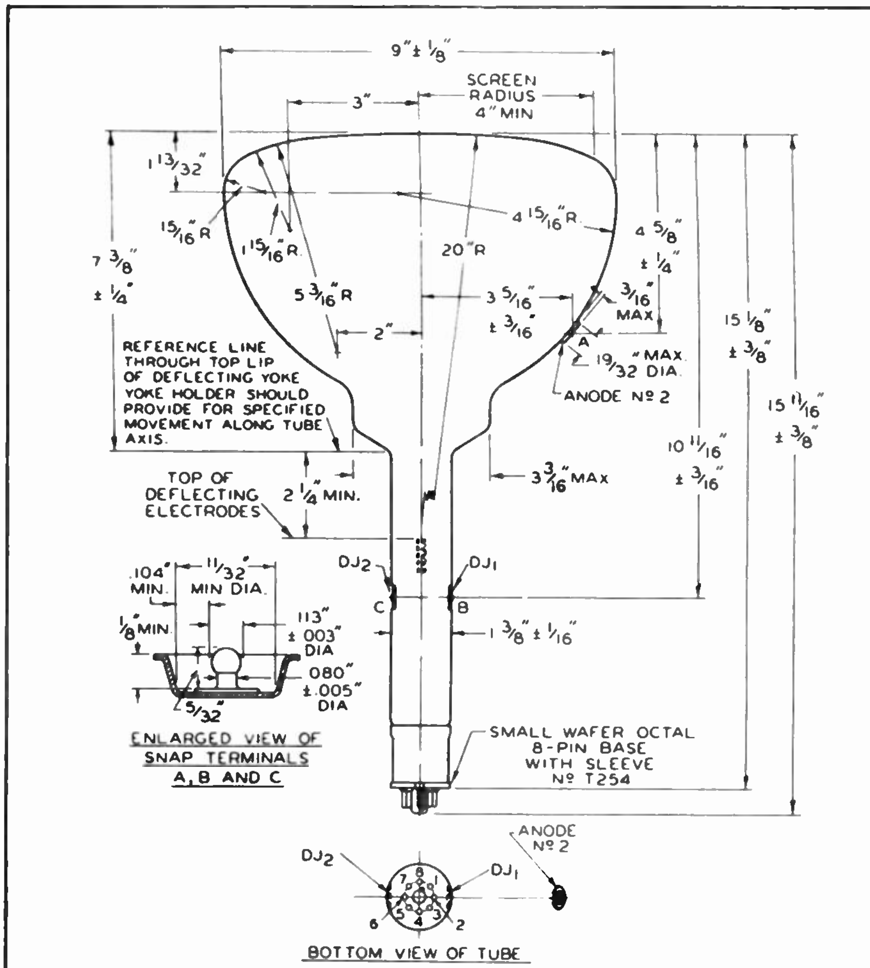
The heater is designed to operate at 2.5 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line voltage conditions. If the circuit design is such as to cause a high voltage between the heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.

The cathode is connected to base pin No. 6, to which the grid and anode returns should be made.

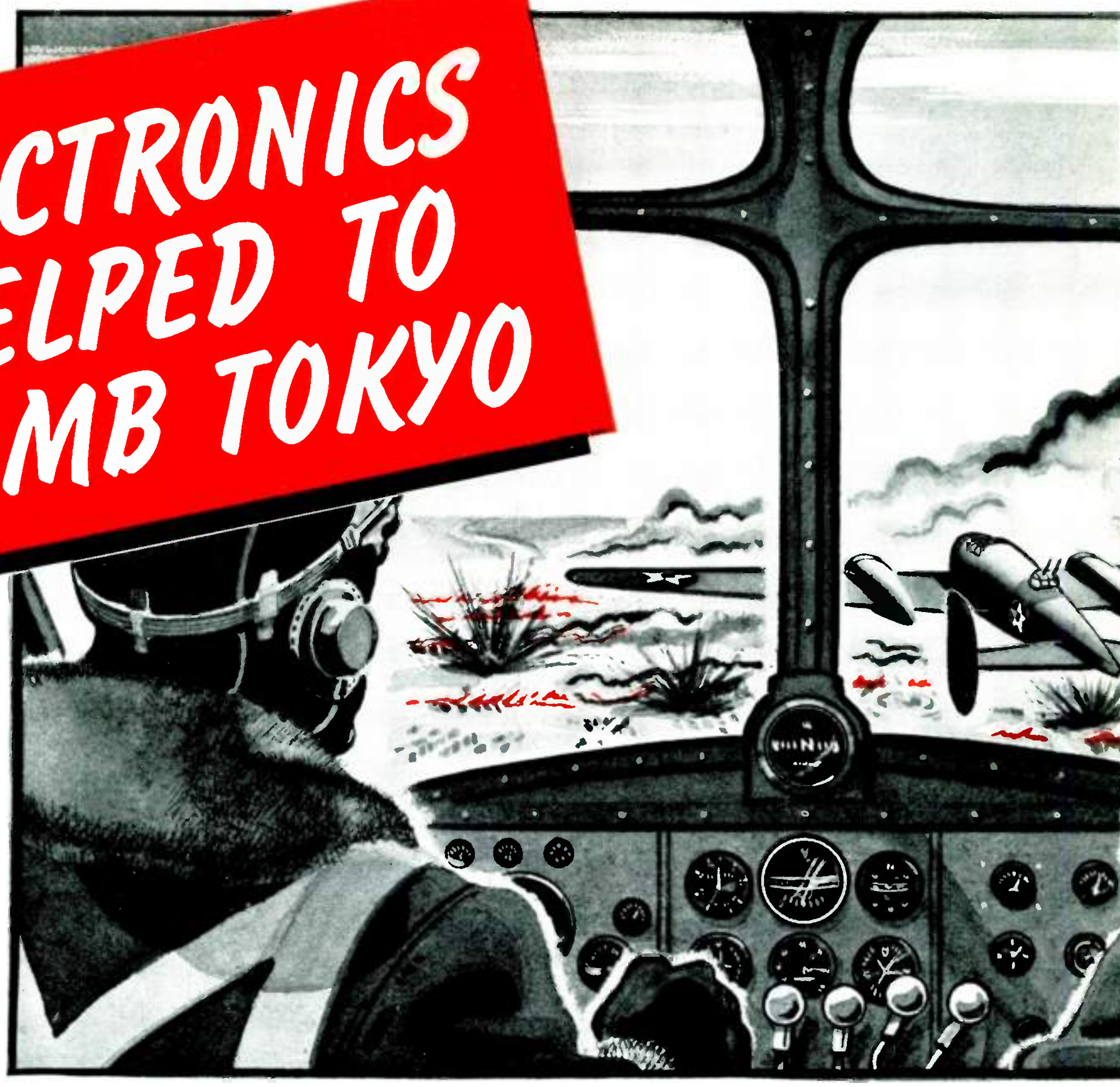
[3] Supply should be adjustable to ±20% of this value.
[4] Cutoff is visual extinction of a stationary focused spot. Supply should be adjustable to ±50% of this value.

The DC supply voltages for the electrodes may be obtained conveniently from a high-voltage, vacuum tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be of either the half-wave or the voltage doubler type. For the same reason, the filter requirements are simple. A 0.5 to 2 mfd. condenser will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended.

Two electrodes, located in the bulb neck, provide for electrostatic deflection of the electron beam. These two electrodes are capable of producing a deflection of approximately 2 ins. The deflection so produced is parallel to the lines of the electrostatic field. The DC potential of each deflecting electrode must be maintained essentially equivalent to that of anode No. 2 in order to avoid building a charge on the deflecting electrodes. A charge on the deflecting electrodes causes a permanent deflection of the beam. The DC potential of the deflecting electrodes may be kept essentially the same as that of anode No. 2 by connecting resistors having values not greater than 10 megohms between each deflecting electrode and anode No. 2. This arrangement by suitable choice of resistor values minimizes pattern distortion and pattern drift resulting from unbalanced potentials on



ELECTRONICS HELPED TO BOMB TOKYO



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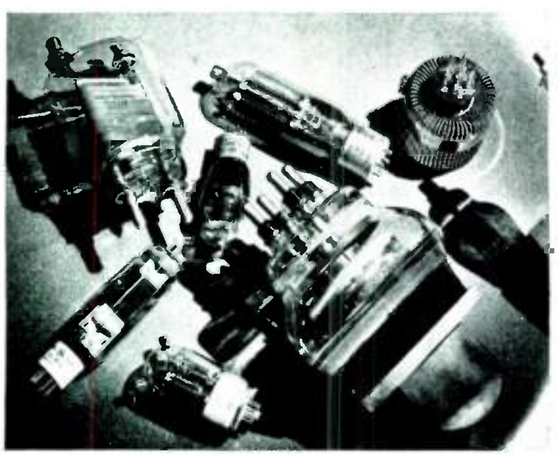

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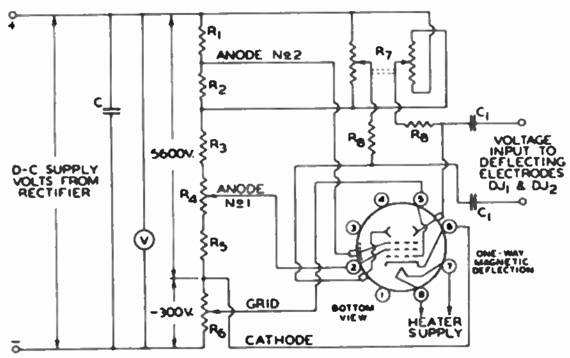
TYPICAL OSCILLOGRAPH CIRCUIT



C = FILTER CONDENSER, 0.5 to 2 μf
C_1 = ISOLATING CONDENSERS, SEE NOTE BELOW
R_1, R_2 = 0.4 MEGOHM
R_3 = 1.2 MEGOHMS
R_4 = 0.5 MEGOHM POTENTIOMETER
R_5 = 0.5 MEGOHM
R_6 = 0.15 MEGOHM POTENTIOMETER
R_7 = 1.5 MEGOHM (EACH SECTION) DUAL POTENTIOMETER FOR BEAM CENTERING
R_8 = POTENTIAL EQUALIZING RESISTORS, SEE NOTE

NOTE: When the cathode or the negative end of the cathode-ray high-voltage supply is grounded, blocking condensers C_1 should have a high voltage rating. When anode No. 2 is grounded, condensers C_1 may be low-voltage condensers.

For DC amplifier service, the deflecting electrodes should be coupled direct to the output of the amplifier by omitting the blocking condensers. In addition, it will usually be preferable to remove the associated deflecting electrode resistor in order to minimize the loading effect of the resistor on the DC amplifier. With the resistor removed, it is essential, in order to minimize the spot defocusing, that anode No. 2 be returned to some point in the DC amplifier circuit such that the potential difference between anode No. 2 and the average voltage across the deflecting electrodes will be as low as possible.

the deflecting electrodes. The smaller the resistor values, the less distortion for a given beam current. The beam current should ordinarily be kept low. At times when it is necessary to use a high value of beam current, as when photographs are to be taken, the value of the resistor should be reduced so that the zero-axis shift will be minimized. The resistor of one or both deflecting electrodes may be connected to a DC bias voltage to obtain centering of the beam.

A second method for deflecting the beam is provided by an electromagnetic system which consists of one or more pairs of coils. Each coil of a pair is arranged diametrically opposite its mate in such a manner that the magnetic field is at right angles to the axis of the tube. The deflection of the beam is at right angles to the direction of the magnetic field. The yoke, placed around the bulb neck close to the bulb flare, should be designed so that the deflection of the beam is accomplished within the space of not more than 2 ins., parallel to the tube axis, measured from the reference line shown on the outline drawing.

Because of the short bulb of the 9JP1, the beam must be deflected through the relatively wide angle of 55° to cover the entire screen width. Although this tube requires but one pair of coils, one pair may be used in conjunction with the electrostatic electrodes of the tube, or both pairs of coils may be used to obtain full magnetic deflection. In the latter case, the electrostatic electrodes may also be used to introduce an additional voltage for deflection of the beam. The yoke should be placed as close as possible to the junction of the bulb cone and the cylindrical neck. This arrangement is necessary to prevent the beam striking the neck when the deflection is sufficient to reach the edge of the screen.

The high voltages at which the 9JP1 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these voltages. Precautions must include safeguards which definitely eliminate all hazards to personnel. All circuit parts which may be at high potential should always be enclosed and interlock switches should be used to break the primary circuit when access to the equipment is required.

In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit because of condenser breakdown or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded.

APPLICATION

A diagram illustrating the essential circuit for the use of the 9JP1 in an oscillograph is shown. The electrode voltages are obtained from a bleeder circuit connected across the high-voltage supply. A bleeder current of 1 or 2 milliamperes is usually satisfactory; considerably larger values may require the use of more filtering than can be provided conveniently by a single condenser shunted across the DC supply. With small bleeder currents, a single condenser filter usually is adequate. A variable DC voltage for the control electrode and one for anode No. 1 can be obtained from potentiometers in the bleeder circuit.

Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No. 1 voltage to anode No. 2 voltage. Ordinarily, the ratio is varied by adjustment of anode No. 1.

Regulation of spot size and intensity can be accomplished by varying anode No. 2 current and/or voltage. The current to anode No. 2 may be increased by decreasing the bias applied to the control electrode (grid). An increase in anode No. 2 current increases the size and the intensity of the spot. An increase in the voltage applied to anode No. 2 increases the speed of the electrons and, therefore, increases intensity and decreases spot size. The maximum anode No. 2 voltage shown under MAXIMUM RATINGS is based on a line-voltage design center of 117 volts. The 9JP1 will operate satisfactorily at lower anode No. 2 voltages, but brilliance and definition decreases with decreasing anode No. 2 voltages. In general, anode No. 2 voltage should not be less than 2500 volts. When any of these adjustments are made, consideration should be given to the limiting voltage ratings shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

Photographs of the phenomena appearing on the screen of the 9JP1 can be made with an ordinary camera. Photographing is done preferably in a subdued light in order to obtain as much contrast as possible between the fluorescent pattern and the screen. The time of exposure will depend on the type of film or plate emulsion used, the magnification of the pattern and the brightness of the pattern. When transients are to be photographed, patterns having low brightness can easily be compensated for by longer exposure. The use of film having high green sensitivity is recommended. Verichrome-type film has been found to give excellent results.

For high-speed photographic work involving non-recurrent phenomena, it is permissible to increase the screen input power per sq. cm. for the short time interval required to make the exposure, above that required for visual observation. The extent to which the anode No. 2 current may be increased without harming the fluorescent screen is a function of the rate of beam travel and pattern size, and an inverse function of duration. Short-interval operation at increased input can be obtained by means of a temporary decrease in the control-electrode voltage. A switching arrangement should be provided to switch the control-electrode voltage rapidly between a negative and a less negative value. The exposure is made while the control-electrode voltage is at the decreased (less negative) value.

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RADIO-ELECTRONIC PRODUCTS DIRECTORY

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

★ Indicates that addresses and phone numbers of representatives in War Production centers are listed at the end of the Radio-Electronic Products Directory

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.
Electronic Mechanics, Inc., Paterson, N. J.
Isolantite Inc., Belleville, N. J.
Louthan Mfg. Co., E. Liverpool, O.
Star Porcelain Co., Trenton, N. J.
Steward Mfg. Co., Chattanooga, Tenn.
Victor Insulator Co., Victor, N. Y.

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.
Ohmite Mfg. Co., 4835 W. Flourney St., Chicago
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
Littlefuse, 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. 334d 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 Av., 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.
Radio City Products Co., 127 W. 26 St., N. Y. C.

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.
Peterson 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.

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

Alrose 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.
Littlefuse, 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.

GENERATORS, Gas Engine Driven

Kato Engineering Co., Mankato, Minn.

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.

HORNS, Outdoor

University Laboratories, 195 Chrystie St., N. Y. C.

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.
Radio City Products Co., 127 W. 26 St., N. Y. C.
Rogan Bros., 2001 S. Michigan, Chicago

LABORATORIES, Electronic Research

★ Browning Labs., Inc., Winchester, Mass.

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.

FM FOR NEW SERVICES

(CONTINUED FROM PAGE 19)

25/30 and 35/40 watts respectively.

An important feature of this unit is that it can be set down anywhere, the antenna put in place, the 6-volt supply plugged in, and communication established as soon as the handset is removed from the cover and plugged in at the front of the case. No further adjustments are required under any operating conditions.

CIVILIAN RADIO DEFENSE UNITS

TWO-WAY radio communication for use during air raid defense emergencies is to be provided by civilian technicians, under a new plan set in motion through the FCC.

It is expected that several thousand two-way units will be constructed from unused junk-box parts by broadcast station engineers and amateurs who will make up the civilian War Emergency Radio Service to be directed by the OCD.

The transmitters will be limited in power to 25 watts, so that their effective range will be kept down to about 10 miles. This is considered sufficient for all needs under emergency conditions.

Printed manuals, planned to facilitate administrative operation, will be distributed by the regional offices of the OCD.

Special operator licenses, designated as War Emergency Service Operator Permits will be issued to those assigned to operate these stations. Permits of this class will be issued only to persons holding regular FCC licenses, and only after the applicant has satisfied the FCC as to his loyalty and integrity.

Chairman Fly described this plan as a standby facility to be used when other means of communication fail. Certain bands above 112 mc. have been set aside for this purpose, and provisions have been made for trials during blackout periods.

ANZAC PILOTS, TRAINING IN CANADA, SPEAK TO THEIR HOMELAND FROM INGEO, G.E. SCHENECTADY STATION WHICH PROGRAMS TWO HOURS DAILY FOR AUSTRALIA

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.

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., 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

Cambridge Inst. Co., Grand Central Terminal, N. Y. C.
De Jur-Amsco Corp., Shelton, Conn.
★ General Electric Co., Bridgeport, Conn.
Hickok Elec. Inst. Co., Cleveland, O.
Hoyt Elec. Inst. Works, Boston, Mass.
Readrite Meter Works, Bluffton, O.
Roller-Smith Co., Bethlehem, Pa.
Simpson Elec. Co., 5218 W. Kinzie, Chicago
Triplett Elec. Inst. 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
Turner Co., Cedar Rapids, Ia.
Universal Microphone Co., Inglewood, Cal.

MONITORS, Frequency

★ Browning Labs., Inc., Winchester, Mass.
★ Link, F. M., 127 W. 17 St., N. Y. C.

MOTOR-GENERATORS, Dynamotors, Rotary Converters

Alliance Mfg. Co., Alliance, O.
Air-Way Mfg. Co., Toledo, O.
Bendix, Red Bank, N. J.
Black & Decker Mfg. Co., Towson, Md.
Bodine Elec. Co., 2262 W. Ohio, Chicago
Carter Motor Co., 1608 Milwaukee, Chicago
Clements Mfg. Co., Chicago, Ill.
Continental Electric Co., Newark, N. J.
Delco Appliance, Rochester, N. Y.
Diehl Mfg. Co., Elizabethport, N. J.
Dormeyer Co., Chicago, Ill.
Eclipse Aviation, Bendix, N. J.
Elcor, Inc., 1060 W. Adams, Chicago
Electric Motors Corp., Racine, Wis.
Electric Specialty Co., Stamford, Conn.
Electrolux Corp., Old Greenwich, Conn.
Emerson Electric Co., St. Louis, Mo.
Eureka Vacuum Cleaner, Detroit, Mich.
★ General Electric Co., Schenectady, N. Y.
Janette Mfg. Co., 558 W. Monroe, Chicago
Knapp-Monarch, St. Louis, Mo.
Leland Electric Co., Dayton, O.
Ohio Electric Co., 74 Trinity Pl., N. Y. C.
Pioneer Gen-E-Motor, 5841 W. Dickens Av., Chicago
Redmond Co., A. G., Owosso, Mich.
Russell Co., Chicago, Ill.
Webster Co., Chicago, Ill.
Westinghouse Elect. Mfg. Co., Lima, O.
Wincharger Corp., Sioux City, Iowa

MOUNTINGS, Shock Absorbing

Lord Mfg. Co., Erie, Pa.

MYCALEX

★ General Electric Co., Schenectady, N. Y.
Mycalex Corp. of Amer., 7 E. 42 St., N. Y. C.

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 Co., Philadelphia
Revere Copper & Brass, 230 Park Av., 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.
Radio City Products Co., 127 W. 26 St., N. Y. C.
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, Spring Type

Eby, Inc., Hugh H., Philadelphia, Pa.
Ucinite Co., Newtonville, Mass.

PLUGS & JACKS, Telephone Type

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 Machine 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
Electronic Labs., 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.
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, Fixed Precision

Instrument Resistors, Inc., Little Falls, N. J.
Ohmite Mfg. Co., 4835 Flournoy St., Chicago

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.

RESISTORS, Variable, Ceramic Base

Ohmite Mfg. Co., 4835 Flournoy St., Chicago

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.

SPEAKERS, Outdoor Type

University Labs., 195 Chrystie St., N. Y. C.

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.

SUPPRESSORS, Parasitic

Ohmite Mfg. Co., 4835 Flournoy St., Chicago

SWITCHES, Rotary Tap, Ceramic Base

Ohmite Mfg. Co., 4835 Flournoy St., Chicago

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.

TUBES, Receiving

★ General Electric Co., Schenectady, N. Y.
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.

VIBRATORS, Power Supply

Turner Co., Cedar Rapids, Ia.

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.

DIRECTORY OF MANUFACTURERS' REPRESENTATIVES & SALES OFFICES IN RADIO WAR PRODUCTION AREAS

★ These manufacturers' names are starred in the Radio-Electronics Products Directory

AEROVOX CORP.
Boston: 94 Portland St., Lafayette 3484
Chicago: 4753 B'way, Long Beach 0169
Cleveland: 219 Film Ex. Bldg., Prospect 0719
Los Angeles: 1341 S. Hope St., Richmond 9121
New York: 347 Fifth Ave., Murray Hill 5-7090
Pittsburgh: 918 Hill St., Churchill 0838

BROWNING LABORATORIES, INC.
Address all correspondence to Winchester, Mass.: 755 Main St., Win. 2121

GENERAL ELECTRIC CO.
Boston: 140 Federal St., Hubbard 1800
Chicago: 840 S. Canal St., Wabash 5611
Cleveland: 4966 Woodland Ave., Endicott 4464
New York: 570 Lexington Ave., Wickersham 2-1311
Philadelphia: 1405 Locust Ave., Pennypacker 9000
San Francisco: 235 Montgomery St., Douglas 3740

LINGO & SON, INC., JOHN E.
Address all correspondence to Camden, N. J.: 28 & Van Buren Ave., Camden 487

LINK, F. M.
Address all correspondence to New York: 125 W. 17th St., Chelsea 3838

SHURE BROTHERS
Chicago: 225 W. Huron St., Delaware 8381
Columbus: 85 E. Gay St., Adams 8928
New York: 136 Liberty St., Worth 2-6550
Philadelphia: 1343 Arch St., Rittenhouse 9778
San Francisco: 234 Ninth St., Hemlock 2625
Washington: 3308 Fourteenth St., N. W., Columbia 3938

THE FACTOR Q

(CONTINUED FROM PAGE 18)

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

The values thus obtained can be used in formulas (18a) to (21a), Part 1, to determine the effective series values desired.

7-D: Anti-Resonant Resistance of a Tuned Circuit ★ This quantity, sometimes called "dynamic resistance," is the resistance of a resonant *LC* circuit as measured at the terminals of the coil or condenser. It is of interest when such a circuit is used as a coupling element in a vacuum tube amplifier having a high plate resistance, since the gain is proportional to the anti-resonant resistance. If the Q of a circuit is not too small, its anti-resonant resistance, R_d, is:

$$R_d = 6.28 \times 10^{-3} fLQ = \frac{1.59 \times 10^8\, Q}{fC} \qquad (50)$$

in which f is the resonant frequency and L, C, and Q are the circuit inductance, capacitance, and Q at resonance.

The anti-resonant resistance of a tuned circuit can be measured with the Q-Meter by treating the circuit as a high resistance and measuring its resistance in a manner similar to that described for resistors in the preceding section 7-C. In this case, however, after resonating the Q circuit of the Q-Meter without the circuit under test connected, and recording the values of Q circuit capacitance and Q as C_1 and Q_1, the circuit under test should be connected to the condenser terminals of the Q-Meter and the Q circuit resonated by *resonating the circuit under test* to the frequency of measurement, f, as indicated by a maximum deflection of the Q voltmeter. The new Q voltmeter reading may be called Q_2. The anti-resonant resistance, R_d, of the test circuit is then:

$$R_d = \frac{1.59 \times 10^8\, Q_1 Q_2}{fC_1\,(Q_1 - Q_2)} \qquad (51)$$

NOTES ON USING THE 170-A Q METER

The type 170-A Q Meter has an oscillator frequency of 30 mc. to 200 mc., accurate to ± 1%. The Q voltmeter is calibrated directly in Q, from 80 to 300. Since the Multiply Q By meter reads from x1 to x4, the total range is from 80 to 1,200.

Certain precautions are suggested here in order to assure accurate measurements:

Short Leads ★ Attention is especially called to the importance of using extremely short and wide leads (of low inductance and low resistance) when connecting coils, condensers, or other impedances to the terminals of the 170-A meter for measurements at high frequencies.

As an example, a typical small molded mica condenser of 25 μμf. nominal capacitance when connected to the condenser terminals with short, ordinary wire leads shows a marked increase in effective capacitance at 200 mc., due to the inductance of the condenser and its leads.

Replacing the wire leads with copper ribbon reduces the lead inductance and the apparent capacitance.

Coupling of Unshielded Coil ★ At high frequencies, a surprising number of objects such as sections of electric light and power lines, electric cords, coils, and other objects may become resonant.

If such objects are adjacent to an unshielded coil which is being measured in the Q-Meter, they may affect the indicated Q of the coil, and its apparent inductance, in the frequency region of this resonance. This condition is indicated by a kink in an otherwise smooth curve of Q versus frequency.

Under some conditions, the indicated Q may be affected by the hands of the operator when placed close to or in contact with the instrument case, even though this is grounded in the conventional manner. Occasionally, greater stability can be obtained by eliminating the ground connection.

Engineers versed in UHF technique are acquainted with such phenomena. A stable condition can be obtained usually by re-arranging the power line cables, or removing the instrument from the region of resonant structures. In general, this condition is not present when shielded inductors are employed.

Stability ★ The 170-A Q-Meter has a self-contained B voltage regulator. However, an external line-voltage regulator is recommended if the AC voltage is subject to fluctuation. A type 162-A constant-voltage transformer is available for this purpose.

A small amount of reaction on the oscillator output voltage is to be expected when the Q measuring circuit is brought into resonance. This is usually of little importance in the direct measurement of the Q of a coil. However, in the measurement of a condenser, it may be of importance, since such measurements frequently involve the determination of small ΔQ values. Under these conditions, the oscillator output should be readjusted to read x1 (or other multiple) when the measuring circuit is resonated to the oscillator.

SIMPLIFIED, NON-DIRECTIONAL ANTENNA DEVELOPED BY G.E. WAS SHOWN AT I.R.E. CLEVELAND CONVENTION

In this instrument, the oscillator output voltage is measured by a diode vacuum tube voltmeter. This is the Multiply Q By meter on the front panel. The level of the oscillator output voltage will vary about 3 to 1 over the total frequency range of the instrument.

As a result of the variation of the output level, the Multiply Q By meter may be driven off scale. While it is desirable to avoid this, there is little danger of damaging the system since this is a vacuum tube voltmeter and not a thermocouple. After the initial warm-up period, the zero should be checked. Thereafter, it will be quite stable.

The Q vacuum tube voltmeter is a small type 955 triode. This tube was chosen for the purpose because of its low input capacitance and circuit loading. Only selected tubes are suitable for use in this application. The Q voltmeter is less stable than the diode vacuum tube voltmeter, and its zero setting should be checked frequently to insure best operation.

Terminal and Contact Resistance ★ The posts on the Q-meter have been designed to reduce the capacitance and internal inductance of the Q measuring circuit to a minimum. Since the series resistance of coils used at high frequencies is usually less than 1 ohm, it is necessary that good contact be made between the terminals of the coil under measurement and the terminal posts of the Q-Meter.

Also, since the inductance of such coils is usually well under 1 μhenry, it is apparent that the terminals of the coil to be measured must fit the terminals of the Q-Meter with sufficient accuracy to permit their removal and subsequent replacement without changing their effective inductance appreciably.

Replacing Tubes ★ In removing and replacing the oscillator tube, care should be taken to avoid distorting the tinned copper strips connected to the grid and plate clips.

To remove the Q vacuum tube voltmeter tube, the Q tuning condenser should be rotated until the plates are fully meshed.

Stock tubes should not be used in this instrument. Tubes specially selected for the Q-Meter are obtainable from the Boonton Radio Corporation.

In the event of the unsatisfactory performance of the Q-Meter, if the trouble is not corrected by replacing the tubes, the instrument should be returned to the factory for repair.

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Question: Why has "Radio-Electronic Engineering & Design" been added to the title of FM Magazine? — Answer: Because the editorial contents have been broadened to cover all phases of radio-electronic engineering and design.

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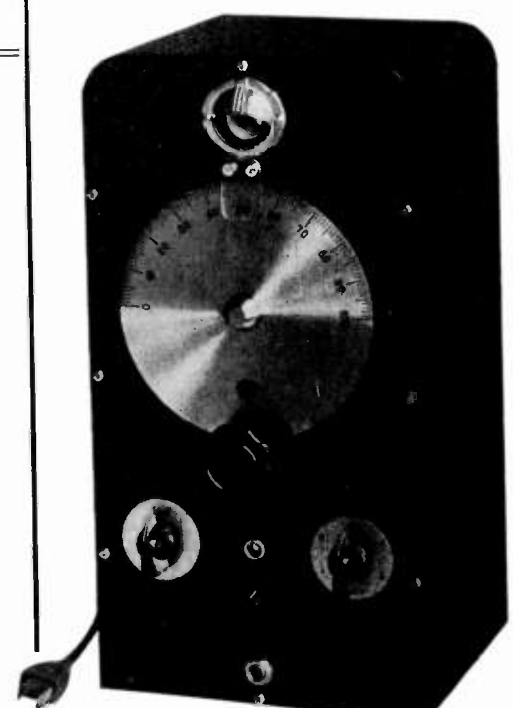

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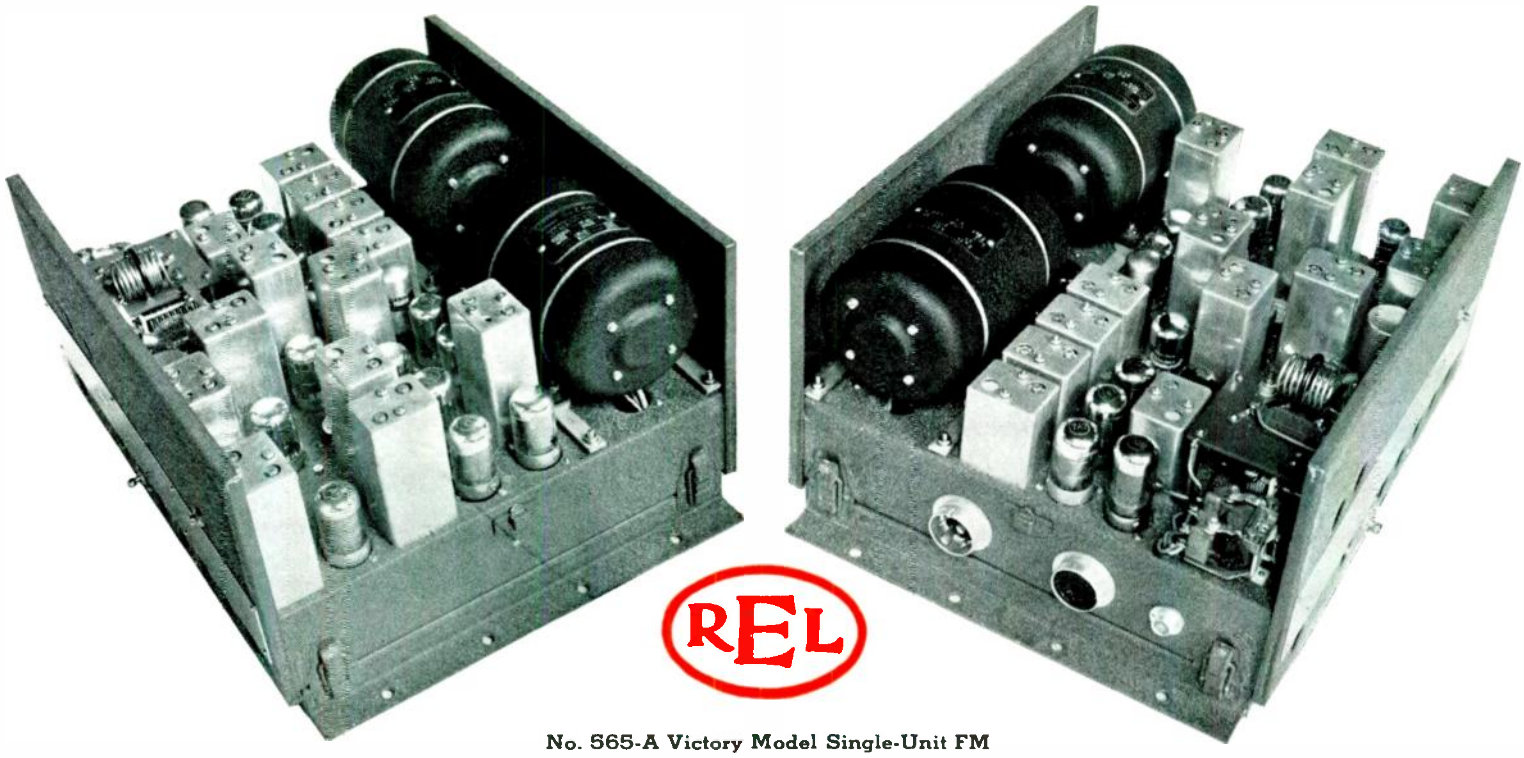

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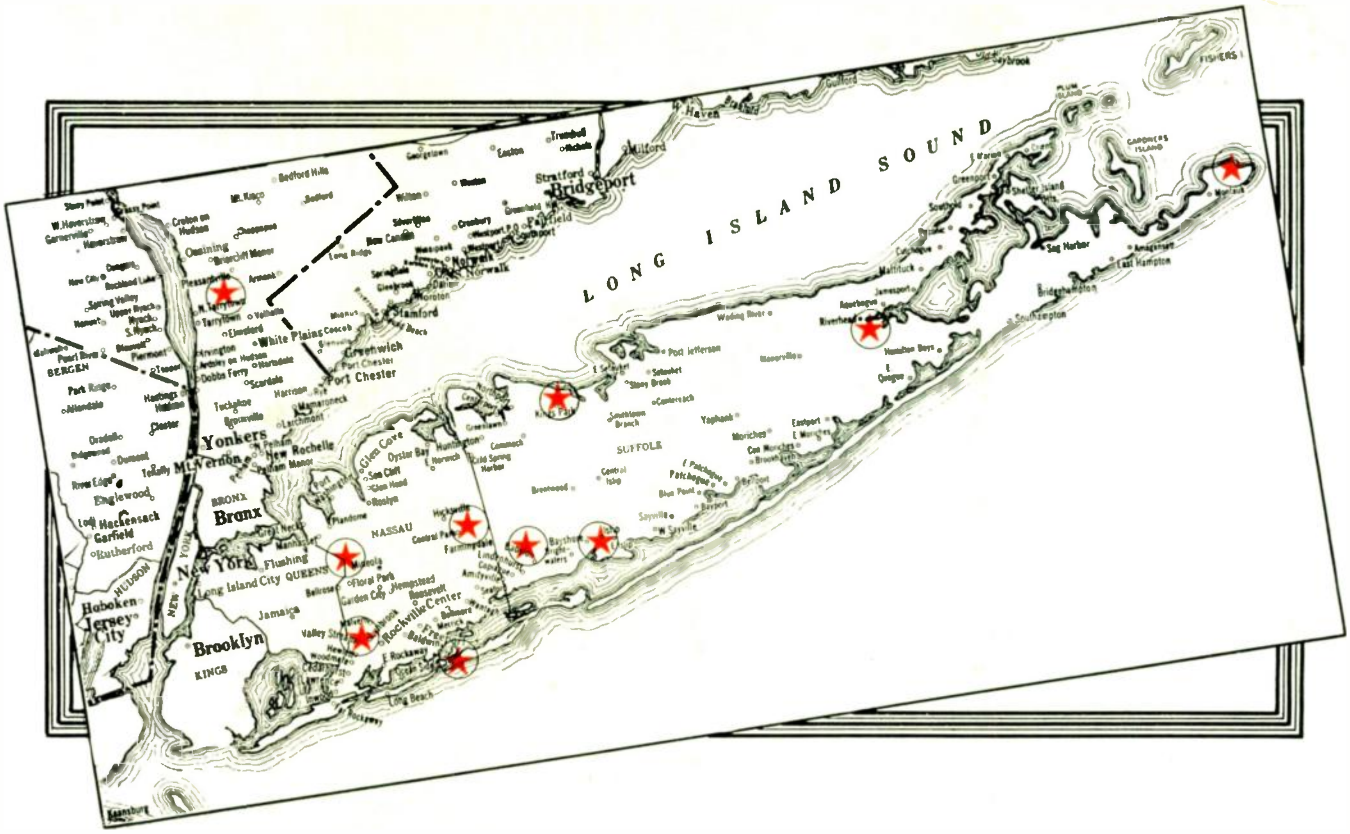

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