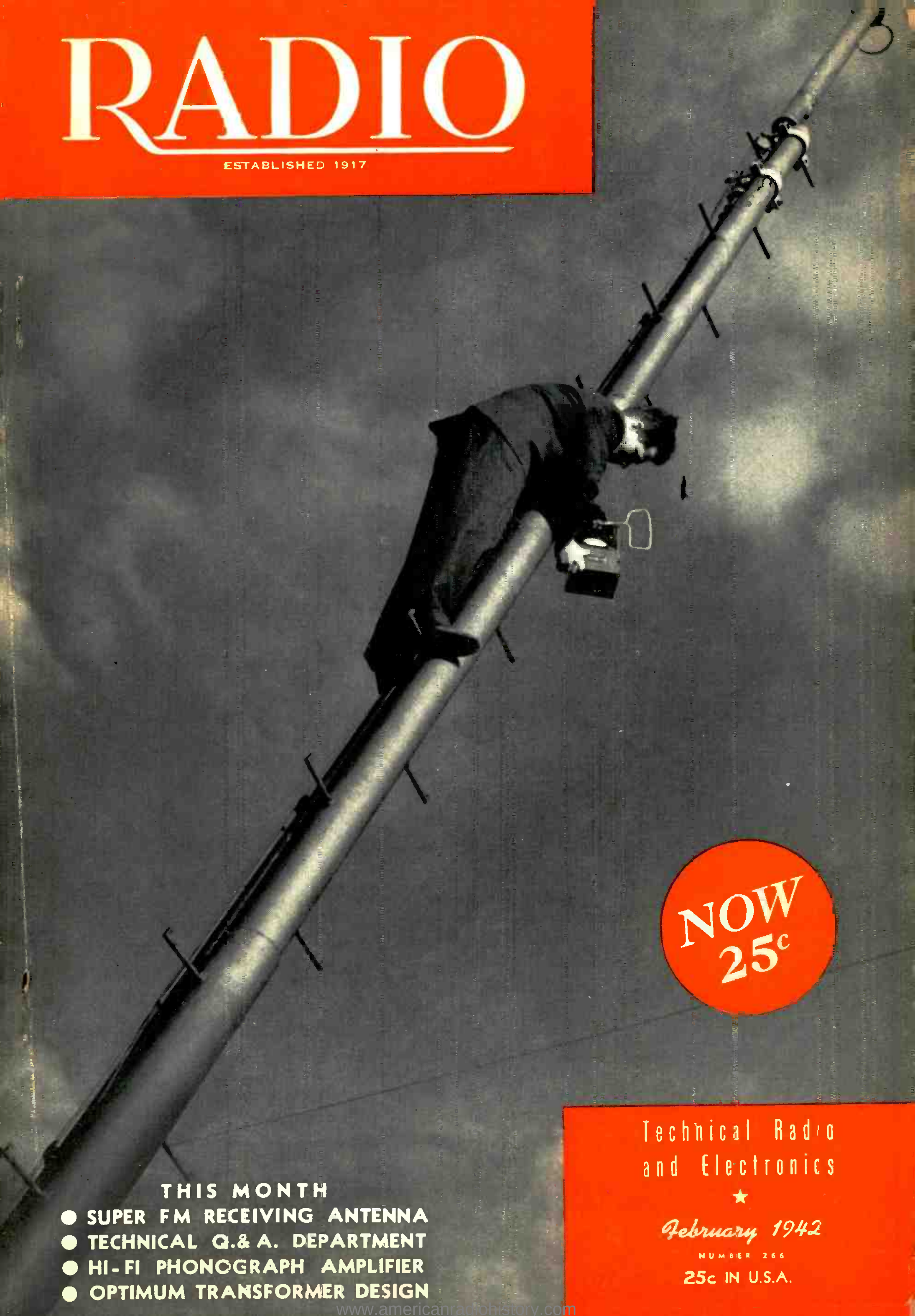
RADIO

ESTABLISHED 1917



NOW 25c

Technical Radio and Electronics

★

February 1942

NUMBER 266

25c IN U.S.A.

THIS MONTH

- SUPER FM RECEIVING ANTENNA
- TECHNICAL Q.& A. DEPARTMENT
- HI-FI PHONOGRAPH AMPLIFIER
- OPTIMUM TRANSFORMER DESIGN

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Past Present and Prophetic

War of the Electrons

It looks as though radio and electronics are going to play an even bigger part in the war effort than had been prophesied by the less conservative. It behooves every radio man not already holding down a job important to defense to offer his services. For men with families, older men, and men with minor physical handicaps, there are many civilian and Civil Service jobs which offer the opportunity to "do something worthwhile."

While it is an admirable trait to want to get into the actual fighting, it must be remembered that for every man on the battle line there must be several behind the lines, and the work done by the latter is just as important even if not as dangerous.

We hope that every one of our readers will investigate thoroughly every call for men with knowledge of radio and electronics, in order to determine where his talents can do the most good. First go through the last few issues of RADIO and *QST*. Then go to your local postoffice and check on the latest Civil Service announcements.

• • •

Rumors of Rumors

Life magazine, in its issue of January 2, takes a left handed slap at the Honolulu radio amateurs, who are reported to have disseminated exaggerated reports of the damage done by the Jap sneak attack. If the report is true, it is to be deplored. But we shall reserve judgment until more evidence is to hand. We haven't yet run across anyone who heard any of the K6 amateurs passing out anything on December 7th that sounded like the voice of doom. But maybe the calamity howlers were on the low frequency bands, or maybe the skip wasn't just right.

Anyhow, let's hope the report of exaggeration is exaggerated.

Shrunk But Not Sunk

Probably the first thing you noticed about this issue of the magazine is that we have lightened ship and trimmed our sails. We hope that our readers won't be too disappointed at the reduction in pages. All we can say is that a careful survey of the situation made the reduction appear to be a wise move, for a number of pertinent reasons.

• • •

Not Asleep

Several of our readers wrote in after receiving their January issue to inquire as to whether we had heard that war had been declared.

We can merely point out that RADIO, like practically all monthly technical magazines, goes to press about three weeks before copies are on the newsstand or in the hands of subscribers. About all we could have done would have been to include a last minute "flash insert," and as there was no good reason for our doing so except to acknowledge the existence of the war, we thought we might as well save the paper.

• • •

Standardization for Defense

Most of our amateur readers are probably aware by now that the A.R.R.L. is sponsoring a "U.H.F. Standardization Campaign." The purpose of the plan is to make the separate units of 112 Mc. emergency stations, as constructed by individual amateurs, universally interchangeable through the use of a standard system of plug and socket cable connections and the adoption of standard voltages and currents. A "standard" receiver, transmitter, and power pack design is recommended for those who have not yet built their equipment. Those already possessing equipment need not rebuild it to conform unless they wish; instead they may simply change over the power connections to conform to the standard practice.

The idea is a fine one, and we heartily indorse it. However, we want to make sure that when we show a u.h.f. receiver or u.h.f. antenna our readers don't get the idea that we are evidencing lack of cooperation with the plan. The A.R.R.L. has stated that they are not trying to "freeze" all u.h.f. design and thereby hamper technical progress. Such would be the height of foolishness.

The idea is to have a "standard" rig on hand and ready to go at all times. If you want to build something different, or do a little experimenting, that is all well and good. Just make sure that you don't rob something from the "standby" emergency rig to get your latest brainstorm finished.

RADIO

the worldwide authority . . .

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DEPARTMENTS

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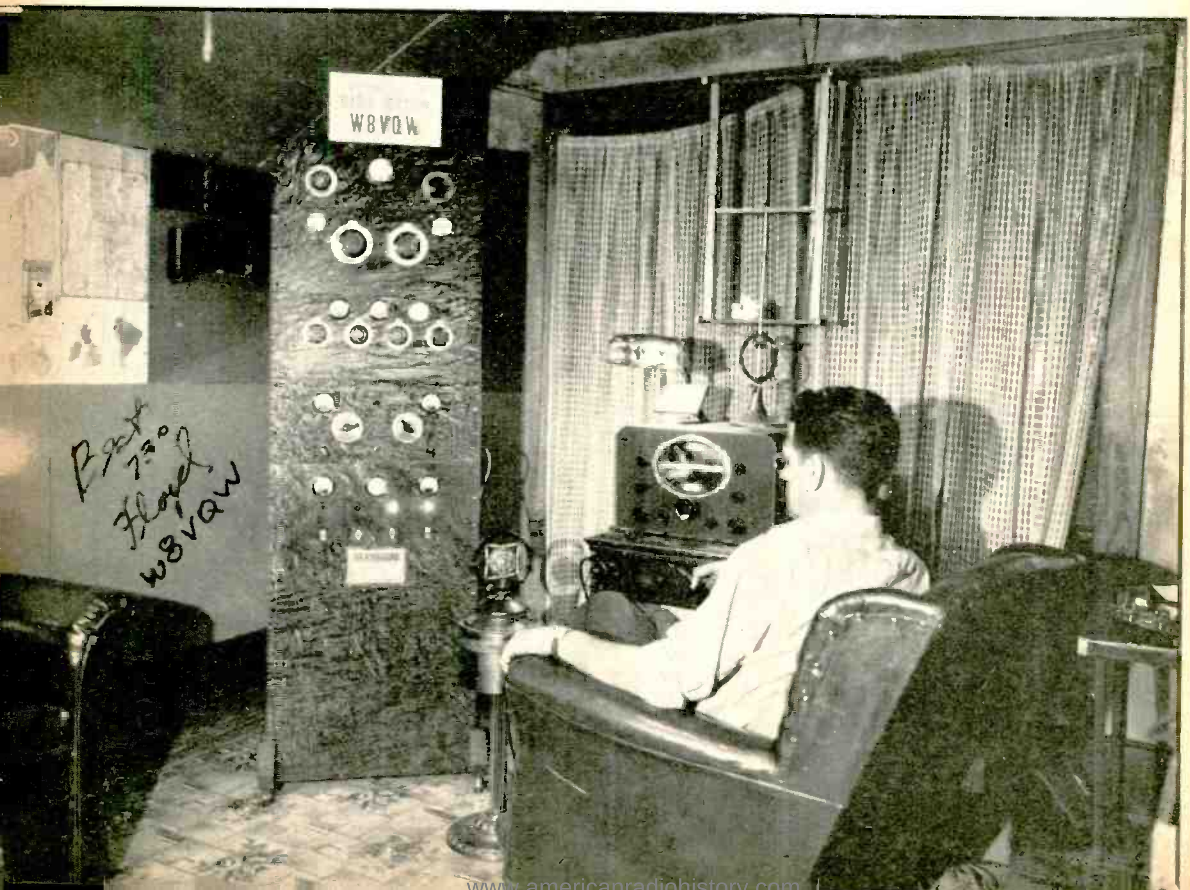
IN THE MOTHBALLS . . .

Temporarily out of normal amateur service for the duration are these three excellent amateur installations. We hope that their facilities will be made available and will be of service to integrated local defense agencies.

Above—W7AEF, Portland, Oregon. Bill and Jean Lucas had been active for the last fifteen years. Left—W5ALA, Dallas, Texas. Jack Moore has been operating this commercial-unit station, with a Hallicrafters HT-9 transmitter and SX-28 receiver, primarily on ten and one-sixty with separate antennas for each band. Below—W8VQW is operated by Floyd Gleason in Holland, Michigan.



A High-Fidelity

PHONOGRAPH AMPLIFIER

By RAY L. DAWLEY,* W6DHG

Describing a sure-fire high-fidelity phonograph amplifier which is very flexible in regard to the components used. The amplifier can, for the most part, be made up from the assortment of parts on hand in the usual amateur's or experimenter's workshop. Degenerative feedback has been incorporated into the design.

Now that the amateurs are, for the most part, off the air and the amateur recording fiends are faced with a shortage of new equipment and blanks, such time as can be spared from defense work will be diverted into new channels. One field of activity which seems to be attracting the interest of a goodly number is the building of high-fidelity phonograph players from such equipment as is on hand or can be borrowed or obtained from the rather depleted stocks of the parts supply houses.

Two of the essential components of the phonograph player can be constructed by the amateur or experimenter: the amplifier and the speaker housing. The different types of speaker housings were described by Gilbert[1] in the December issue of RADIO, and the construction of a simple amplifier that almost every experimenter can build from parts on hand is described herein. It is assumed that a good sized loudspeaker (12″ or greater cone diameter) of modern design will be used and that a good crystal pickup with low needle point damping will be employed.

The Output Stage

The design of any audio amplifier hinges, quite naturally, upon the type of output power amplifier stage that is to feed the loudspeaker. All the other sections of the unit—voltage amplifier, phase inverter, and power supply—will then be designed around the excitation voltage and plate power requirements of the power stage.

In the course of casual experimentation to determine a satisfactory output amplifier arrangement, quite a large number of different tube combinations and circuits were lashed up. Naturally, the first tubes tried were beam tetrodes, 6L6's and 6V6's. The high power sensitivity of these tubes, plus their high power output and reasonable plate power requirements, made it appear at first that they would be the ideal combination. Preliminary tests showed that all the above suppositions were true, and in addition showed that distortion arising from the stage could be cut down to a negligible amount through the use of degenerative feedback.

But when the checkups were made upon the frequency response of the tetrode amplifier, the results were not quite so encouraging. True, the highs were good, their normal predominance in a tetrode amplifier being flattened out by the feedback. But the low frequencies, considering the medium-priced output transformer and speaker we were using, were not satisfactory. The amplifier was good down to about 60 cycles (it was considerably down at this point without the feedback) but below this point the waveform rapidly approached a sawtooth form and the amplitude dropped. This

*Editor, RADIO

[1]Gilbert, "Baffling the Loudspeaker." RADIO, December, 1941, p. 32.

type of result would have been considered satisfactory for a medium-priced broadcast receiver or record player but since we were just experimenting it was decided to see what could be done with the same power supply, output transformer, and speaker using triodes in the output stage.

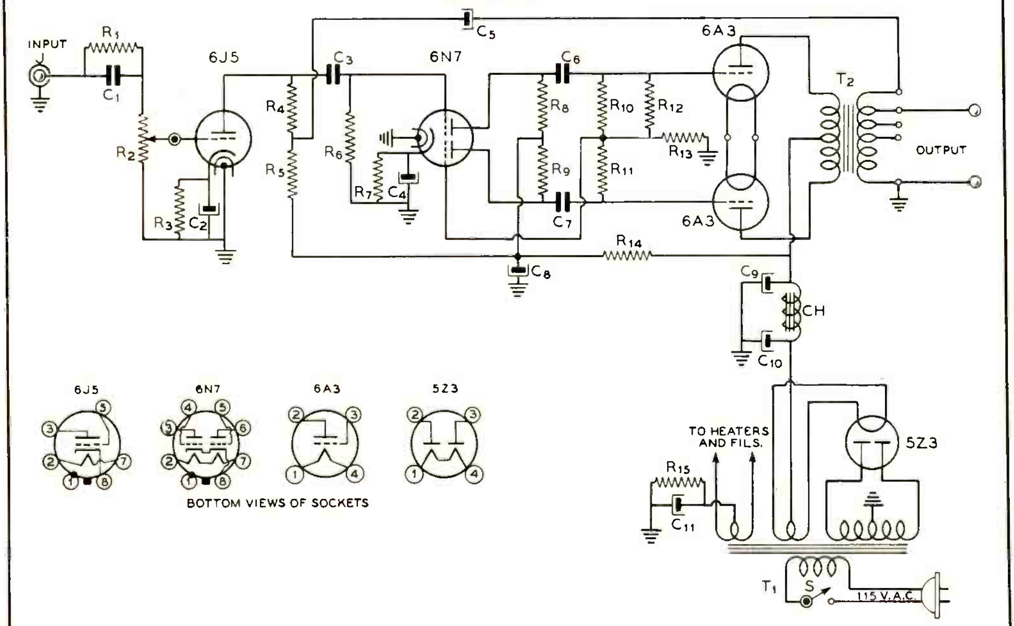
A pair of 2A3's were used in the first version of the amplifier, without feedback and with the same phase inverter (a 6SC7 was being used as phase inverter). An improvement in response was immediately apparent; the low frequency response was substantially flat down to 30 cycles and the highs were as good as had been obtained with the tetrodes and feedback. But we immediately ran into difficulty in obtaining sufficient voltage output from the phase inverter to excite the grids of the 2A3's.

Phase Inverter Circuits

A pair of 2A3's require a peak grid-to-grid swing of about 140 volts. This means that each side of the phase inverter must be capable of putting out about 70 volts without distortion at the lowest and highest frequencies to be handled by the amplifier. An inspection of the Resistance-Coupled Amplifier Chart in the RCA Receiving Tube Manual shows that about the only triode which is capable of delivering this output voltage, at 300 applied plate volts, is one section of the 6N7. With a supply voltage of 300, a plate load resistance of 100,000 ohms, and a grid leak on the next tube of 250,000 ohms, each section of the 6N7 has a voltage output of 83 volts. This value gives a satisfactory safety factor over the 70 volts or so actually required.

Several phase-inverter circuits were tried, but the conventional "self-balancing" circuit was found to be the most satisfactory for an output voltage of the magnitude required above. But it is important to note that this so-called "self-balancing" circuit will only give the same voltage on each grid of the output stage when the proper resistor values have been used. Once the proper resistor values have been determined the circuit is actually self balancing regardless of supply voltage variations and small differences in tube characteristics.

The phase inverter circuit is really comprised of the essential resistors R_8 through R_{13} in the main circuit diagram. It is the value of these various resistors which determines the effectiveness with which the circuit operates. The most satisfactory manner in which to get the circuit operating properly is to check the amplifier with a constant tone of about 400 cycles on the input, and with R_{12} removed from the circuit. An oscilloscope will usually indicate (assuming that R_8 and R_9 are the same and that R_{10}



Wiring diagram of the wide-range phonograph amplifier.

C_1—.0005-µfd. mica
C_2—10-µfd. 25-volt electrolytic
C_3—.05-µfd. 600-volt tubular
C_4—25-µfd. 25-volt electrolytic
C_5—8-µfd. 450-volt electrolytic
C_6, C_7—0.1-µfd. 600-volt tubular
C_8, C_9—8-µfd. 450-volt electrolytic
C_{10}—8-µfd. 600-volt electrolytic
C_{11}—50-µfd. 100-volt electrolytic
R_1—500,000 ohms, ½ watt
R_2—250,000-ohm potiometer
R_3—2500 ohms, ½ watt
R_4—60,000 ohms, ½ watt
R_5—25,000 ohms, ½ watt
R_6—500,000 ohms, ½ watt
R_7—1500 ohms, 1 watt
R_8, R_9—100,000 ohms, 1 watt
R_{10}, R_{11}—250,000 ohms, ½ watt
R_{12}—500,000 ohms, ½ watt
R_{13}—100,000 ohms, ½ watt
R_{14}—10,000 ohms, 10 watts
R_{15}—750 ohms, 10 watts
T_1—750 c.t. 100 ma., 6.3 v. 3.5 a., 5 v. 3 a.
T_2—5000 ohms plate-to-plate, tapped voice coil secondary
CH—15 hy. 125-ma. choke
J—Input jack
S—A. c. line on-off switch

and R_{11} are the same value) about 20 per cent more voltage from the grid of the top 2A3 (in the diagram) to ground than from grid-to-ground on the other tube. For exact balance in the circuit it is necessary that R_{10} (or the parallel combination of R_{10} and R_{12}) be somewhat *lower* in resistance than R_{11}. The exact value for these two resistors can be determined mathematically[2], but the normal tolerance in resistors is great enough so that the adjustment is best made experimentally. In fact it is only necessary to place different values of resistance at R_{12}, continually checking the ratio of the two 2A3 grid-to-ground voltages with an oscilloscope, until an exact balance is obtained.

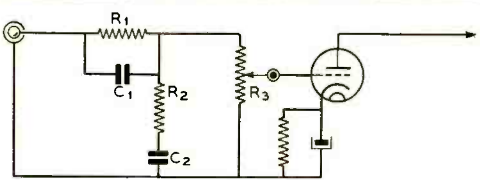
In two of the amplifiers built following this circuit diagram the values for the three resistors given in the caption to the wiring diagram were found to give equal voltages (resistors R_{10}, R_{11}, R_{12}). But in the amplifier shown in the photograph the use of the additional resistor was eliminated by using selected "250,000-ohm" resistors for R_{10} and R_{11}. By using a so-called ¼-meg. resistor at R_{10} that was somewhat low and another ¼-meg. at R_{11} that was somewhat high it was possible to obtain an exact balance. But unless one has quite a selection of resistors the additional resistor R_{12} is the simplest way of obtaining a balance.

[2]Wallman, "Perfect Balance Self-Balancing Phase Inverter," RADIO, October, 1941, p. 46, December, 1941, p. 62.

Degenerative Feedback

Although degenerative feedback is not generally used with triode push-pull class A amplifiers, it was decided to incorporate some feedback into this amplifier to see what benefits would be obtained. The results have been quite satisfactory. It was possible to use about 10 db of feedback with the circuit shown in the main diagram. Hum, tube noises and distortion within the feedback loop were reduced by the amount that would be expected with this amount of degeneration.

However, a considerable amount of difficulty was experienced in determining a feedback circuit that could be used with a circuit arrangement of this type. At first it was thought that it would be possible to use a dual cathode tube for the phase inverter. But no dual cathode tube (which would allow the use of feedback to the cathode of the first section of the phase inverter) was available which would deliver sufficient peak voltage output to excite the grids of the 2A3's. So it became necessary to return the feedback energy ahead of the phase inverter. Feedback was at first attempted in the cathode of the 6J5 first amplifier. This proved unsatisfactory; there was too much phase shift throughout the amplifier and output transformer and instability resulted.



Equalizer circuit for high-frequency compensation and bass boost.

R_1—500,000 ohms, ½ watt; R_2—100,000 ohms, ½ watt; R_3—500,000-ohm potentiometer; C_1—.0005-µfd.; C_2—.003-µfd.

The feedback circuit that did prove satisfactory is the one shown in the amplifier circuit diagram. Voltage is returned from a high-impedance tap on the output transformer to the decoupling condenser in the 6J5 plate feed circuit. If a sufficiently high impedance tap is available on the output transformer it will be possible to use 10 db of feedback with this circuit with perfect stability. With this amount of degenerative feedback in the amplifier the amount of input voltage required on the grid of the 6J5 (about ¾ volt peak) is a little more than three times that required without feedback—for full output from the 2A3's. With this amount of feedback in the amplifier it is substantially flat in response, within 2 db, from 20 to 20,000 cycles and the waveform is perfect over this range. The response is down about 3 db at 16 cycles, but the waveform is still very good.

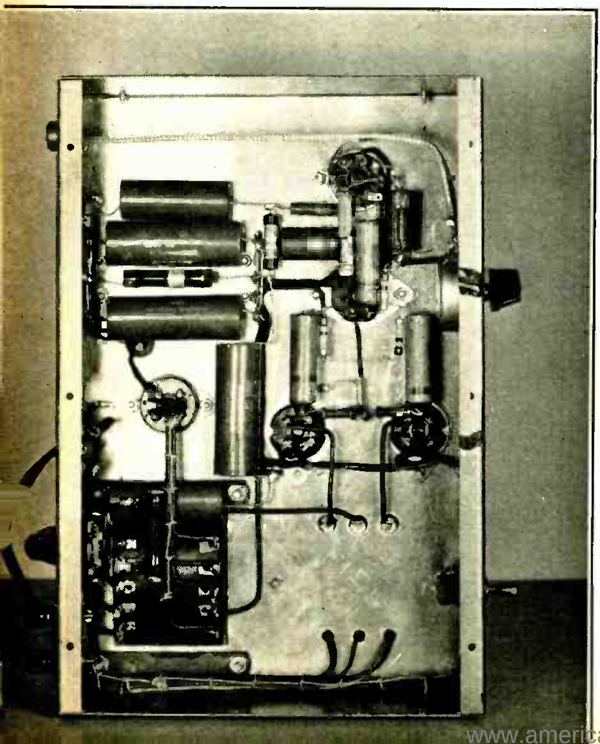
Naturally, as is the case with all feedback circuits, the voltage that is returned must be of the proper phase for degeneration. But we have the advantage in determining the proper polarity that it is a go or no go proposition. If the polarity is incorrect a violent oscillation will be set up in the amplifier. In this particular circuit arrangement it will then be necessary to ground the other end of the output transformer secondary winding, and then take the feedback voltage from the end of the winding which was previously grounded. If this procedure would be inconvenient (due to a tapped voice coil output transformer) the two primary leads that go to the plates of the 6A3's or 2A3's should be reversed.

Power Supply

A pair of 2A3's, 6A3's, 6B4-G's, or 6A5-G's are rated at a plate voltage of 300 to 325 volts and a plate current of 80 ma. The 2A3 filaments require a 2½-volt supply at about 5 amperes, while the other three types require a 6.3-volt supply at about 2 amperes. From this data it can be seen that any small b.c.l.-type power transformer capable of about 100 ma. drain with 350 to 375 volts each side of center on the high voltage winding will be capable of handling the amplifier. If the transformer is a 2½-volt one 2A3's can be used, with a 53 phase inverter and a 56 or triode 57 as the first amplifier. Or a small 6.3-volt filament transformer may be used to supply the first amplifier and the phase inverter while running the 2A3 filaments from the power transformer.

Of the three amplifiers so far constructed, all have operated identically with the exception of the power output and the extreme low fre-

[*Continued on Page 53*]



Notice the simplicity of construction evident in this underchassis photograph.

A "SUPER DX ANTENNA"

For F. M. Reception

When one is located but a few miles from f.m. broadcast stations, almost any receiving antenna will give good results. Even a loop or indoor antenna will prove satisfactory. But for the suburban resident who is 50 miles or more from the city, with possibly some hills intervening, the best antenna is none too good. To get the full benefits of f.m., the signal must be comfortably above the "threshold" level, giving definite limiter action.

Unlike high-power a.m. stations, f.m. stations usually are right in the city or not far out. This means that when the owner of an f.m. receiver is located 50 or 100 miles from a single large city, all the f.m. stations will be within a few degrees of one direction. This permits one to make use of a highly directional antenna without the need for its being rotatable.

The customary "deluxe" f.m. antenna installation for dx reception consists of a horizontal dipole, as high as possible, with a single reflector or director and rubber-covered twisted pair feed line. This antenna has several shortcomings. First, it does not have very much gain over a simple dipole to begin with, the reflector or director providing only 4 or 5 db gain at most. Secondly, the twisted pair transmission line has so much loss at these frequencies that any advantage gained by placing the antenna high in the air is largely offset by the losses in the transmission line. And thirdly, the antenna cannot be made to work over the whole f.m. band with anything approaching equal effectiveness. When the director or reflector is adjusted for maximum gain at the center of the f.m. band, the pick-up at either edge of the band will be no better than that of a simple dipole without reflector or director.

The antenna illustrated in the accompanying diagram has so much gain that a signal which is insufficient to provide satisfactory limiter action on a dipole antenna will permit first class "program" quality when this antenna is employed. Technically it is known as one variation of the Sterba "barrage" or "curtain," and has a pattern like a *very sharp* figure "8."

Construction

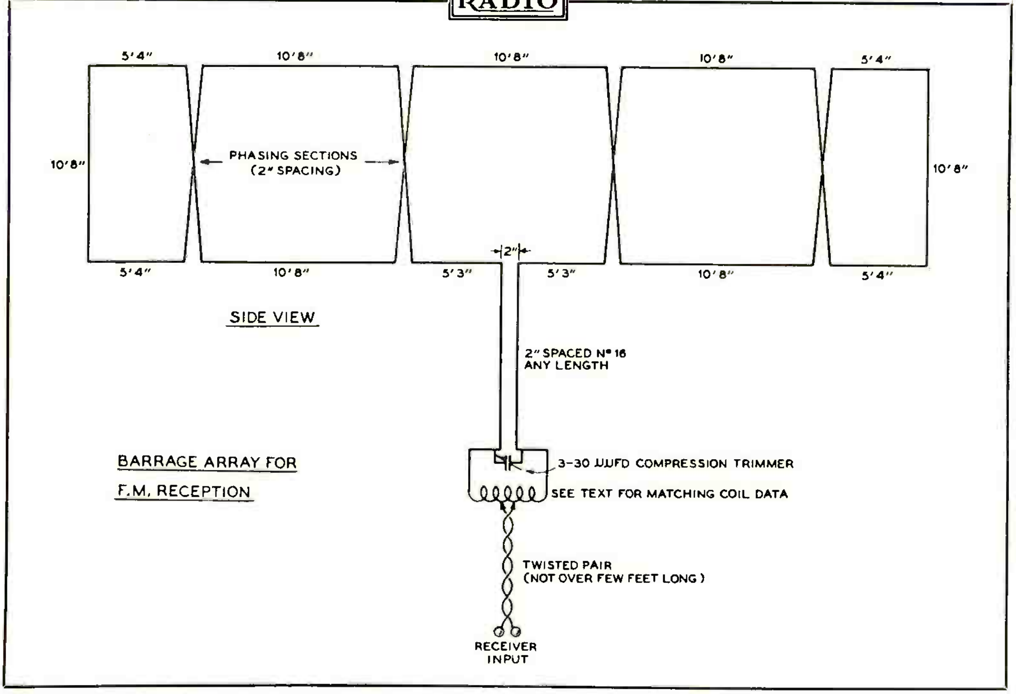
The antenna is not expensive of construction, considering the results it provides, and the only disadvantages are its size and the fact that it is effective only over a very narrow arc. The array is highly directional broadside, and stations which are not within 10 degrees of a right angle with the array will be noticeably weaker, and those more than 20 degrees off the nose of the "beam" will be very weak.

The antenna must be oriented very carefully, because of its high directivity. In orienting the array, one should not forget the distinction between true north and magnetic north, as this difference may be sufficient to throw the beam out of whack. A span of at least 45 feet between poles is required.

Because the antenna has very high radiation resistance, neither the voltage nor current reaches a very high value. This means that losses will be low, even though conductors and insulators may not be of the highest quality. For instance, if copper wire is not available, galvanized iron wire may be used, with an imperceptible loss in gain. If galvanized iron or copper clad steel wire is used, no. 14 will be satisfactory for the antenna proper. If solid copper is used, no. 12 is preferable, as no. 14 will have a tendency to stretch with time if the array is pulled tight. This will throw the resonant frequency lower.

No. 16 copper wire, spaced 2 inches, is used for the feed line. This line may be made any reasonable length with negligible loss. Two-inch ceramic spreaders are inexpensive and may be used both for the feed line and the phasing sections. Be sure to note that each phasing section is transposed *once,*—that is, that the wires cross over.

Two-inch spreaders may be sawed out of



⅛-inch sheet Lucite if desired, or if difficulty is experienced in obtaining suitable ceramic spreaders. Commercially manufactured Lucite spreaders are available, but are more expensive than the ceramic type. Spreaders should be spaced not more than 18 inches unless especial care is taken to prevent the feeder wires from twisting on themselves and shorting out during a high wind.

While it is advantageous to place the array as high as possible, excellent results will be obtained if it is placed only high enough to be clear of trees and other surrounding objects. Because of the very high radiation resistance of the antenna, two highly important advantages are realized: The antenna tunes very broadly, giving uniform response over the whole f.m. band when cut for the middle; and a low loss open wire transmission line may be used without the need for a matching section. The radiation resistance is of the same order as the characteristic surge impedance of the open wire transmission line, and therefore the transfer efficiency is high.

Most f.m. receivers are designed with low impedance doublet input (50 to 100 ohms), so that they may be used with a twisted pair line. To provide an efficient match and minimize standing waves on the transmission line, a tuned autotransformer is needed at the receiver. This may consist simply of a small, tapped coil shunted with a 3-30 μμfd. ceramic type compression mica trimmer. The coil may consist of 8 turns of bare copper wire 1 inch in diameter and spaced to a length of 1 inch. A ceramic or polystyrene coil form should be used, and the coil should be tapped every turn.

A short length of twisted pair is connected to the receiver input and tapped one turn each side of center on the matching coil. A station near the middle of the f.m. band is tuned in and then the ceramic trimmer is adjusted by means of an insulated trimmer tool for maximum pickup as indicated by maximum limiter action. (This may be indicated by a magic eye on the receiver or by a high resistance voltmeter connected to read the bias developed by the limiter.)

The adjustment will be very broad, and when set for the center of the band will hold satisfactorily over the whole band. The taps on the matching coil then are adjusted for maximum pickup. This is done by moving them in and out, keeping them the same distance from center, until the best adjustment is obtained. Each time the taps are altered, it is a good idea to retrim the condenser, just to be on the safe side. A regular screwdriver should not be used for this adjustment, as the metal will detune the condenser slightly when touched to the metal adjusting screw.

While this adjustment procedure may sound formidable, it may be done in less than 20 minutes, and has to be done only once.

Q. & A. STUDY GUIDE

Covering Radio Theory and Practice

(A MONTHLY FEATURE)

CONDUCTED BY W. W. SMITH

In acquiring a knowledge of any art, the student is aided greatly by a correlated "self-quiz." It is for this reason that school textbooks usually contain a set of pertinent review questions at the end of each chapter.

The following questions are taken from the F.C.C. Study Guide for commercial radio operator examinations, and constitute an excellent self-quiz regardless of whether or not the student intends to take the examination for a commercial license. Only the technical questions are included.

It will be noted that the answers include a comprehensive explanation of the answer and its method of derivation, except in a few cases where the answer is self-explanatory. This department is not being run with the express purpose of enabling a student to obtain a commercial license with the least possible study, but rather to help the student to enhance his knowledge of the radio art.

When all technical questions in the F.C.C. Study Guide have been covered, appropriate questions similar in scope will be originated in order to permit continuance of the department as a monthly feature.

ELEMENT 2

(First Installment)

(01) By what other expression may a "difference of potential" be described?

Difference of potential is most commonly known as "voltage" or "voltage difference."

(02) By what other expression may an "electric current flow" be described?

An electric current flow is a flow of electrons, the rate of flow being designated as the *amperage*.

(03) Which factors determine the amplitude of the e.m.f. induced in a conductor which is cutting lines of magnetic force?

The amplitude of the e.m.f. is determined by the rate at which the conductor cuts lines of force. This in turn is dependent upon the flux density, the speed of travel of the conductor with respect to the lines of force, and the direction of travel of the conductor with respect to the direction of the lines of force. Obviously a conductor traveling at uniform speed will cut the maximum number of lines of force (assuming uniform flux density) if the conductor is traveling at right angles to the lines of force.

(04) Name four methods by which an electrical potential may be generated.

1. Battery or cell (chemical).
2. Generator of dynamo type (mechanical).
3. Photo cell of photo-voltaic type (light).
4. Thermocouple (heat).
5. Generator of static machine type (friction).
6. Generator of piezoelectric type (pressure).

(05) If the diameter of a conductor of given length is doubled, how will the resistance be affected?

When the term "resistance" is not qualified, it refers to d.c. resistance. The d.c. resistance of a conductor of given length and uniform cross section varies inversely as the *area* of the cross section. Thus, if the diameter of the conductor is doubled, the cross section will be quadrupled and the resistance will be $\frac{1}{4}$ as great.

(06) If the value of a resistance, to which a constant e.m.f. is applied, is halved, what will be the resultant proportional power dissipation?

Power is equal to E^2/R. Therefore the power is inversely proportional to the resistance for a given e.m.f. Hence, if the resistance is halved, the dissipation will be doubled.

(07) What method of connection should be used to obtain the maximum no-load output voltage from a group of similar cells in a storage battery.

The cells should be connected in series.

(08) What is the sum of all voltage drops around a simple direct-current series circuit, including the source?

Considering the voltage drops algebraically (the drops in the external circuit as positive and the internal generator drop as negative) the sum is zero. (Kirchhoff's second law.)

(09) What method of connection should be used to obtain the maximum short-circuit current from a group of similar cells in a storage battery?

Short-circuit current is inversely proportional to the internal resistance of a cell. By connecting similar cells in parallel the internal resistance is reduced correspondingly and the short circuit current will therefore be maximum.

(10) If the value of a resistance, across which a constant e.m.f. is applied, is doubled, what will be the resultant proportional power dissipation?

The amount of power dissipated as heat will be cut in half. (Refer to answer 06.)

(11) Name four materials which are good insulators at radio frequencies. Name four materials which are not good insulators at radio frequencies, but which are satisfactory for use at commercial power frequencies.

Some good r.f. insulators are polystyrene, Pyrex, quartz, isolantite and steatite. These are good even at u.h.f. Ordinary porcelain and clear mica are good insulators at radio frequencies if the frequency is not in the u.h.f region.

Power frequency insulators considered inferior at radio frequencies are empire cloth (varnished cambric), shellac, transformer oil, paraffin, and electrical slate.

(12) Explain the factors which influence the resistance of a conductor.

The resistance is determined by the composition of the conductor, by the cross sectional area of the conductor, by the length of the conductor, and by the temperature of the conductor. The latter is determined not only by the ambient temperature, but also by the power dissipated in the conductor. The resistance of an ordinary Mazda lamp filament at room temperature is less than half the resistance of the filament when dissipating its normal wattage.

(13) What effect does the cross-section area of a conductor have upon its resistance per unit length?

Refer to answer 05.

(14) Name four conducting materials in the order of their conductivity.

Silver, copper, aluminum, and iron.

(15) What effect does a change in the dielectric constant of a condenser dielectric material have upon the capacitance of a condenser.

The capacity of the condenser is directly proportional to the dielectric constant.

(16) Explain the effect of increasing the number of plates upon the capacitance of a condenser.

Increasing the number of plates will increase the capacity of the condenser. Assuming uniform plates and spacing, and neglecting the "stray" capacity of the condenser, the capacity is directly proportional to N — 1, where N is the total number of plates. Thus, a condenser with 3 plates has twice the maximum capacity of a similar condenser with 2 plates.

(17) State the formula to determine the capacitive reactance of a condenser.

$$X_c = \frac{1}{2\pi fC} \text{ ohms}$$

Where C is in farads
f is in cycles

(18) If the specific inductive capacity of a condenser dielectric material between the condenser plates were changed from 1 to 2, what would be the resultant change in capacitance?

When C.G.S. units are used, the specific inductive capacity is numerically equal to the dielectric constant. Therefore, the capacitance would be doubled.

(19) State the formula for determining (1) the amount of electricity a condenser will hold? (2) The energy stored in a condenser?

$$Q = CE$$

where Q is in coulombs
C is in farads
E is in volts

$$W = \frac{Q^2}{2C} = \frac{1}{2} E^2$$

where W is in joules
Q is in coulombs
E is in volts
C is in farads

(20) Neglecting temperature coefficient of resistance and using the same gauge of wire and the same applied voltage in each case, what would be the effect, upon the field strength of a single layer solonoid, of a small increase in the number of turns?

The strength of the magnetic field would not change. This will be apparent from study of the equation for m.m.f., M, due to an electric current:

$$M = 0.4\pi NI$$

where N is the number of turns
I is the current in amperes

The current will be inversely proportional to the resistance (number of turns). The reduction in current I and the increase in turns N would produce exactly equal and opposite effects.

(21) How will a magnetic compass be affected when placed within a coil carrying an electric current?

The north pole of the compass will be deflected toward the south pole of the coil if the current is sufficiently strong. (If the left hand is held so that the thumb is outstretched and parallel to the axis of the coil, with the fingers curled to indicate the direction of current flow around the coil, then the thumb points in the direction of the north pole of the coil.)

(22) What material should be used for shielding an r.f. magnetic field?

Metal having high conductivity, such as copper, should be used. The shield should be of heavy gauge and have no holes other than small ones for the connecting wires to the coil. When requirements are not stringent. thinner gauge metal or metal of lesser conductivity may be used in the interest of economy.

(23) What is the advantage to be gained by "bank winding" an inductance?

Bank winding permits a multi-layer coil having lower distributed capacity than a regular "back and forth" multi-layer coil.

(24) Which factors influence the direction of magnetic lines of force generated by an electromagnet?

The direction of the lines of force is determined by the direction which the current takes around the metal core. (Refer to answer 21.)

(25) Explain the meaning of and factors which determine the "Q" or "figure of merit" of an inductance.

The Q of an inductance is determined by its ratio of reactance to resistance. Because the resistance varies with frequency, the Q of a coil is not directly proportional to frequency. In an iron core coil the resistance is made up not only of losses in the wire, but also core losses.

The Q of an inductance is affected by: the wire size, whether the wire is solid or Litz, the kind of metal comprising the wire, the physical size of the whole inductance, the method of winding, the insulation of the wire, type of shielding, type of winding form, and frequency. An iron core inductance also is affected by the permeability of the core material and whether it is laminated or powdered, and also the thickness of the laminations and the size of the grains.

(26) Define the term "permeability."

The permeability of a material is an index as to its ability to conduct magnetic lines of force. It is the ratio of the magnetic flux density produced in the material to the intensity of the magnetic field, or to the magnetic flux density produced in air by the same field. Some materials conduct lines of force much better than air, others not as good.

(27) What unit is used in expressing the alternating current impedance of a circuit?

Impedance is a term combining resistance and reactance, and is expressed in ohms.

(28) What is the unit of resistance?

The ohm.

(29) Explain the meaning of the prefix "micromicrofarad".

The term "micro" means "one millionth." Therefore the prefix "micromicro" means "divided by a million million." One micromicrofarad is equal to 10^{-12} farads.

(30) What is the unit of capacitance?

The farad is the standard unit, but the *microfarad* (.000001 farad) is more commonly used.

(31) What instrument, alone, may be used to measure resistance? Electrical power? Electrical current? Electromotive force?

Resistance may be measured by an ohmmeter, power by a wattmeter, current by an ammeter, and e.m.f. by a voltmeter.

(32) Define the term "residual magnetism."

"Residual magnetism" is the magnetism existing in a body after removal of the magnetizing force.

(33) What is the unit of electrical power?

The watt.

(34) What is the unit of conductance?

The mho.

(35) What is the unit of inductance?

The henry.

(36) What is the meaning of the prefix "kilo"?

The prefix *kilo* indicates that the following term is to be multiplied by 1000. In other words, a kilowatt is 1000 watts.

(37) What is the meaning of the prefix "micro"?

The prefix "micro" indicates that the following term is divided by 1,000,000. For instance, a microfarad is .000001 farad.

(38) What is the meaning of "power factor"?

Power factor is a measure of the efficiency of an alternating current circuit or device. When voltage and current are 90 degrees out of phase, the work done is zero and the power factor is zero. When they are in phase the efficiency is the same as for a d.c. circuit, and the power factor is 1.

The power factor is obtained by dividing the true watts (as read on a wattmeter) by the apparent watts (as indicated by a voltmeter and ammeter).

Power factor also is used to indicate the goodness or "Q" of a coil or condenser. An ideal inductor or capacitor would have zero power factor.

(39) What is the meaning of the prefix "meg."?

The prefix *meg* indicates that the following term is to be multiplied by 1,000,000. For instance, a megohm is 1,000,000 ohms.

(40) Define the term "conductance."

Conductance is a measure of the ability of a circuit or device to conduct an electric current. The unit of measurement is the *mho,* or reciprocal ohm.

(41) What instrument is used to measure current flow?
An ammeter.

(42) Define the term "decibel."
The decibel is a unit used to express the ratio between two power or energy levels. As the unit indicates a ratio rather than absolute values, it is a logarithmic term. This simplifies electrical and sound calculations, where power ratios of several million are common.

A power ratio expressed as 10 times the common logarithm of the ratio gives the difference in decibels between the two power levels. The formula for conversion to decibels (db) is:

$$N_{db} = 10 \, Log_{10} \frac{P_1}{P_2}$$

Because multiplying the logarithm of a number by 2 is the same as squaring it, the formula for converting voltage ratios to decibels simply calls for the substitution of 20 for 10 in the formula, as follows:

$$N_{db} = 20 \, Log_{10} \frac{E_1}{E_2}$$

(43) What is meant by "ampere turns"?
The magnetic field or flux density produced by a current passing through a coil is proportional to the current times the number of turns in the coil. The magnetomotive force in gilberts is equal to 1.26 NI, where N is the number of turns and I the current in amperes passing through the coil.

(44) Define the term "inductance."
Inductance is that property of an electric circuit, usually a coil, which causes a current change through the circuit to produce an e.m.f. which opposes the current change. This *self induction* causes the current change to lag behind the voltage change producing it.

The unit of inductance is the *henry*. A coil has an inductance of one henry when a voltage of 1 volt is induced by a current change of 1 ampere per second.

(45) Define the term "coulomb."
A coulomb is an *amount* of electricity. If a current flows past a given point on a conductor for 1 second at the rate of 1 ampere, then 1 coulomb of electricity will have passed by the point.

(46) Define the term "power factor."
Refer to answer 38.

(47) What is the unit of magnetomotive force?
The gilbert. The m.m.f. may be determined from the ampere turns by multiplying the ampere turns by 1.26.

(48) Express 1 horsepower in watts.
One horsepower is equal to 746 watts.

(49) State the three ordinary mathematical forms of Ohm's law.

$$I = \frac{E}{R} \qquad R = \frac{E}{I} \qquad E = IR$$

(50) State Ohm's law.
In a d.c. circuit the strength of an electric current is directly proportional to the e.m.f. producing it and inversely proportional to the total resistance through which the current is flowing.

(51) If a vacuum tube having a filament rated a one-quarter ampere and 5 volts is to be operated from a 6 volt battery, what is the value of the necessary series resistor?
A fully charged "six volt" battery actually delivers more than 6 volts, but since modern vacuum tubes are designed to operate a few percent above or below the rated filament voltage, this need not be taken into consideration.

The resistor must provide a drop of 1 volt when ¼ ampere is flowing through it. From Ohm's law:

$$R = \frac{E}{I} \quad \text{or} \quad R = \frac{1}{0.25} \quad \text{or} \quad 4 \text{ ohms}$$

(52) If the voltage applied to a circuit is doubled and the resistance of the circuit is increased to three times its former value, what will be the final current value?
From Ohm's law we know that the current varies directly with voltage and inversely with the resistance. Increasing the resistance three times would reduce the current to one third its original value, while doubling the voltage would double this current to two-thirds its original value. Therefore the final current would be two-thirds its original value.

(53) If a relay is designed to operate properly from a 6 volt d.c. source, and if the resistance of the winding is 120 ohms, what value of resistance should be connected in series with the winding if the relay is to be used with a 120 volt d.c. source?
There are several ways to attack this problem, the following being as simple as any.

The voltage drop across resistances in series is proportional to the values of resistance, because the current through all series elements is the same. The voltage drop across the required resistor is to be 114 volts. Therefore,

$$\frac{120}{6} = \frac{X}{114} \quad \text{and} \quad X = \frac{13{,}680}{6} \quad \text{or } 2280 \text{ ohms}$$

(54) What should be the minimum power dissipation rating of a resistor of 20,000 ohms to be connected across a potential of 500 volts?
The wattage rating of a resistor ordinarily applies to "free air" operation (that is, with the resistor not confined to an enclosure which restricts the cooling). Assuming the resistor is operated in "free air," then the rating theoretically could be the same as the maximum dissipation. In actual practice, however, at least a 100 per cent safety factor usually is allowed.

The dissipation, W, is equal to I^2R, but the current is not given. It is determined from Ohm's law as follows:

$$I = \frac{E}{R} \text{ or } \frac{500}{20{,}000} \text{ or } 0.025 \text{ ampere}$$

$$I^2R = 12.5 \text{ watts}$$

Therefore, the dissipation is 12.5 watts. and in open air a 25 watt resistor is recommended. In a closed space a still higher rating would be desirable.

(55) If resistors of 5, 3, and 15 ohms are connected in parallel, what is the total resistance?

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = 1.66 \text{ ohms}$$

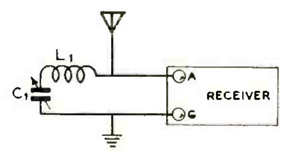
(56) What is the maximum rated current carrying capacity of a resistor marked "5000 ohms, 200 watts"?

$$W = I^2R, \text{ or } I = 0.2 \text{ amp.}$$

(57) Show how you would use a wave trap to exclude an undesired radio signal from a receiver.

Refer to diagram 57. The trap L_1C_1 should be resonated for minimum interfering signal.

57



(58) A milliammeter with a full-scale deflection of 1 milliampere and having a resistance of 25 ohms, was used to measure an unknown current by shunting the meter with a four (4) ohm resistor. It then read 0.4 milliamperes. What was the unknown current value?

The first thing to do is to find out how much current is flowing through the shunt when the meter is drawing 1 ma. (full scale). The total current will be this plus the meter current of 1 ma. From this figure the "multiplier" factor can be determined for the shunt, and then any current can be determined simply by multiplying the scale reading by the multiplier factor.

The currents through the resistances (meter and shunt) will be inversely proportional to their resistances. Or,

$$\frac{1}{I_S} = \frac{4}{25} \text{ and } I_S = 6.25 \text{ ma.}$$

The total current at full scale deflection then is 6.25 plus 1 or 7.25 ma. Thus the multiplier factor is 7.25, and when the shunted meter reads 0.4 ma., the current is 7.25 times 0.4 ma., or 2.9 ma.

(59) What will be the heat dissipation, in watts, of a resistor of 20 ohms having a current of one-quarter (1/4) ampere passing through it?

$$W = I^2R, \text{ or } 1.25 \text{ watts}$$

(60) If two 10 watt, 500 ohm resistors are connected in parallel, what is the power dissipation capabilities of the combination?

As long as the resistances are the same and the wattage ratings are the same, the permissible dissipation is doubled. Therefore in this case the dissipation capability is 20 watts.

(61) What is the formula used to determine the total capacitance of three or more capacitors connected in series?

$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots}$$

All terms must be expressed in same units: farads, microfarads, etc.

(62) What is the formula for determining the capacitative reactance of a condenser?

$$X_c = \frac{1}{2\pi fC}$$

where X_c is in ohms, f is in cycles, and C is in farads.

(63) If condensers of 1, 3, and 5 microfarads are connected in parallel, what is the total capacitance?

The resultant capacitance is the simple arithmetical sum of the individual capacitances, or 9 microfarads.

(64) What is the formula used to determine the total capacitance of three or more condensers connected in parallel?

$$C = C_1 + C_2 + C_3 \ldots$$

All terms should be expressed in the same units: farads, microfarads, etc.

(65) If condensers of 5, 3, and 7 microfarads are connected in series, what is the total capacitance?

Applying the formula given in answer 61, the resultant capacitance is 1.479 microfarads.

(66) The charge in a condenser is stored in what portion of the condenser?

The charge is stored in the dielectric in the form of an electrostatic field.

(67) Having available a number of condensers rated at 400 volts and 2 microfarads each, how many of these condensers would be necessary to obtain a combination rated at 1600 volts 1.5 microfarads?

Assuming that the condensers have exactly the same internal d.c. resistance, or that series elements are shunted by "equalizing" resistors, the voltage rating of several capacitors of equal capacitance and voltage rating is equal to the rating of one condenser times the number of condensers. Thus four, 2 microfarad 400 volt capacitors in series would have a voltage rating of 1600 volts, and the resultant capacity would be 0.5 microfarad. To obtain

1.5 microfarad at this voltage rating, three such series banks would have to be connected in parallel, calling for a total of 12 condensers.

(68) The voltage drop across an individual condenser of a group of condensers connected in series across a source of potential is proportional to what factors?

If the source of potential is d.c., then the voltage drop across each condenser is inversely proportional to the d.c. resistance of the condenser. (A good dielectric has very high resistance, but nevertheless it is not infinitely high.)

If the source of potential is a.c., the voltage drop across each condenser is determined primarily by the capacity, the drop being inversely proportional to the capacity. The d.c. resistance of the condenser is so high in proportion to the reactance of the condenser that the d.c. resistance has little effect upon determining the relative drop across each of several condensers in series when the source of potential is a.c.

If the source of potential is d.c. with an a.c. component, then the relative drop across each condenser is determined by both the d.c. resistance and the capacity. Which has more effect upon determining the relative drop depends upon the ratio of d.c. to a.c. which is applied to the bank of series connected condensers.

(69) What factors determine the charge stored in a condenser?

The condenser capacity and the potential to which the condenser is charged.

(70) Given two identical mica condensers of 0.1 μfd. capacity, each. One of these is charged to a potential of 125 volts and disconnected from the charging circuit. The charged condenser is then connected in parallel with the uncharged condenser. What voltage will appear across the two condensers connected in parallel?

The charge, Q, is equal to CE. Therefore, if the capacity is doubled, the charge being divided between the two condensers, the voltage is cut in half.

It should be observed that when charging the uncharged condenser no *electrons* are lost. They simply divide between the two condensers. However, half the stored *energy* is dissipated in the arc and resistance of the connecting leads at the time the second condenser is charged. Therefore the two 0.1 μfd. condensers will each have a 62.5 volt charge, but the total energy stored in both condensers will be only half as great as that contained in the single 0.1 μfd. condenser charged to 125 volts. Remember that the *energy* stored is proportional to the capacity times the *voltage squared.*

(71) State the formula which is used to determine the reactance of an inductance.

$$X_L = 2\pi fL$$

Where X is the capacitative reactance,

Where X_L is in ohms, f is in cycles, and L is in henries.

(72) What will be the inductive reactance of a 30 henry choke coil at 100 cycles?

Applying the formula of answer 71 will give 18,840 ohms.

(73) What is the effect of adding an iron core to an air core inductance?

The effect is to increase the inductance, the increase depending upon the type of core and the permeability of the core material.

(74) What will be the effect of a shorted turn in an inductance?

The effect will be to reduce the inductance, and to reduce the Q of the inductor. If there is close coupling between turns, so that the leakage reactance is low, an inductance with a shorted turn will have approximately the same inductance value as a similar inductance with two less turns. The shorted turn tends to nullify the inductance contributed by one active turn.

No d.c. will pass through the shorted turn, but if there is a strong a.c. potential or component across the choke, heavy a.c. current will flow in the shorted turn and it may overheat and cause the winding to burn out.

(75) What is the relationship between the number of turns and the inductance of a coil?

As the number of turns is increased, the inductance is increased. The exact relationship depends upon many factors, and most formulas require "correction factors."

If the winding length of a single layer solonoid is maintained constant, then the inductance is proportional to the square of the number of turns. However, when the turns spacing rather than the winding length is maintained constant, this no longer holds.

The inductance of a single layer solonoid having 20 turns of wire is approximately 2.5 times the inductance of a coil having 10 turns with the same diameter and turn spacing, or approximately 4 times the inductance of a coil having 10 turns with the same diameter and winding length.

(76) Define the term "reluctance."

Reluctance is equivalent to magnetic resistance, indicating the ratio of m.m.f. to magnetic flux. The unit of reluctance is the *oersted.* One oersted is the measure of reluctance offered by 1 cubic centimeter of air.

(77) What are some of the factors which determine the figure of merit or "Q" of an inductance?

Refer to answer 25.

(78) State the formula for determining the resonant frequency of a circuit when the inductance and capacitance are known.

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Where L is in henries and C is in farads

(79) What is the formula for determining the power in a d.c. circuit when the voltage and resistance are known?

$$P = \frac{E^2}{R}$$

where P is the power in watts, E is the voltage in volts, and R is the resistance in ohms.

(80) What is the formula for determining the power in a d.c. circuit when the current and resistance are known?

$$P = I^2R$$

(81) What is the formula for determining the power in a d.c. circuit when the current and voltage are known?

$$P = EI$$

(82) What is the formula for determining the wavelength when the frequency, in kilocycles, is known?

The wavelength in meters is equal to 300,000 divided by the frequency in kilocycles.

(83) What is the frequency corresponding to a wavelength of 375 meters?

The frequency in kilocycles is equal to 300,000 divided by 375, or 800 kilocycles.

(84) Define the term "apparent power."

"Apparent power" is a term used in a.c. circuits to indicate EI. Unless the power factor is unity, the apparent power is greater than the real power.

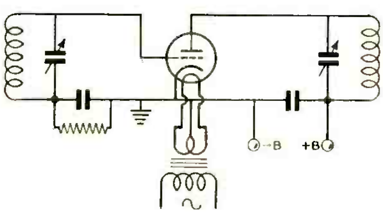
(85) State Ohm's law for a.c. circuits.

In an a.c. circuit the current varies inversely as the total impedance of the circuit and directly with the impressed voltage.

(86) Draw a simple schematic diagram showing a tuned-plate tuned-grid oscillator with series-fed plate. Indicate polarity of supply voltages.

Refer to diagram 86.

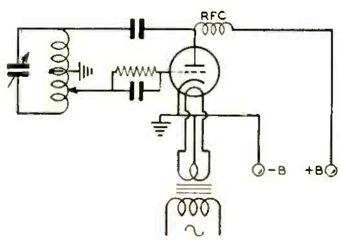
86



(87) Draw a simple schematic diagram showing a Hartley triode oscillator with shunt-fed plate. Indicate power supply voltages.

Refer to diagram 87.

87



(88) Draw a simple schematic diagram showing a tuned-grid Armstrong type triode oscillator, with shunt-fed plate. Indicate power supply polarity.

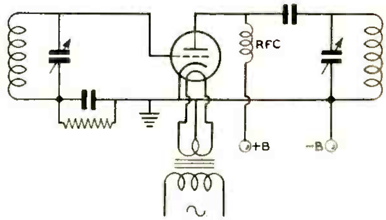
There are several modifications of the basic Armstrong oscillator circuit. The tuned-grid tuned-plate oscillator is commonly called the "Armstrong." A shunt fed oscillator of this type is shown in diagram 88-A. Another version, with plate tickler and shunt feed is shown at 88-B.

(89) Draw a simple schematic diagram showing a tuned-plate tuned-grid triode oscillator with shunt-fed plate. Indicate polarity of supply voltages.

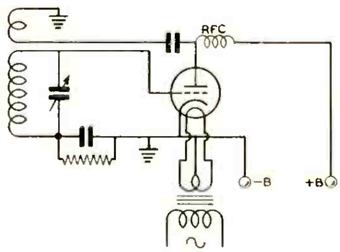
Refer to diagram 88-A.

88

A



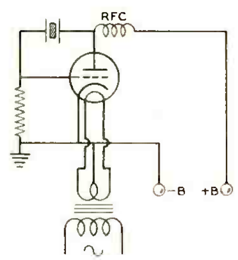
B



(90) Draw a simple schematic diagram of a crystal controlled vacuum tube oscillator. Indicate polarity of supply voltages.

A diagram of the Pierce crystal oscillator, the simplest crystal oscillator, is shown in diagram 90.

90



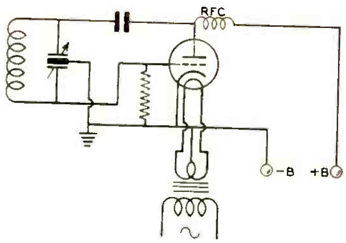
(91) Draw a simple schematic diagram showing a Colpitts type triode oscillator, with shunt fed plate. Indicate power supply polarity.

Refer to diagram 91.

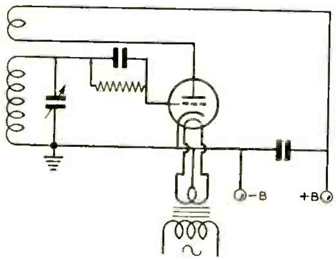
(92) Draw a simple schematic diagram showing a tuned-grid Armstrong type triode oscillator, with series fed plate. Indicate power supply polarity.

One such circuit is shown in diagram 86. Another is shown in diagram 92.

(91)

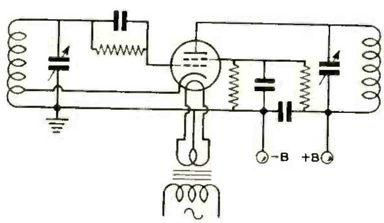


(92)



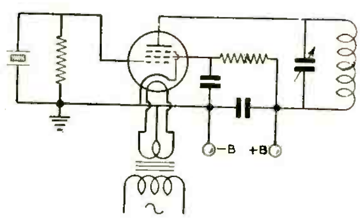
(93) Draw a simple schematic diagram of an electron coupled oscillator, indicating power supply polarities where necessary.
Refer to diagram 93.

(93)



(94) Draw a simple schematic diagram of a pentode type tube used as a crystal controlled crystal oscillator, indicating power supply polarities.
Refer to diagram 94.

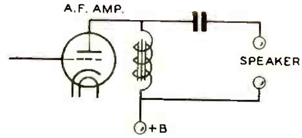
(94)



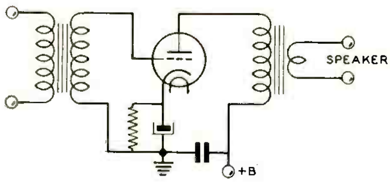
(95) Draw a simple schematic circuit showing a method of coupling a high impedance loudspeaker to an audio frequency amplifier tube without flow of tube plate current through the speaker windings, and without the use of a transformer.
Refer to diagram 95.

(96) Draw a simple schematic diagram of a triode vacuum tube audio amplifier inductively coupled to a loudspeaker.
Refer to diagram 96.

(95)

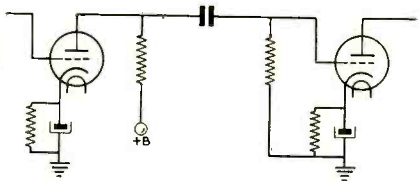


(96)



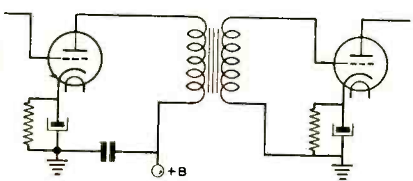
(97) Draw a simple schematic diagram showing a method of resistance coupling between two triode vacuum tubes in an audio frequency amplifier.
Refer to diagram 97.

(97)



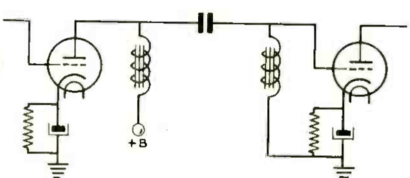
(98) Draw a simple schematic diagram showing a method of transformer coupling between two triode vacuum tubes in an audio frequency amplifier.
Refer to diagram 98.

(98)



(99) Draw a simple schematic diagram of a method of impedance coupling between two vacuum tubes in an audio frequency amplifier.
Refer to diagram 99.

(99)



(100) Draw a diagram of a method of coupling a single radio frequency amplifier using a triode vacuum tube to a push pull radio frequency amplifier using triode vacuum tubes, showing proper neutralization of the push pull amplifier.

[*Continued on Page 52*]

The Experimental Determination of Optimum Factors in the Design of a Transformer

By WILBUR E. GEMMILL,* W3AAO and
NELSON K. STOVER,** W3BBV

Not many of us have available the equipment that will enable us to determine the properties of core materials for constructing transformers, as outlined by Thomas A. Gross in his article in March, 1941 issue of RADIO. Probably also, many of us are a little rusty on the subject of a.c. measurements through which we passed in our trip through College. When a good core is available, one usually turns to the tables in the HANDBOOK for the necessary data to construct that needed transformer.

Most of us know the losses of a transformer are divided between the core and the copper, and that by using the proper sized copper wire, the losses due to the copper may be kept satisfactorily low. The control of core losses and the regulation of the finished transformer remain as problems about which we are vaguely cognizant, and about which we usually do little.

Mr. Gross points out in his article that if variable dissipations could be diminished even at the expense of slightly higher fixed losses, the regulation could be improved. Here is a way that this can be accomplished without a jot of worry about flux densities, hysteresis losses, or the permeance of the core material at hand. While in College, one of the writers, W3AAO, was taken on a tour of the GE works at Schenectady at the time the class was studying Electrical Measurements. There a Junior Engineer had before him a design that was being tried out. A few questions elicited the information that although the designs were based on sound engineering principles, the practicability of the various factors were actually tried out before the design was sent into the shop for production.

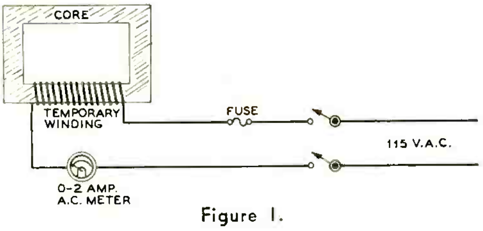


Figure 1.

The only instrument needed for this work is an a.c. ammeter of one or two amperes range, or an ac.. voltmeter of low range shunted with a resistor of a few ohms resistance, selected to give almost full scale deflection with about two amperes of current through the resistor.

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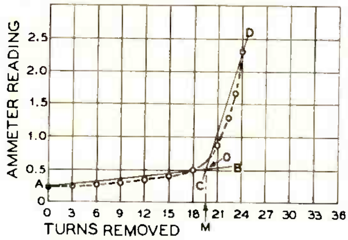
Suppose we have at hand a core of a burned out 500-watt transformer, or wish to make a 500-watt transformer from core material at hand. Measure the cross-sectional area of the available core; then, from the cross-section, look up in the tables in the HANDBOOK the number of turns that should be put on the core for the 115-volt primary winding. Using either bell wire or no. 18 d.c.c. wind this number of turns on a form of cardboard made to fit the core. Then insert the core material completely, being certain to interleave in order to have the lowest possible core reluctance. Then connect this winding up as in figure 1. A small circulating current will result. This represents the copper loss and the magnetizing energy.

We are now ready to determine the optimum factors to make a transformer. Provide a sheet of cross-section paper, marking ordinate in reading of the ammeter, and abscissa in number of turns removed. Note the above reading of the ammeter on the zero abscissa, which represents the current obtained with the full number of turns as taken from the HANDBOOK. Turn off the a.c., remove three turns, reconnect and note the ammeter reading on the cross-section paper at the 3-turns-removed point. Proceed thus, removing three turns at a time and recording the ammeter reading at each change, until a larger increase than before has been noted. The point of optimum number of turns for the magnetizing properties of the core material and cross-section are being approached. At this point remove a turn at a time. Finally, a point will be reached where single turn removals will give large increments of ammeter readings. Take readings until almost full scale of the ammeter is reached. If you now draw in a line connecting the various points, you will obtain a graph as shown by the dashed line of figure 2. With a straight edge draw in the lines A-B and C-D, through the average of the points of slight upward slope and the average of the points of steep slope. These lines will intersect at "O", and a vertical dropped from O to M will intersect the abscissa at M, which represents the number of turns that must be deducted from the data in the HANDBOOK Tables to obtain a transformer with lowest fixed and variable losses, and best regulation.

This procedure indicates the ease with which we may determine experimentally exactly the right number of turns for the least reactive component in the primary, and the minimum primary inductance.

One may proceed from this point, using the proper sized wire for the current to be delivered by the transformer, as taken from the HANDBOOK Tables. The corrected number



READINGS

TURNS REMOVED	AMMETER READING
0	0.25
3	0.26
6	0.27
9	0.30
12	0.33
15	0.40
18	0.50
21	0.90
22	1.30
23	1.70
24	2.30

WIND TRANSFORMER WITH NUMBER OF TURNS FROM HANDBOOK LESS THE NUMBER INDICATED AT "M". THIS GIVES THE CORRECTED NUMBER OF PRIMARY TURNS.

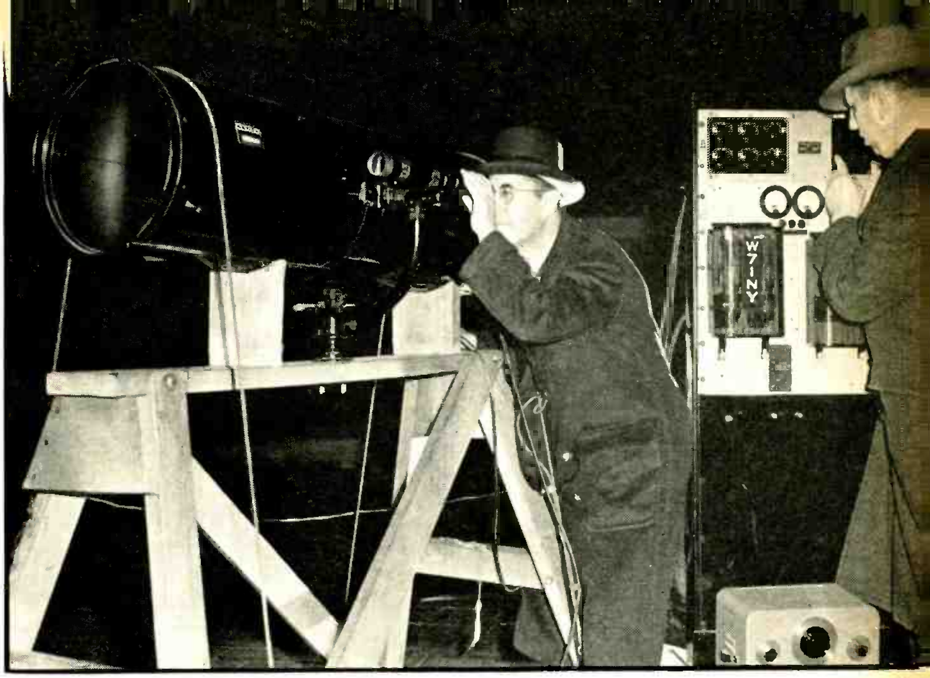
Figure 2.

of primary turns divided by the a.c. line voltage (115 v.) gives the volt-per-turn ratio, which in turn enables one to calculate all secondary windings.

Most of the power transformers on the market today are wasteful of materials, and are made with large safety factors. That is why the usual test instrument of the amateur, a screw driver, can be used to short out windings to determine continuity. Don't ever do it to a transformer wound according to this experimental method. You will ruin your tools and blow the fuses as well. Also never test a power supply by grounding the high voltage terminal when using one of these transformers. You will promptly spoil your 866's.

Sometimes it will be found that the window in the core is larger than necessary because of the increased volt-per-turn factor this method allows. This can be utilized for increased insulation, or larger wire sizes, thus further improving the regulation. Without exception, in the many transformers we have constructed by this method, their regulation was vastly better, and their power capabilities were increased. It is often possible to make a good 750-watt transformer from a commercial 500-watt core. We even made a transformer around an old filter choke from a receiver, using it to step up the 2.5-volt winding on the power transformer to 6.3 volts, in order to use 6-volt tubes on an otherwise good set with a 2.5 volt filament supply.

In use, it will be observed that transformers thus made will have excellent regulation, and that, if a low resistance filter choke is used, there will be little voltage drop when such transformers are used in class B Modulator supplies. They are about perfect to deliver the demands of class B peak audio swings. A note of caution should be sounded. Insulate the high voltage secondary windings and filament windings of rectifier circuits unusually well, or a breakdown will dump the local power house right in your shack.



For the dedication of the new W71NY transmitter a modulated light beam was used as a link to the WOR studios some distance away.

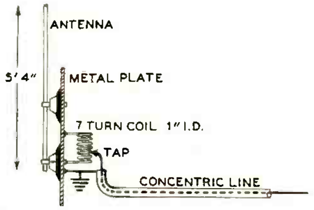
DEPARTMENTS

- **Police Department**
- **Sound Department**
- **The Amateur Newcomer**
- **U. H. F.**
- **Yarn of the Month**
- **What's New In Radio**
- **New Books and Catalogues**
- **Postscripts and Announcements**

POLICE DEPARTMENT . . .

MOTORCYCLE ANTENNAS

By H. W. BRITTAIN,* W6OQX



Simplified semi-schematic of the method of installing the antenna tuning circuit on the rear of the motorcycle.

In experimenting with motorcycle transmitters for police use some difficulty was experienced in getting an antenna that would load well without using a tuned network of some sort. A successful antenna system for a motorcycle must of necessity be as compact as possible, yet it must be efficient and employ very few parts. Naturally a self-resonant antenna would be the answer were it not for the fact that such an antenna is just too long for motorcycle installation when using the 31-Mc. police band. So it was decided to attempt bottom loading of a shortened antenna.

A coil consisting of 10 turns of no. 8 copper wire was wound and inserted between the bottom of the 5′ 4″ whip antenna and the frame of the motorcycle. Half a turn at a time was then clipped from the coil until the antenna system approached resonance. Then the final adjustment for resonance was made by squeezing the coil or stretching it out. A very fine adjustment can be made in this way. If the coil is rigidly mounted and wound of heavy conductor the adjustment of the antenna loading coil will hold despite the serious road shocks experienced by a motorcycle in normal service.

The coupling coil in the transmitter can consist of a two-turn link around the output plate tank. The r.f. energy runs through a short concentric line and is coupled to the loading coil at the base of the antenna by tapping the line onto the coil. Coupling from the transmitter to the antenna system is varied by tapping the clip a varying amount up from ground on the loading coil. One and one-half to three turns has been found to give the proper amount of loading with the installations that have been made. If more than three turns of coupling is required at the antenna coil, the antenna system is not resonant and some more adjusting of the antenna coil is in order.

The most satisfactory tuning procedure has been found to be the following: Start with the antenna at full length and with the full loading coil in the circuit. Use about three turns of coupling to the link going to the transmitter. Then try alternately squeezing and stretching the coil and taking off a half a turn, checking the plate current of the amplifier stage to determine the approach of resonance. When resonance has been found (in both the installations now in use the loading coil ended up with 7 turns spaced about ⅛ inch between turns) decrease the coupling until proper loading of the amplifier is obtained.

The results obtained with this antenna tuning arrangement have been excellent. The range of the 6 to 8 watt motorcycle transmitters has been increased several miles above that obtained with a coil and condenser tuned antenna circuit.

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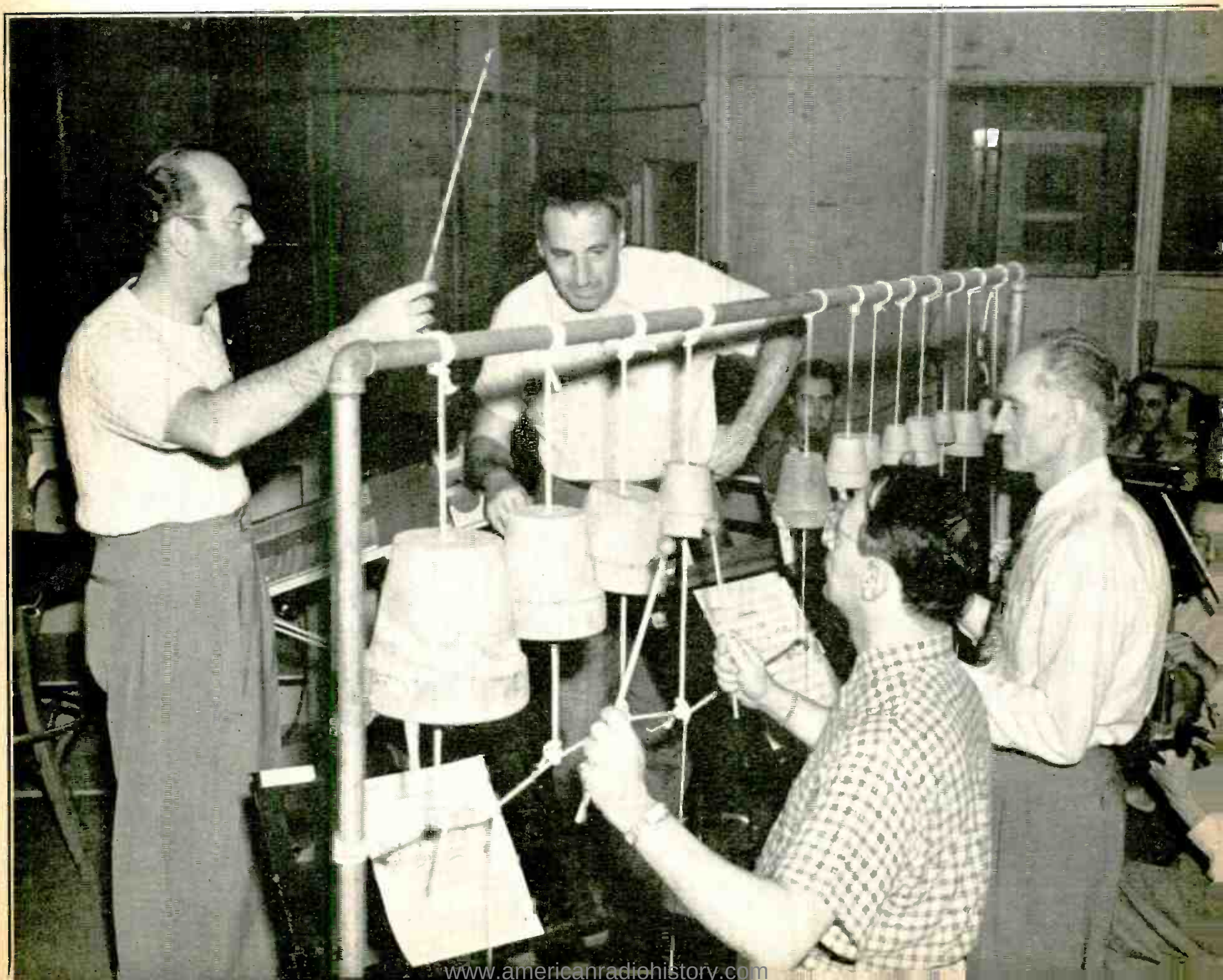
*Radio Supervisor, Santa Barbara Police Department, Santa Barbara, Calif.

Sound

RECORDING AND REPRODUCTION

Plain, old-fashioned flower pots recently were used in the elite realm of classical symphony instruments to provide "new and unusual tones" which could be secured from no other "musical" source. The earthen pots, which varied from tea-cup size to huge two-gallon affairs, were played by being struck by mallets. They were introduced as musical instruments by no less an authority than Dr. Ernest Toch. Toch, whose classical works are played by noted symphony orchestras from coast to coast, was called to Hollywood to create "something different" in musical scores for the Columbia picture "Ladies in Retirement." Striving to achieve an audible symphony beyond the range of all previously existing orchestral arrangements, Toch wrote the music for the "flower-pot obbligato" in seconds instead of the conventional musical notes. He contends that his startling innovation is strictly "according to Hoyle" in all precepts of music ethics.



THE DUB CLUB

By MARTHA JOAN GOETZ*

Dubbing a program.

A training camp for neophyte broadcasters—that's the Dub Club. Its recruits are University students and business and professional people who have the burning urge to make their life work some phase of radio.

This Dub Club has no station time; yet each week it "broadcasts" an hour program using member musicians, dramatists, announcers, sound effect operators, engineers, and recording technician.

On that word "recording" hangs the Dub Club's story. As you've probably guessed, this group records rather than airs its programs. The participants work in a regulation studio and use only broadcast quality program material. This is all timed to a split second for the reason that recording discs adhere to a given amount of time even more rigidly than a commercial station schedule. Such procedure affords excellent training in attaining "time consciousness," an essential attribute for anyone in the radio field.

The following schedule is typical of their recorded programs.

TIME	PROGRAM
8:55	Kay Kyser Kollege
8:59:30	Sign on (Dub)
9:00	News
9:05	Women's News
9:09:30	Spot (Commercial for Comedy Show at 9:35)
9:10	Drama Workshop
9:24:30	Spot (Commercial for Republic Drug)
9:25	Musicale (Live talent)
9:34.30	Spot (Comm. for Denham theatre)
9:35	Comedy Show (M.C. and audience)
9:44:30	Spot (Colorado Tourist Bureau)
9:45	Transcribed music
9:54:30	Spot (Waltham Pens and pencils)
9:55	Radio Scrapbook (Poetry and Organ music)
9:59:30	Sign Off (Dub to. . . .)
10:00	Texaco Star Theatre (Network)

It can readily be seen that Dub Clubbers have plenty of opportunities to expose their talents. It is truly an exposé when the records are played back. The candid-ear-shot each person gets of his own (and the others') performance points up good and bad qualities more clearly and efficiently than would months of criticism from someone else.

The studio proper and a small adjoining control room are each equipped with two turntables. These make it possible to record continuously for one hour, using two sixteen-

*Radio Dept., School of Commerce, University of Denver, Denver, Colorado inch discs cutting at 33⅓ rpm; also to play musical transcriptions and sound effect records (for dramas) on the program. The acetate blanks cost is covered by Dub Club dues.

It appears that the club members do a vast amount of work for only practice, but the pay-off comes when one of them lands a broadcasting position. Radio employees drawn from the Dub Club ranks during the past year include three announcers, an actor, a script writer, a commercial spot writer, two women publicity directors, a sound effect operator, a special technician for open-air and remote broadcasts, and an NBC engineer.

Last but important is the Dub Club's sponsor, without whose tolerance and help the group might have ceased to exist. He is Roscoe K. Stockton, radio pioneer writer, actor, and advertiser, and now head of the Broadcasting Department at the University of Denver.

• • •

Small, 10-watt class B output transformers, of the type designed to match push pull 6F6, 89, 6N7, etc., to class C load of from 3500 to 7000 ohms make excellent class AB driver transformers when used "backwards." They can be used to match a 45, triode connected 6F6, 2A3, or a similar single-ended driver to class AB 6L6's, 807's, HY69's, etc.

Better look through the junk box before investing in a new driver transformer when designing a new modulator.

Mike Stand

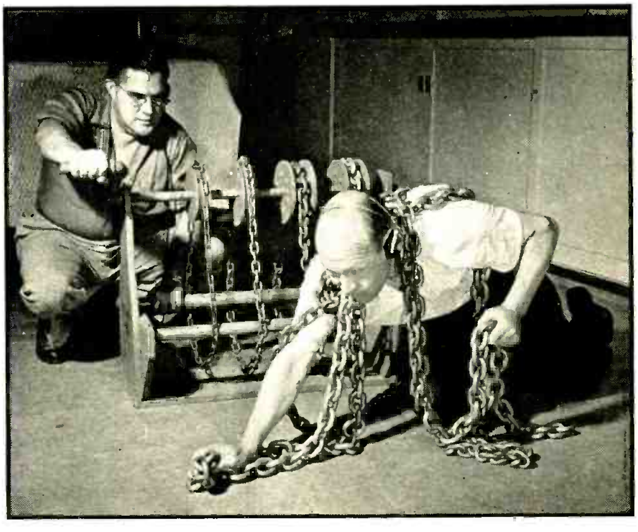
I recently solved the problem of a serviceable but cheaply constructed microphone stand by using a discarded music stand. The coupling between the stand and the "mike" was made from a microphone cable connector by loosening the set screw and removing the spring. Next the metal extension rod of the music stand was filed to fit into the cable connector. The threads of the cable coupling ring fit perfectly on the "mike" and it is not necessary to remove the center contact of the connector. If the set screw does not hold the coupler tightly on the rod it may be necessary to heat the rod and solder around the connector at the base or drill a small hole in the extension rod for the set screw to tighten into.

Wilbur Hull,
301 Prairie St., Stevens Point, Wis.

• • •

Sound, of which there are so many pleasing and annoying variations, may be used in the future to help fight disease. A new short wave sound generator has been constructed that produces sound that will kill staphylococci bacteria which cause boils and carbuncles. The device consists of a nickel tube in a fluctuating magnetic field. The resultant rapid oscillating motion of the tube produces sound with a high frequency of 9,300 cycles a second, which is deadly to certain bacteria.

The Ohmite News.



It is serious business, but visitors to the Walt Disney Studios often have difficulty in keeping a straight face when the sound effects boys give with their best efforts. Here two of them simulate the clink-clank of elephants chains for the latest Disney production "Dumbo". Notice that both men wear an earphone. This carries a "beat" pattern to them to enable them to synchronize the sound effects with the action.

How We Speak and Hear

By R. M. GILBERT*

The science of physiological acoustics, as the study of speech and hearing is termed, is one that has occupied many eminent scientists for their lifetime; so we can't in one short article expect to do much more than become acquainted with a few of the simpler facts concerning these interesting processes. However, a knowledge of these few pertinent facts is of value to the serious recordist.

The lungs provide the *energy* for speaking in the form of an air stream, which passes through a slit formed by a pair of muscular strips in the *larynx*. These muscles (the vocal chords) are tensed by contraction and vibrated by the passage of the air when speaking. The air then comes into a cavity called the *pharynx* in a series of rapid puffs, at the natural frequency of the vocal chords.

We now have a sound—one that is rich in harmonics. The overtone structure of this complex sound can be controlled to a certain extent by varying the air pressure and the tenseness of the muscles.

This sound passes from the pharynx through the mouth and out between the lips. But in traveling this distance it is influenced by several resonant cavities and apertures. The first of these cavities is the pharynx itself, which extends from the esophagus up to the nasal cavity. This second cavity has a fixed resonant frequency, so that its effect upon the sound is varied by changing the shape and size of the aperture leading into it.

The mouth is the third cavity. At the back of the mouth, where the sound enters, is located the soft palate. The roof is formed by the hard palate, and the bottom, of course, is the tongue. The soft palate, tongue, teeth and lips are moved to alter the size and shape of the mouth and the openings into it and out of it.

These changes in the speech mechanism are the means of varying the tone structure of the sound which issues from the mouth. When the adjustable elements are so positioned that the throat, nasal and mouth cavities reinforce harmonics within certain frequency ranges (due to resonance effects) the vowel sounds are produced. Such sounds as *w, y,* and *h* are formed by beginning the vowel sounds in certain ways, and others like *ch, sh,* and *f* do not require the use of the vocal chords at all.

A person shouting as loudly as possible produces a peak power of about 5,000 microwatts, while 0.01 microwatt represents the power produced by a faint whisper. This is a range of 500,000 to 1 in intensity. The average power, under typical conditions, is about 10 microwatts for American speech. When one realizes that a modern radio receiver may have a power output of several watts, while 10 microwatts is only 0.00001 watt (ten millionths of a watt), it is apparent that speech powers are very low. The fundamental pitch of the average male vocal chords is in the neighborhood of 125 cycles, and that of the average female vocal chords is approximately one octave higher, or about 250 cycles.

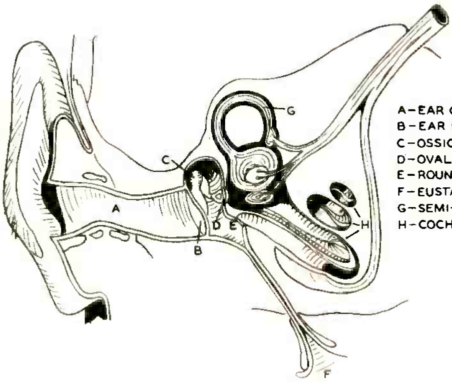
Hearing

To a person engaged in the design of sound equipment or to one concerned with the acoustics of buildings the properties of the human ear are of great importance, since the ear is the final judge of their efforts. Great strides have been made in the study of the ear and how it operates, but there still remains much to be done.

The hearing mechanism is divided into three parts: the outer, middle and inner ears. In addition to the part visible on the outside of the head, the outer ear includes the ear canal and ear-drum. The middle ear is a small chamber containing the *ossicles* and connected with the pharynx by the eustachian tube. Air passes through the tube from the pharynx to equalize the pressure on the two sides of the ear-drum. The ossicles are three small bones (the *hammer,* the *anvil,* and the *stirrup*) which connect the ear-drum with the *oval window.* The hammer is attached to the ear-drum and connects through a sort of ball-and-socket joint with the anvil, which in turn connects to the stirrup, and the foot-plate of the stirrup is attached to the oval window.

Extending inward from the oval window is the inner ear, an irregular cavity in the skull entirely filled with a liquid. This cavity is

*Contributing Editor, RADIO.



Rear section of the right ear of man. The parts labeled are those discussed in the text.

divided into two parts, one containing the semi-circular canals which help to maintain balance, and the other, in the form of a spiral, which is actually concerned with the hearing.

The spiral section of the cavity is called the *cochlea* and contains the auditory nerve endings. A spiral ledge projects into the cochlea cavity and the flexible basilar membrane serves to separate the liquid above the ledge from that below it. The liquid is confined within the spiral cavity by the oval window and a round window at the base, but a small hole is provided in the membrane at the apex of the spiral so that the liquid can equalize itself. The auditory nerves end in small hairs extending into the cochlea on one side of the basilar membrane. These hairs respond to different frequencies, progressing from the higher frequencies near the oval window to the lower frequencies near the apex.

When a sound wave strikes the ear-drum, it sets up a vibration which the ossicles transfer to the oval window. The vibration of this window causes waves to be sent through the liquid in the inner ear, and these waves set the resonant nerve ends into motion, which sends the impulse to the brain.

The loudness of a sound at a particular frequency depends upon the number of nerve fibres set into vibration by the sound and the amplitude of their vibration. Pitch depends chiefly upon the location of the nerve fibres which respond to the sound waves, and tone quality is determined by the same three conditions (number, location, and amplitude of the vibrating fibres).

Limitations and Peculiarities of the Ear

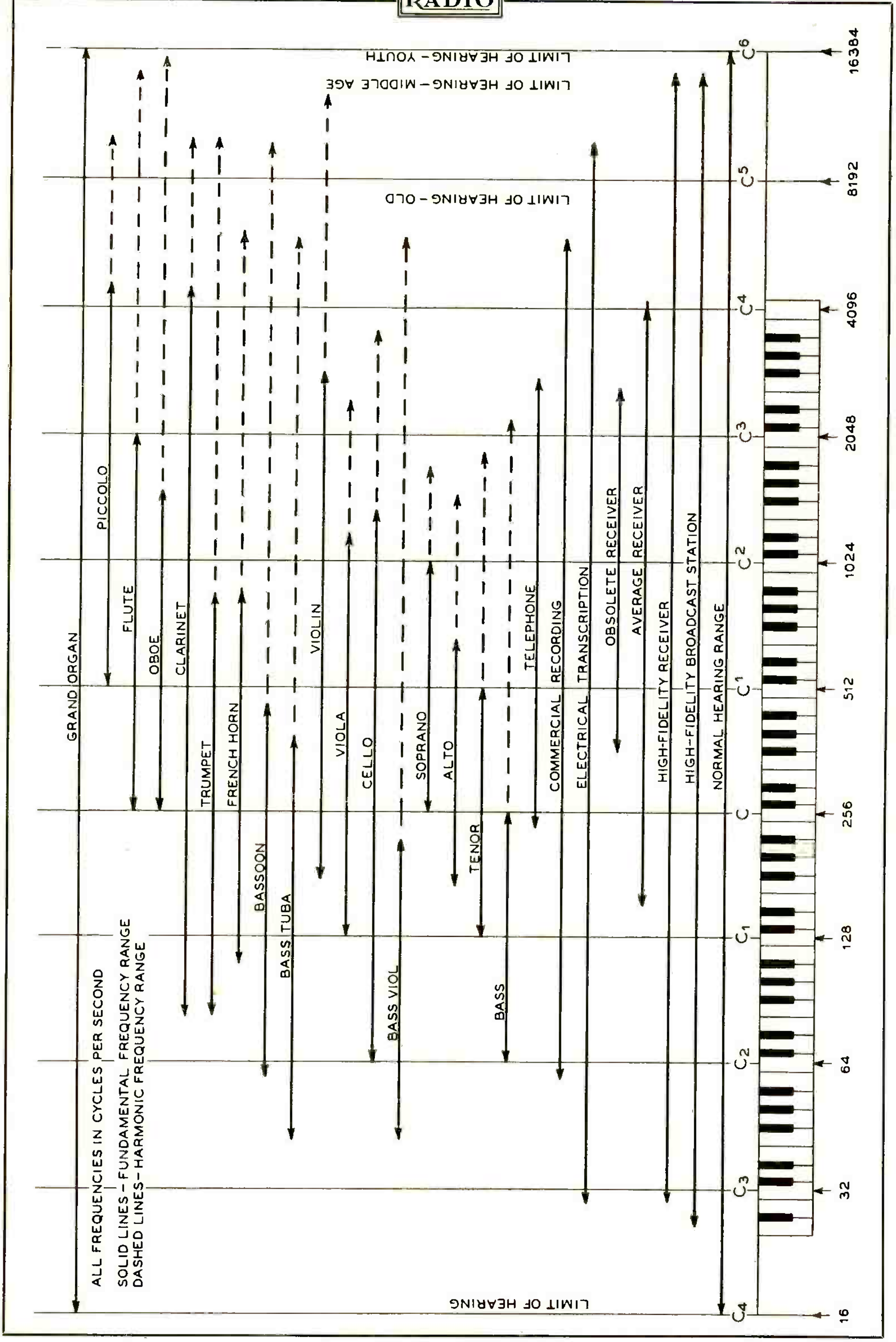
The ears of an average young person will respond to frequencies from approximately 16 cycles to approximately 16,000 cycles, and some ears can hear frequencies as high as 20,000 or 25,000 cycles. As one grows older the upper limit decreases until, at about middle age, 10,000 or 12,000 cycles is the highest frequency to which the ear will respond. About 6,000 or 7,000 cycles is the limit for an elderly person. All of the hearing characteristics vary with different people; even the two ears of the same person usually are not alike.

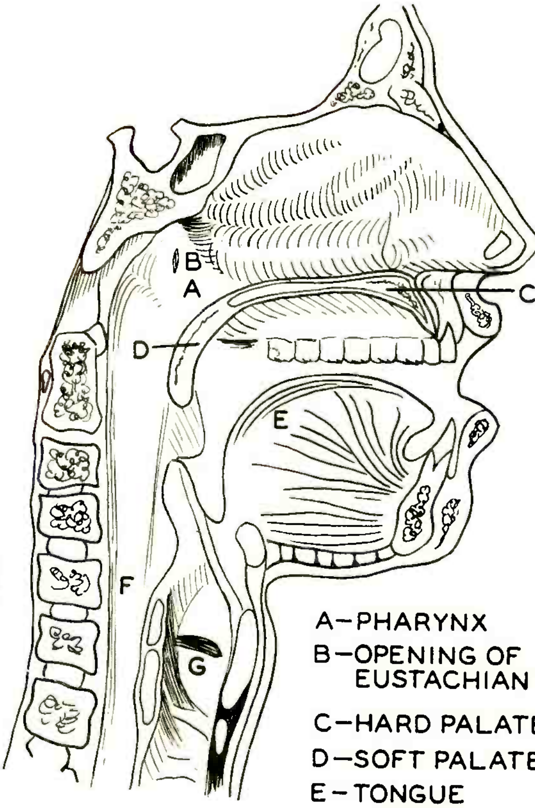
The presence of an additional sound, whether it be music, speech, or noise, will *mask* the sound one is listening to, the amount of masking depending upon the relative loudness of the wanted and unwanted sounds, and upon the frequencies involved. The masking of a high frequency sound by one of low frequency is much more pronounced than the masking of a low frequency sound by one of high frequency.

Another characteristic of the ear is that the apparent pitch of a tone depends upon its loudness level. Below about 2,000 cycles the apparent pitch decreases as the loudness level is increased, and the reverse is true above this point. The greatest change occurs at about 200 cycles.

The ear has what is known as a non-linear response to sound waves of large amplitude. This results in the production of harmonics and sum and difference tones in the ear itself which are not in the original sound. These *subjective tones,* as they are called, are the reason that the elimination of the fundamental frequency does not alter the apparent pitch of a complex sound. The harmonics recreate the fundamental by combining in the ear to produce a subjective tone. This characteristic of the ear helps to make the smaller radio receivers sound reasonably good by supplying the missing low frequencies as subjective tones.

Between a fundamental frequency and its harmonics there is a particular phase relation that produces the least loudness, as well as one that produces the greatest loudness. The phase of a given harmonic also affects the amount of distortion that can be noticed and


ALL FREQUENCIES IN CYCLES PER SECOND
SOLID LINES – FUNDAMENTAL FREQUENCY RANGE
DASHED LINES – HARMONIC FREQUENCY RANGE
LIMIT OF HEARING – YOUTH
LIMIT OF HEARING – MIDDLE AGE
LIMIT OF HEARING – OLD
LIMIT OF HEARING
GRAND ORGAN
PICCOLO
FLUTE
OBOE
CLARINET
TRUMPET
FRENCH HORN
BASSOON
BASS TUBA
VIOLIN
VIOLA
CELLO
BASS VIOL
SOPRANO
ALTO
TENOR
BASS
TELEPHONE
COMMERCIAL RECORDING
ELECTRICAL TRANSCRIPTION
OBSOLETE RECEIVER
AVERAGE RECEIVER
HIGH-FIDELITY RECEIVER
HIGH-FIDELITY BROADCAST STATION
NORMAL HEARING RANGE
C6 16384
C5 8192
C4 4096
C3 2048
C2 1024
C1 512
C 256
C1 128
C2 64
C3 32
C4 16



Section of the human head, showing the parts that play important roles in producing speech. The vocal chords are located between the larynx and the esophagus.

the quality of a complex sound.

The ability of a person to locate sounds accurately is due to the phase and intensity differences of the sound reaching the two ears. The "binaural phase effect" is limited mainly to frequencies below 1,000 cycles, and the intensity differences are most noticeable above about 1,000 cycles. The head is turned until it points toward the source, as evidenced by the phase and intensity becoming the same in each ear.

Musical Instrument Acoustics

The sounds produced by musical instruments frequently extend beyond the human hearing range at either the high or low frequency end, sometimes at both ends of the audible spectrum. But these very high and very low frequencies are made apparent by their effect upon the portion of the sound that can be heard. The frequency range of most reproducing equipment such as radio, phonographs, sound motion pictures, and telephones, however, is somewhat less than the range of human hearing.

To reproduce orchestral music with high fidelity a frequency range of from 40 to 14,000 cycles and a volume range of 70 db is required, while for equally good reproduction of speech a range of from 100 to 8,000 cycles in frequency and 50 db in volume is sufficient. All instruments produce some noise when played, such as key clicks, bow scraping, air hissing, etc., and this noise takes the form of a more or less pitchless range of frequencies at the upper end of the instrument's audible range.

Musical instruments, singly and in com-

[*Continued on Page 66*]

Frequency ranges of various instruments, voices, and equipment compared with the human hearing range. The chart is based upon the scientific scale in which middle C has a pitch of 256 cycles per second. Note that many of the examples show a harmonic range that exceeds the fundamental range.

A Grid Leak Type FIELD-STRENGTH METER

By W. W. SMITH,* W6BCX

A portable field-strength meter which exhibits good sensitivity has many uses, the uses being so numerous and obvious that there is no point in enumerating them here.

If the f.s. meter is to contain more than a single tube and the absolute minimum in batteries, it might as well consist of a portable superheterodyne with "R" meter. When extreme sensitivity is required, such an arrangement is the only practical one. However, when a lesser degree of sensitivity will suffice, a single tube circuit often will fill the bill if the single tube is made to really do the job.

Just as a grid leak detector is more sensitive than a "power" or bias detector, so a grid leak type field strength meter will give readable indication on a weaker signal than will one of the bias detector or v.t. voltmeter type. This is particularly true when the tube is of the directly heated cathode (filament) type, and when the plate voltage is at least the amplification factor times the filament voltage of the tube. The reasons for the latter consideration will be discussed further along.

Another advantage of the grid leak type meter is that its response is nearly logarithmic over a wide range. The bias detector, on the other hand, is fairly linear over the useful portion of the scale, the top half of the meter scale representing only 6 db. The result is that the bias detector type meter has a useful range of about 20 db, the grid leak type a useful range of nearly 30 db.

A grid leak type field strength meter utilizing a type 19 tube was described by the author in the March, 1940 issue of RADIO. However, because the sensitivity (ratio of plate current change to grid voltage change) is determined only by the transconductance, a lower μ tube of the same approximate transconductance may be used without sacrifice in sensitivity. The lower plate resistance of the low μ tube allows the use of a lower voltage plate battery (assuming a plate meter of the same full scale deflection).

By substituting a triode connected 1T4-GT for the type 19, a 22½ volt battery will suffice for plate supply, and the filament drain is much less. With batteries as scarce as they are, this is an important item. The circuit of the meter is shown in figure 1.

The plate voltage is adjusted so that the meter reads exactly full scale with no signal. This is done by means of the potentiometer R_2. The meter then will give a reverse deflection with signal, the amount of deflection depending upon the strength of the signal. To make the indicating meter forward-reading it is mounted upside down.

The instrument is individually calibrated in db. This can be done by reducing the power to a class C amplifier or a grid leak type oscillator by 50 per cent and taking the displacement of the meter needle as 3 decibels. Full power is restored and the coupling is reduced until the needle is on the lower calibration point. The power is cut in half again and another 3 db point is obtained. The procedure is repeated until calibration points are obtained for the full usable scale.

Only about 2/3 of the meter scale can be used. Beyond a critical point the plate current no longer drops with an increase in r.f. input; in fact, with sufficient input the plate current may begin to increase. This satura-

*RADIO

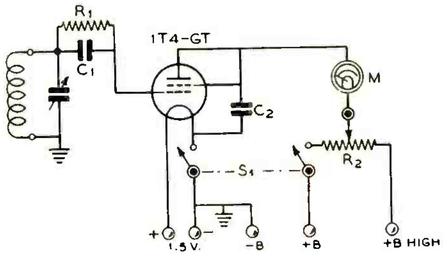


Figure 1. Sensitive, grid-leak type f.s. meter. A 22½ volt Burgess no. 5156 battery is used on the plate. A flashlight cell may be used for filament supply.

R_1—2 megohms, ½ watt
R_2—10,000 ohm pot., linear taper
C_1—100 μμfd. midget mica
C_2—.002 μfd. midget mica
M—0-1 ma. d.c.
S_1—D.p.s.t. toggle switch

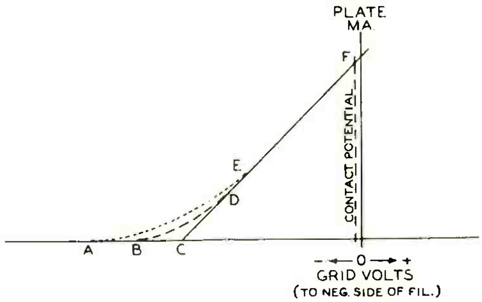


Figure 2. Illustrating effect of filamentary type cathode upon characteristic curve. BD is typical of tube having unipotential type cathode, AE of a tube similar except for a directly heated cathode and d.c. filament supply.

tion or blocking point is easily determined simply by gradually increasing the r.f. input until the plate current no longer falls off. The meter then is calibrated just up *to* this point.

The reason for this saturation or blocking point is that after the signal once is strong enough to bias the tube beyond cutoff, it then acts as a variable angle of flow device, the plate current being determined by the width of the excitation pulse. When the bias reaches a point several times cut off, a tremendous increase in signal voltage is required to make any appreciable reduction in the angle of flow.

With the tube specified, the instrument may be used up to approximately 125 mc. if a suitable u.h.f. tank circuit is employed. Needless to say, the leads should be very short for operation at this frequency. A tuned coaxial tank will give noticeably better results than a regular tank at frequencies above 50 mc.

No antenna coupling is shown, as this will depend upon the type of pick up employed. For greatest sensitivity, the antenna should be resonant and the coupling should be such that maximum voltage is developed across the tank.

Series resistance in the plate circuit, if an appreciable percentage of the plate resistance, will reduce the sensitivity of the meter because of the degenerative effect produced thereby. Series resistance is minimized by making R_2 a potentiometer rather than a straight dropping resistor.

A Burgess type 5156 battery is used because of its many taps. With R_2 turned full on, the "B minus" and the "B plus high" leads are experimentally connected across various taps until the meter reads just slightly more than full scale. The "B plus" lead then is connected to the closest lower "plus" voltage tap and the potentiometer varied until the meter reads exactly full scale.

Under these conditions the maximum series resistance is 2500 ohms, yet the "bleeder" current drawn by the potentiometer itself is less than 0.5 ma. This assumes that the voltage across the potentiometer is not more than 4½ volts, as the voltage across it need not exceed this value if the multi-tapped battery specified is used. To prevent the potentiometer from drawing current when the meter is not in use, a d.p.s.t. switch is used to break the voltage to one side of the potentiometer when the filament circuit is opened.

Theoretical Considerations

The solid line CF of figure 2 represents the characteristic curve of an "ideal" tube having a unipotential cathode. The straight line characteristic is something that cannot be obtained in practice, however. Near cutoff it will follow the dashed line BD.

If the cathode is of the filamentary type, other factors enter into the picture. The negative end of the filament (assuming d.c. supply) has less bias on it by the amount of the filament voltage. This causes an aggravation of the "knee" in the curve near cutoff, so that the curve is similar to that of AE. In fact, if the plate voltage is low and the tube has a high amplification factor, simply returning the grid to the negative end of the filament may produce sufficient bias to prevent emission from the positive end of the filament.

As transconductance is represented by the steepness of the curve, it is apparent that it is highly desirable to place the operating point

[*Continued on Page 61*]

U. H. F. . . .

By PERRY FERRELL, JR.*

"They have everyone down fighting the war, so I'd sure appreciate it if you would handle the column for a little while until things get settled down." These were the words that rolled out of a telephone a few days before Christmas to greet your very much surprised writer. It was "Bill" Conklin sure enough, and his situation could easily be understood. Thus, with a promise to do our best on such short notice, overnight we took on a job at which we are plenty rusty. If our readers will excuse this somewhat jumbled column in view of a better one to come, we too, will be greatly appreciative.

It does seem ironical, however, that those of us who have used the u.h.f. solely, and therefore have been doing the unusual in radio amateurism, will soon be called upon to provide the basis for an intricate nation-wide net of civilian defense u.h.f. stations. Undoubtedly one takes new faith in the old adage, "The worm shall turn."

The latest advices from Washington indicate that the F.C.C. will act as in the original announcements. A few more stipulations may arise, i.e., the interested amateur (preference will be toward the experienced u.h.f. operators) with equipment in order, talks the local situation over with his defense board, the board thereupon intercedes in behalf of the amateur and his permit for 5 or 2½ meter operation (or both bands) is granted. In this way local nets are formed. Evidently the F.C.C. doesn't quite contemplate the use of the u.h.f. for inter-city or state wide hookups, and it may be considered monkey business if we try to hook some "local 100—200 mile" QSO's. Random contacting may also fall in the same category. Although it appears this would defeat the original purpose, if these stations are to be used in emergencies where you may not be too choosey in your hurried contacts. Anyhow, don't put up any uni-directional beams because right now it looks like a "big-time" Tuesday night session of the Horse-traders, and if handled properly could be about as much fun!

You know considerable time could be spent right here in passing out credit to those who are down there fighting for us and have changed that "Dismantle" order into "Build and get on the air with portable u.h.f. equipment." But we believe it would be best to conform to the opinion that this is an era of business the like of which, in plain language, many of us haven't quite yet comprehended. So the credit and orchids will have to wait until the whole job is done.

Quantitative Reception Data

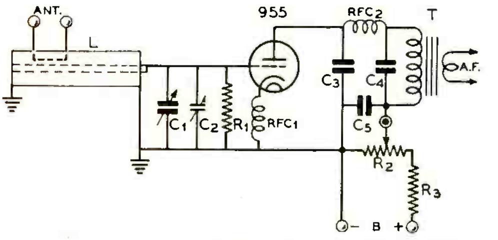
It seems necessary to contradict the idea that this is wholly a proposition of "build it, get it working and keep it working." This, unfortunately may only further abet the situation where our operating technique is far outclassing our knowledge of the laws of the propagation of the u.h.f. This writer was amazed to find recently that a state of affairs was arising from the inconsistency of the reports and interpretations of sporadic E. More than a few experimenters were actually dubious of its existence and a tilted auroral layer, which still remains an amateur invocation and has not even been recognized by any other body of radio engineers, sounds practically fantastic.

Whether we are going to stand by our discoveries is up to each u.h.f. operator. This column, which has faithfully endeavored in the past years to present the latest data in u.h.f. wave propagation to the gang, is now asking that we all get out and at least keep listening on the u.h.f. bands. If and when you hear aurora dx, E_s signals, bursting tropospheric reception, or believe signal absorption bands have interrupted u.h.f. communication in your locality, let this writer know about it as soon as possible, since the information may be invaluable. Quite a bit may be gleaned from a penny postal that gives the time, date, stations heard or worked and signal strengths. Every report we receive will be acknowledged. Shortly it is hoped to present a new complete paper covering aurora and sporadic E theory with many new points gained from observation of the dx worked and heard this past year. But more on that later.

FM Skip Interference

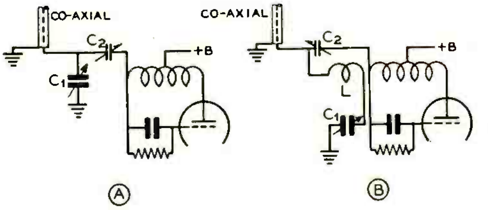
With the use of FM becoming so widespread, some questions concerning interference have popped up and many mistaken impressions have been cast before sufficient operating

*A.M.I.R.E., 107 East Bayview Ave., Pleasantville, N. J. Send contributions to Mrs. Josephine Conklin, W9SLG-W3JUX, 300 Wilson Lane, Bethesda, Maryland, for future issues.



Revised version of the "French 75 Shell" superregenerator.

C1, C2—Tuning and band-set condensers made from plates and fittngs of other condensers mounted on polystyrene.
C3—Midget .002-µfd. mica
C4—0.01-µfd. 400-volt tubular
C5—0.5-µfd. 400-volt tubular
R1—10 to 20 megohms, ½ watt
R2—50,000-ohm potentiometer
R3—20,000 ohms, 1 watt
RFC1—Midget u.h.f. choke
RFC2—2½-mh. r.f. choke
T—3:1 audio transformer



The W6QLZ system for coupling a concentric line into a superregenerator.

"Most amateurs use a link or else a 3-30 coupler from the center conductor to the tuned circuit. Then they find that they have dead spots or the antenna loads up on the low end of the band and falls off on the high end. By adding a second 50-µµfd. midget (C_1) maximum gain may be controlled from the front. Also, by adding a two-turn link sharper tuning may be had (B)."

data could be accumulated and classified. However, in a report from a well known expert in this field, whose name we are withholding, he had this to say about FM skip signals:

"It appears that too much emphasis has been placed upon the so-called FM skip interference for point to point communication work which has in a few widespread instances been noticed. I do, however, see reason to believe that in the FM broadcast bands, after they become fully developed, much shared channel interference will exist at the edges of the primary service areas and particularly in the rural areas where very low (comparatively) field strengths are found. This naturally assumes that there is sufficient density in the E region to reflect signals of this ultra-high frequency. It has been possible to observe some twenty odd FM skip signals and even the most critical listener found no irregularities in the audio quality of these signals and perfect fidelity was apparently maintained over paths varying from 500 to 1200 miles. Signal strengths on six occasions rose to values exceeding 1000 mv/m, which would be a serious interference factor under any circumstance were it not for the severe fading which quickly dispels such peaks. In the two years of observation at no time did the strength of an FM skip signal exceed 500 mv/m for more than 30 consecutive seconds. Such was the intensity and severity of fading."

November 28

As the December sporadic E season rolled around again, only a few contacts were made before the official closing of the bands. Most important of the reported days was November 28th when the band opened around 7:00 p.m., e.s.t. and held for three to four hours with unusual strength.

W6OVK heard W5, 6, 8 and 9 on 10 before 6 o'clock local time and came back after his supper to hook W5HTZ on the first CQ with a terrific signal on both ends. After signing with HTZ, OVK spent over one hour searching a wide open band for signals, hearing only harmonics and one or two very weak carriers. Finally W5DNN shifted to 5 at 8 o'clock after hearing W6QLZ come booming through 40 db above S9 only to find QLZ signing to go back to work. W6OVK heard W5DNN come on and so, with intermittent breaks to see what else might be coming through, they kept it up for a half hour until the band began to slack off. W6SLO meanwhile worked W5HTZ and then too ran off to work. No reports were received from the eastern gang, which may be partially explained by the fact that Friday evening is a very poor membership night for 5, as your writer listened to a very interesting high school football game over W45BR in Baton Rouge, Louisiana for well over two hours. Jim, 6OVK, says he was also tuning W45BR, so it certainly looks as though the gang missed a pretty good two hop skip from W2-3 to W6.

Random Thoughts

You know, it seems that any number of investigators who have had access to large amounts of u.h.f. reception data sooner or later, as the case may be, find themselves engrossed in working out predictions for future occurrences of aurora DX and whatnot. Then, with a few lucky hits, they automatically believe they have the situation well in hand and almost without exception "step forth out the open window." And so into the trash pile invariably goes another nice picture of, "what to expect, and when."

Since it is interesting to see just what chance one does have in predicting future ionospheric disturbances that might bring aurora or sporadic E, the correlation coefficients in figure 1 have been prepared, especially based upon the year 1941-42, in such a manner to enable each single storm to have a repeat disturbance within the basic year.

The correct approach in measuring such cycles is to utilize the time measurement "hour," not "day," which is entirely too general and does not readily show the effect of minor factors that may cause serious inaccuracies over extended periods. In such a way 648 hours is about 27 days, which with the allowed discrepancy of 0.02 (or 13 hours) of the predicted time, showed the surprisingly low coefficient of 0.24, although if the discrepancy were to be enlarged to 0.05 or 30 hours (over one day either side of the predicted time of occurrence) the coefficient could be made 0.463, which is still only one chance in two accuracy. Not so good, eh?

A 1296 hour period when corrected to sidereal time gave a fair coefficient of 0.43, still within 13 hours. Enlarging the inaccuracy to about 24 hours gave a factor of 0.545, which in some instances proves itself satisfactory for rough work, at least preferable to the 27 day cycle.

The next cycle amounted to approximately 81 days, which is very seldom used in any type of prediction work. Out of the basic year a coefficient of 0.37 was obtained, at which time it was decided a 20 hour inaccuracy could be tolerated on such a long period cycle and a corrected 0.498 was accepted.

The last cycle is undoubtedly one which will in the future form the background of all prediction work, since even without reduction to absolute sidereal time from 2592 hours a coefficient of 0.504 was found. Although no corrections were attempted, it seems reasonable to believe 0.65 can be obtained.

Much can be said for the extended period cycles, and while on that subject it is recalled that a paper was presented in the November 1940 *I.R.E. Proceedings* on the time relationship between individual solar and terrestrial disturbances in which transit times for the corpusclar streams is assumed to be anywhere from one or two days to as much as three months; i.e., while general solar activity correlation is always excellent, the association of individual storms with specific sunspot groups has always been very poor. It is explained a possible anomaly may lie in longer transit times than has heretofore been considered. It might also be pointed out in making predictions, that corrections must be applied for the moving about of the disturbing sunspot group on the surface of the sun, while something can also be said for the angle of emission of the corpusclar stream from the sun spot. Just what the angle of arrival in the earth's magnetic field means can only be guessed.

The subject is interesting, and, speaking of interesting subjects W6OVK has one of his own which concerns the formation of cirrus clouds on sporadic E days or even preceding days. Jim says, "I'll never give up this issue; those high cirrus clouds and occasional short skip showed up together on November 25th. The clouds kept getting heavier and heavier day by day until they covered the whole sky yesterday (November 28th)!" Keep it up, Jim. Each observation takes coincidence down a fraction of a notch.

	Discrepancy within			
Cycle in hours	13 hrs.	20 hrs.	24 hrs.	30 hrs.
648	0.24	0.365	0.463	0.463
1296	0.43	0.48	0.545	
1944	0.37	0.498		
2592		0.504		

These are correlation coefficients for repetition in ionosphere and magnetic disturbances affecting radio transmission 1941-42. Note the unwarranted use of the 648 hour cycle (27 days) and the accuracy of the 2592 hour cycle.

Miscellany

The horizontally polarized gang in the East was growing with W1HDQ, W1KLJ, W1MIQ, W2BYM, W3FHY, W3AUX, W3OR, W3HWN and W3HXI using it more or less regularly and several more were practically between the stages of conversion and conviction. A net was planned to meet on Monday at 8 p.m., however ———. Don't believe W1DEI cares much for such goings on. Picture Mel chasing the "Western influence" out of the East with a New England pitchfork in his hand and W5VV, W4EDD and W9ZJB running like mad!

W5AJG finally got some of the 9000 series tubes and will probably whip up a good 112-Mc. receiver using them and some "pipes" in the front end.

W9LLM says 112-Mc. was fine in Chicago up until ———. Frank has a new crystal controlled rig on 114,144 kcs.

Steve, 5DNN, calls himself a "Long

[*Continued on Page 63*]

HEY SPIKE, HE USES GL-807's JUST LIKE THE COPS!

IF Spike and Joe make a habit of stopping at hams' homes, they will find a lot of amateurs using GL-807's "just like the cops." For your sake, we hope they don't start collecting them instead of silver.

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YARN of the MONTH

THE PROPHET TAKES A LOSS

Jeremiah Hapgood pushed the glasses back from his nose and tried again to coax headphones and spectacle frames into compatability. The percolator at his elbow contained just a half cup of murky beverage, and after fishing the longest and least gritty butt from the ashtray, he sat back alternately sipping and puffing.

An eight-hour stretch in the first week-end of the Sweepstakes Contest had just ended. As he sat back trying to enjoy the toxic potion, he listened to the swish of signals. A page and a half of his log book was closely filled with contacts, but the pace was slowing. It had been a cinch at first, but after milking the spots around his three crystal frequencies it had more and more become a case of sitting tight and waiting for a v.f.o. to drift along.

At the other end of town, Wilbur Greeno was busily twirling the knob of his v.f.o., shifting here and there wherever he heard a juicy CQ SS. Jeremiah scratched his nose thoughtfully as he heard his rival swoop to his own frequency and steal a North Dakota contact from him.

The telephone rang just as the last bite of pie disappeared. Already sidling towards the operating table, Jeremiah stopped and listened to the one-sided conversation being carried on by the xyl.

"Why yes, I'm sure he could fix it. Yes, certainly . . . yes, he'd be glad to, I'm sure. Just a minute."

"Who is it? Tell 'em I'm not home. I don't know how to fix a radio, why I haven't even a volt-ohmmeter. You know darn well Betty I can't test tubes and they're usually what's wrong."

"Now Jeremiah, it's that nice Mrs. Van Twerp and her radio is screeching and she says Mrs. Nicolas told her that you know all about radios, and the serviceman did a bum job . . ."

"But I tell you I haven't any equipment, I . . . ."

"And besides, I told Mrs. Nicolas how you fixed our set and what will she think . . . ."

"Does she expect me to go up there now?"

"I'll have to tell her something. She's still waiting on the phone. Oh why don't you run over there, it won't take long?"

"All right, I'll go, but I know darn well I'll make a fool out of myself and you too."

Jeremiah got out the old leather case dubbed "diaper bag." He rummaged through the drawers and dropped in a soldering iron, three pairs of pliers, some wire, a filter condenser, and for effect, an old 0-50 d.c. voltmeter. Huh! Nice serviceman's assortment. Better take an old tube or two. He shook a 56 to see if it rattled, then on a hunch put a spare 80 in the bag. Grumbling and mumbling about test equipment, he grudgingly pecked a kiss at Betty's cheek and left.

"Oh dear, I'm so glad you've come Mr. Hapgood, our radio acts just as if it were crazy. It makes such strange noises, and that serviceman charged us $5.00 and I don't think he even looked at it although it did play for a while, but you just don't know who you can trust nowadays, and I'm so glad we've found you because . . . ."

Jeremiah had been standing just inside the door politely twirling his hat and assuming what he judged was a very professional pose. At first sign of a break in the monologue, he cleared his throat a little too loudly.

"May I look at the uh ah miscreant?"

His tentative giggle was immediately amplified into trills of spinsterish laughter, and he found himself left high and dry with his own final guffaw . . . . somehow, not quite fair.

The set was an ancient Stromberg. After struggling with lamps, book-ends, vases, and pictures, he finally hauled the cabinet around to where he could duck behind into more familiar terrain. Almost oblivious to the steady chatter of Mrs. Van Twerp, he clicked on the switch still quaking for what the next hour would bring.

As the filaments began to warm, so did his heart, for from the 80 came the most beautiful array of fireworks and blue gas that he had ever seen. With one motion he scooped the 80 from his bag and replaced the sick tube. A blast of music poured from the speaker.

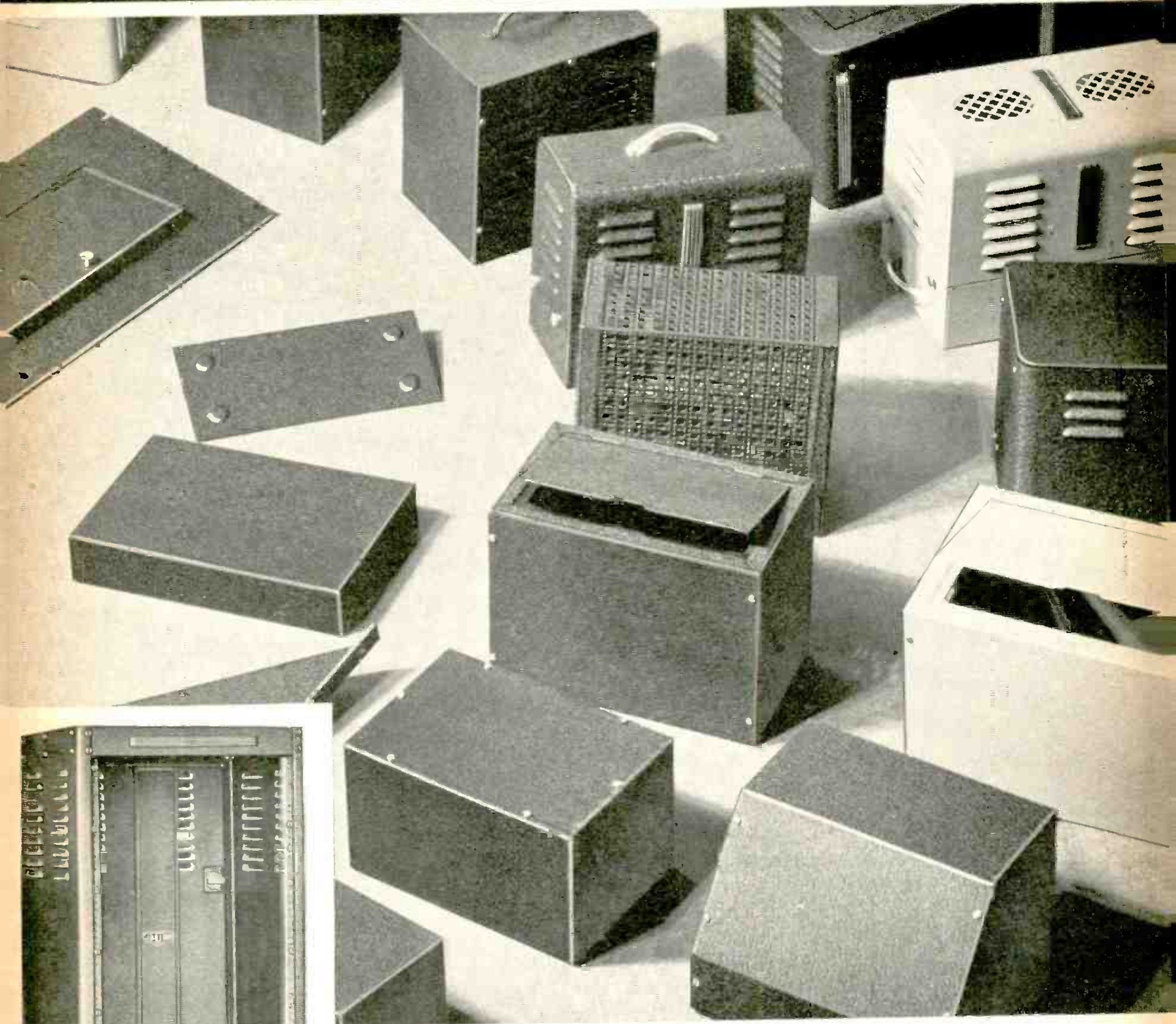
"Now if that isn't always the way," twittered Mrs. Van Twerp.

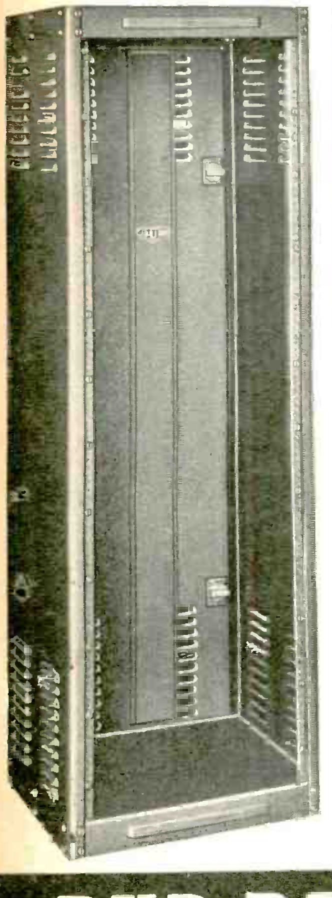
"No sooner than you call a Doctor, the patient gets well.

"Just because you're here, it works fine."

By ERIC LEDIN, W6MUF

Use BUD Sheet Metal . . . .





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"But I just put in a new tube. See, here's the old one." With a defeated look, he held out the old 80 as if it would squeal assent.

"Well I never! To think how helpless we women are. Why I didn't even see you replace it. Now how much will that be?"

Jeremiah who was already edging towards the door stopped suddenly and wrinkled his forehead. That was an angle he had forgotten about. Rapidly calculating, he fixed a practioners stare at the speaker grill and mentioned a dollar as being "about right."

"Oh now really, Mr. Hapgood, I'm sure that's not enough," but with considerable agility Mrs. Van Twerp had meantime crossed the room dived into her purse, and planted a dollar bill in Jeremiah's hand.

Walking home, Jeremiah's mind began to work in rather unaccustomed channels. Must be quite a bit of easy money to be picked up that way. He could have hauled out the chassis and stalled a bit, in which case she would doubtless have been just as pleased at double the price. It would be nice to own an e.c.o. Greeno wouldn't be so high and mighty if there were a little more money thrown around the Hapgood shack. A plan was incubating.

Betty was expecting the worst, but hardly prepared for this. The unpredictable Jeremiah calmly announced that he was entering the servicing business.

If this were a movie short, the fade-out, the flash-back, whirling clock hands, and flipping pages on a desk calendar could all be put to excellent use. If it were anything but a yarn, we could simply say, "The scene changes." Since it is only the chronicle of an era in the life of one of the least of our "brethren" the tale must carry on through more dismal and less interesting paragraphs. But the virtue of brevity is most easily attained. Avaunt!

Jeremiah pushes a doorbell with a re-juvenated "Mighty Mite" tucked under his arm. A bill for $2.00 is in his vest pocket. Jeremiah emerges a half hour later lugging an ancient Philco, the bill still in his pocket.—Lots of salvage in that old set, and since they offered it to him, why naturally he'd call the bill square. Net loss $1.12.

Jeremiah climbs a path with bcl set No. 2. Simple job, only a tube replacement. This was his friend Mr. X, so six-bits profit would be enough. Jeremiah emerges a bit unsteadily two hours later. He's singing and his spectacles are slightly awry. Four scotch and sodas have changed the complexion of servicing also. Heck no, he wouldn't charge a friend . . . . at least not after the fourth scotch. Net loss $.62.

Jeremiah leans across the counter of the Globe Radio Service Co. "Well you see this permeability tuning is something new to me, and I just don't have the equipment." Globe Radio Service Co. understood perfectly. Too perfectly. They did not feel particularly amenable towards amateur competition, and the charge of $3.50 carried no professional reciprocity. Collection $3.50.—Profit nil.

The "Mighty Mite" sizzling away melts a by-pass condenser. Hapgood replaces free, and reputation wavers in spite of the gesture.

BCL set no. 3 plays merrily on in the shack. Intermittent short has failed to show up. Customer phones nightly asking if job is finished.

Sixteenth of the month rolls by, and ORS report shows "no activity."

The "Mighty Mite" blows a dial light and goes dead. Second free call and now $1.45 is invested in the junked Philco.

Jeremiah invests $10.00 in volt-ohmmeter.

Wilbur Greeno drops in to display a new portable-mobile 2½ meter rig. Jeremiah catches up on his QSL mail.

It was a crisp cool evening. The dishes were dried, and Betty was buffing her nails before leaving for her bridge club. Jeremiah turned up the gain on his Super and listened to the familiar babble of C.W. signals. He switched on the filaments in the rig, then decided to wait until Betty had left. Just then the doorbell rang. Betty answered. From the hall he listened to the voices, ready to slink into the bedroom.

"My mother sent me down with this radio. It doesn't work any more, and she says if Mr. Hapgood can't fix it so it stays fixed he ought not to be wasting people's time and money. Dad's pretty mad too, and says that radio just better be fixed for the fight tomorrow night."

To the eternal credit of Betty, she made no comment when she brought the set in and set it on the table. Her look was a question and he nodded. "Yes. I heard." She kissed him a bit more tenderly than usual, and left the house. It was the "Mighty Mite" again.

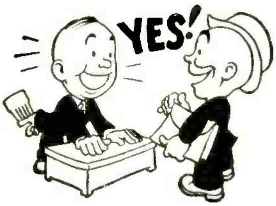
The filaments began to glow in the rig. A melodious K6 started a CQ, his frequency near the pencil mark on the dial marking Jeremiah's 7057 crystal.

He walked over to the window, opened it, and looked upwards along the disappearing feeder lines. Far below in the yard a cat tripped daintily along the fence, no doubt eyeing the garbage can which had carelessly been left lidless.

Jeremiah turned to the "Mighty Mite" on the table. He flicked the switch and listened to the rattling hum emitted by its puny speaker, then carefully removed the rectifier tube, and the panel light.

At the window again, he looked with concentration down into the darkness. A resounding crash sent the cat into squalling flight. A contented smile formed on Jeremiah's face. The "Mighty Mite" had scored a bulls-eye.

HOT STUFF!



"NO! Is that a fact! Hot stuff?"

"Yessir! Really HOT STUFF coming up in the next issue of Radio."

"Maybe I'd better plan to get a copy. Where can I be SURE of getting one?"

"What! Aren't you a regular subscriber? Say, chum, you'd better send in your order right away. $2.50 a year—or if you want to procrastinate, send only $1.00* for the next five issues."

"Okay. Where do I send it?"

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THE EDITORS OF RADIO

CORPORATE NAME: EDITORS AND ENGINEERS, LTD.

technical publishers

1300 KENWOOD ROAD, SANTA BARBARA, CALIFORNIA

What's New . . . .

IN RADIO

FLUORESCENT LAMP RESISTOR

A new Ward Leonard resistor Type K-40878 is for use with 6-watt T-5 fluorescent lamps on either alternating or direct current with a manual momentary contact starting switch.

When operating these lamps on 120-volt circuits these resistors eliminate the need of an auxiliary. The K-40878 resistor unit measures approximately 1¾ x 6½ inches overall, can be mounted in any standard fixture or wiring trough, and is insulated for 15,000 volts to ground.

OIL-FILLED PLUG-IN CAPACITORS

In step with the growing popularity of the plug-in capacitor technique, already widely used in the electrolytic and wax-filled paper types, the Aerovox Corporation of New Bedford, Mass., announces a new Series 72 oil-impregnated oil-filled capacitor with four-pin base that fits into a standard UX socket, as distinguished from the octal base of the other plug-ins.

The aluminum-sprayed tin-plate round can comes in 2-, 2½-, and 3-inch diameter sizes, and from 2½ to 4¾ inches high. It is provided with a mounting ring with lugs, so as to be held securely in place and in accordance with Underwriters' requirements. These oil-filled plug-ins are available in single-section units up to 16 μfd., and up to 4-4-4 μfd. in multiple-section units, in both the 400 and 600 volts D.C.W. ratings.

These plug-in oil-filled capacitors are particularly desirable for equipment used by the Army, Navy, police, broadcast stations, public address and sound movie systems. They are ideal for aircraft radio where duplicate receivers and transmitters are not available but where prompt servicing of single units is absolutely essential. The UX base insures the correct insertion of the capacitor into the circuit.

CONCENTRIC TRANSMISSION LINE TERMINATIONS

Concentric disc resistors, now being supplied by the International Resistance Co., 401 N. Broad St., Philadelphia, Pa., are proving a practical answer for the engineer faced with the problem of getting pure resistance loading of low-power concentric transmission lines.

Available in a variety of sizes and resistance values, these concentric disc resistors have a minimum of inductance and capacity. As a result, they should prove generally useful in high-frequency measurement circuits, signal generating equipment, and ultra-high frequency devices now under development.

NEW MIKES

The Turner Co., Cedar Rapids, Iowa, is offering a new dynamic microphone, Model No. 211, for radio stations, loud speaker systems, p.a. men, bands, and others requiring a quality microphone with extended high frequency range. Turner 211 dynamic utilizes a new type magnet structure and acoustic network, offering outstanding performance characteristics. The saltshaker type is dictated by these two features, and to those Turner has added style and streamlining.

Modern Turner engineering has extended the high-frequency range, and the extreme lows have been raised 2 to 4 decibels, to compensate for overall deficiencies in loud speaker systems. The unique diaphragm structure results in extremely low harmonic and phase distortion, without sacrificing high output level. Turner 211 is equipped with tilting head, balanced line output connection and 25 feet of heavy duty cable. It is finished in rich satin chrome. Further information may be had by writing The Turner Co., Cedar Rapids, Iowa.

NEW 15-WATT AMPLIFIER

A newly developed 15-watt amplifier which achieves an increase in operating efficiency when compared with an earlier model it replaces, has been announced by George Ewald, Manager of the Commercial Sound Division of the RCA Mfg. Co.

While rated at 15 watts, the new unit is capable of 21 watts of output as a maximum. At its rated output, distortion is less than 3½ per cent. Provision is made for microphone and phonograph inputs, the former at 560,000 ohms, and latter at 500,000 ohms. A terminal board is provided for making output connections. Separate volume controls are supplied for the microphone and phonograph inputs. A continuously variable tone control and voice-music switch are also incorporated in this amplifier.

Gain of 125 db is provided for the microphone input, 85 db for phonograph. Frequency response is from 30 to 10,000 cycles. Dual

TAYLOR

ON DUTY FOR YOUR *Defense!*

Serving:

ARMY
NAVY
POLICE
AIRLINES
BROADCASTERS
INDUSTRY
THOUSANDS OF LOYAL AMATEURS

"MORE WATTS PER DOLLAR"

Extra Dependability - - Plus Performance

Notable among the many key applications of Taylor Tubes in America's vital war effort are the 866 Jr., 866A/866, 872A and 875A rectifiers. This is not without significance — for Taylor has consistenly pioneered in working out industrial rectifier problems — in fact, has contributed directly to many advancements responsible for increased efficiency, longer life and outstanding dependability in service. Today, an ever increasing supply of Taylor Tubes is being produced for a wide range of exacting civilian and governmental requirements. If you seek the finest in quality, uniformity, service and extra value, you can depend on Taylor Tubes.

Taylor HEAVY **CUSTOM BUILT** DUTY **Tubes**

TAYLOR TUBES, INC., 2341 WABANSIA AVE., CHICAGO, ILLINOIS

control intro-tube mixing is another feature of the new unit. The fuse is easily accessible. A microphone plug is furnished with the unit.

Nothing has been sacrificed to appearance in the amplifier, which is designated as Model MI-12222. It is housed in an attractively styled cabinet of modern lines, painted a neutral grey. Its dimensions are 14½ inches long, 8¾ inches deep, and 8½ inches high.

ULTRA-HIGH-FREQUENCY ALUMINUM-CASE TRANSMITTING CAPACITORS

Engineered and especially recommended for use in ultra-high-frequency radio transmitters, television and f.m. transmitters, as well as in miscellaneous applications in the ultra-high-frequency range, the new Type 1860 transmitting capacitor is now made available by Aerovox Corporation of New Bedford, Mass. In such applications this capacitor is readily adaptable for use as a fixed tuning capacitor, for by-passing, blocking, coupling and neutralizing, and as an antenna series capacitor. Losses are extremely low because of the highly refined sulphur compound utilized as the dielectric, the elimination of corona as well as the unique design and construction. The case is grounded and a single high-tension mica-insulated brass terminal is used. The aluminum case is 2 inches in diameter by 2 or 2½ inches high, and is provided with a mounting base with 2 holes for 10-32 screws. These units are available in .00001 and .000025 μfd. in 10,000 volts and .00005 μfd. in 5,000 volts.

HALF-WAVE COAXIAL VERTICAL ANTENNA

The advantages of the present half-wave coaxial vertical antenna to obtain maximum radiated power in the ground plane are so well known and accepted today that no attempt will be made to list these many advantages here.

The Wunderlich Type 5CA Coaxial Antenna, manufactured by Wunderlich Radio Co., 1337 Fargo Ave., Chicago, Ill., incorporates all of the most desirable features, mechanically and electrically, for both transmitting and receiving.

It is shipped cut for your operating frequency and requires no matching network and no tuning. Just connect your concentric transmission line to the section which comes with the antenna, and then to your transmitter-receiver, and it is ready to operate. Tests indicate that the Type 5CA coaxial vertical antenna will increase signals up to 8 db over a conventional open type J.

Field tests also indicate that the Type 5CA, because of the formula used in cutting the whip and skirt to operating frequency, will provide considerable increase in signals over coaxial antennas not so designed.

NEW BOOKS *and catalogs*

The RADIO HANDBOOK

THE RADIO HANDBOOK, Eighth (1942) Edition, by the Editors of RADIO. Published by Editors and Engineers, Ltd., 1300 Kenwood Road, Santa Barbara, California. 640 pages 6½" by 9½", profusely illustrated with 577 line drawings and halftones, and 41 tables. Price of clothbound edition, $1.75 in continental U.S.A., elsewhere $2.00.

The RADIO HANDBOOK is a general compilation of information on the practical aspects of radio. Its content can be divided into three classifications: (1) basic theory of electricity, radio, vacuum tubes, and antennas, written from the standpoint of practice rather than from the engineering viewpoint; (2) constructional information on the building of a wide variety of types of high frequency and u.h.f. transmitters and receivers for phone and c.w. use, coupled with information on the construction of many useful pieces of test equipment; (3) tube characteristic tables, reference charts and graphs, and a collection of formulas useful to the practicing radioman.

Investigation to determine the principal sale of previous editions indicates that there were two main classes of buyers: those who were using the Handbook as a reference work and hence had greatest need for the comprehensive tube tables, charts, tabular material, and formulas; and those schools who were using the Radio Handbook as a radio instruction textbook.

As a consequence of this investigation the tube tables have been expanded as well as brought up to date, and the reference material has been considerably increased. To assist those using the Handbook as a text the theory chapters have been rewritten and expanded with an eye to increasing their suitability to this application. Due to a more compact type style and an increased number of pages these increases in text and reference material have been made with no sacrifice in the amount of space devoted to constructional information.

Investigation also showed that one reason this Handbook is so widely used as a textbook is that no other comparable book contains so much up-to-date information suitable for instruction in the subjects of F.M. and U.H.F. Communication, in addition to the usual radio and electrical theory. The RADIO HANDBOOK contains the most comprehensive information available in any one book on all types of transmitting, receiving, and special-purpose tubes. A total of 54 pages is devoted to this extensive listing. Both transmitting and receiving tubes are listed in the order of their assigned number to make it possible to find the characteristics of the desired tube in the least amount of time.

The list of the 27 chapter headings gives an excellent indication of the subject material treated.

[*Continued on Page 62*]


Always NEW!
A radical plate design in 1936 greatly improved power capabilities and efficiency of 250T
In 1941 further improvements and still greater efficiency.
VETERANS of many outstanding achievements in radio, yet there's no such thing as an OLD tube type at Eimac. Past achievements paved the way for present leadership in the field. Leadership made possible by "heads-up" developments in tube construction and performance capabilities. The tubes today are not the same, by a long way, as those originally used. And yet basically they are the same. Note the pictures of plates in Eimac tubes today are not the same... above. See one of the early models and the improvement in the modern design which represents greater efficiency. By such constant improvement, Eimac tubes are kept "always NEW"...always a step ahead of the needs of the industry. Each tube has behind it the successful years of its predecessors...radical departure from conventional tube design...ability to perform without strain where many others failed.
Such is the Eimac 250T. Originally the Eimac 150T, it surprised the industry by performing so easily, the task of much larger tubes that, with slight modifications, its rated capabilities were boosted by more than 60%. The record today shows these comparatively small triodes being used in newer transmitters for jobs once thought impossible. Eimac tubes are like that, one and all. They are the only tubes on the market which carry unconditional guarantee against tube failures resulting from gas released internally.
Follow the leaders to
Eimac TUBES
Eitel-McCullough, Inc.
San Bruno, Calif.
EIMAC 250T
Plate Dissipation (normal) . . . . 250 Watts
Filament Voltage . . . . 5 to 5.1 Volts
Maximum Plate Voltage 3000
Power Output at 3000 volts on plate . 750 Watts
EIMAC REPRESENTATIVES
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HERB BECKER, 530 W. 104th St., Los Angeles, Cal.
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ADOLPH SCHWARTZ, 252 Grayson Place, Teaneck, New Jersey.
Wash., Ore., Idaho, Mont.
GENERAL SALES CO. Verner O. Jensen, 2605-07 Second Ave., Seattle, Wash.
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RICHARD A. HYDE, 4253 Quitman St., Denver, Colo.
Chicago, Illinois, Wisconsin
G. G. RYAN, 549 W. Washington Blvd., Chicago, Ill.
N. Caro., S. Caro., Georgia, Tenn., Flor., Ala., Miss.
JAMES MILLAR, 316 Ninth St. N. E., Atlanta, Georgia
Texas, La., Okla., Ark.
J. EARL SMITH, 2821 Live Oak St., Dallas, Texas
Ohio, Mich., Ky., Ind., Minn., Mo., Kan., Neb., Iowa
PEEL SALES ENGINEERING CO., E. R. Peel, 154 E. Erie St., Chicago, Ill.
Export Agents: Frazar & Co., Ltd., 301 Clay Street, San Francisco

POSTSCRIPTS... *and Announcements*

Synchronize Your Skeds with Arlington Time

The last three records on the chart, figure 3, on page 17 of the December RADIO seem completely wrong. This chart appeared in the article by J. H. Poole, "Sychronize your Skeds with Arlington Time." The chart shown below gives a more logical sequence as indicated by the first five records. Note that 37 hours pass between the check on the 8th and that on the 9th. Therefore the error changes by 37/24ths of 17 seconds.

DATE	STATION	TICK H M S	CLOCK H M S	ERROR M S	RATE SEC/24H
NOV. 3	NSS	02 00 00	01 55 37	04 23 SL	
4	NSS	02 00 00	01 55 53	04 07 SL	
5	NSS	01 58 00	01 54 10	03 50 SL	
6	NSS	01 59 00	01 55 27	03 33 SL	−17
8	NSS	01 58 00	01 55 01	02 59 SL	−17
9	NPG	15 00 00	14 57 27	02 33 SL	−17
13	NPG	14 58 00	14 56 41	01 19 SL	−18
17	NPG	15 00 00	15 00 16	00 16 FST	−19
18					

Dud Little Award

The Ultra-High Frequency Club of Chicago has asked us to remind the U.H.F. gang that January 31, 1942, is the deadline for nominations for the first award. The Dud Little Award, presented by the U.H.F. Club of Chicago, will be made on March 14, 1942, the anniversary of Dud's death.

Attention is called to the rules as published by RADIO on page 92 of the October issue.

All nominations should be sent to Mr. Edward Hamel, in care of the Columbia Broadcasting System, 410 N. Michigan Ave., Chicago, Illinois.

Maritime Service

Some 1,200 new merchant ships will be launched during the next 2 years and will require 40,000 additional seamen in deck and engine departments, as radio operators, and as cooks and bakers. Young men are needed at once and those accepted for training are assured of good jobs at unusually good pay because there is a lack of trained men to man these new vessels.

Public employment offices in every State will assist in enrollment of apprentice seamen and radio operators for training by the Maritime Service which is administered for the Maritime Commission by the U. S. Coast Guard. Apprentices are paid while in training. Upon completion of this free training course they are expected to serve in the merchant marine for at least a year thereafter.

Young men between the ages of 18 and 23 may apply at their local State employment office. They will have to meet physical and character standards established by the Maritime Service. Though the Maritime Service is not an enlisted service, Selective Service boards have instructions to waive induction, where possible, of men in the merchant marine. Apprentices may join the Merchant Marine Reserve of the U. S. Navy Reserve and thus be exempt from selective service.

Trainees will receive free transportation from the point of enrollment to the school. A clothing allowance will be furnished amounting to $100. Trainees will receive quarters, subsistence, and free medical and dental care. On completion of the course, free transportation will be furnished to assigned ports. In addition, men in the radio school will receive from $36 to $54 monthly. Radio operators' base pay for graduates employed on ocean or Great Lakes merchant ships varies from $105 to $165 per month, plus bonuses and extra payments. Base pay plus bonuses, in almost all cases, will amount to more than $200 a month.

The radio school is at Gallups Island in Boston Harbor.

The local State employment offices will give information and preliminary interviews to applicants, then refer them to Maritime Service enrollment officers with headquarters in 40 inland and coast cities.

Clark Electronic Bug

"The electronic bug described by Clark on page 36 of the October 1941 RADIO does a surprisingly good job, but one characteristic was noticed which made it difficult to key. Namely the timing of the dashes was not exactly correct. The dashes were too long and the spaces in between dashes were very short. Even at slow speeds it was difficult to send letters where dots and dashes were intermingled, such as *C, R, K*, etc.

"An investigation disclosed that the value of R_{10} (250,000 ohms in the diagram) controls the duration of the dash and also the value of the spaces in between. Increasing R_{10} results in shorter dashes and longer intervals between them. One megohm, however, is too high a value and the sending becomes 'choppy'. A potentiometer of about a megohm in value is a good aid for adjusting the timing. This does not mean that we have three controls for speed, however, because once R_{10} is set it will hold pretty well over a wide range of speed. Therefore R_{10} could be mounted under the chassis with a screwdriver adjustment.

"I suspect that this may have had some connection with regard to the difficulty experienced in learning to operate the bug, because the transition from mechanical to electronic keying should be quite easy if all is operating properly."

W. B. THOMPSON, W8OKC.

The Gimmick

An error appeared in the schematic diagram for the Gimmick on page 25 of the December issue of RADIO. The coupling condenser C_{13} should be connected directly to the grid of the 6Q7-G instead of to the junction of the grid leak and the bias cells as shown.

Navy Seeks Recruits for Radio and Communications Duties Among Amateur Operators and Allied Trades

An opportunity for radio "hams" and technicians to serve their country in Class V-6 of the United States Naval Reserve and, at the same time, receive valuable training is being offered by the Navy Department, which is seeking several thousand recruits for one of its newest operations branches.

Qualified applicants will be enlisted immediately as Radiomen, Second Class, which is equal to four full promotions over original enlistments as apprentice seamen. Radiomen Second Class receive a base pay of $72 per month and allowances while on duty as technicians and Radar maintenance men. Applicants must be high school graduates and must hold, or have held, Amateur Class "A" or "B" licenses. If applicants lack the license qualifications, they must be actively engaged in radio repair or service work, or have had experience with high frequency design, transmission or reception. They do not necessarily have to be familiar with Morse or other codes.

Men enlisted west of the Mississippi River will be ordered to the Naval Radio Training School at Los Angeles, California, for a course in Naval Communications. Those enlisted east of the Mississippi River will be trained at the Naval Radio Training School at Noroton, Connecticut. After February 1, students will be sent either to the San Francisco Radio Material School or to the Radio Material School at Bellevue, D.C., until the capacities of the two institutions are filled.

After training, students will have a chance for advancement in rating up to that of Chief Radioman, which carries a base pay of $99 per month.

"Radar" men will operate the newly perfected radio device which locates planes in flight, the delicate and complicated instrument developed in England and used with such meritorious success by the Royal Air Force. The patents have been turned over to the United States by Great Britain. Details of the device are being kept a deep secret, but it is said to have been used both on the ground and in the air, and is a vital addition to the nation's defense armory.

Federal Communications Commission Radio Operators Examination Schedule, 1942

Boston, Massachusetts, Customhouse, 7th Floor.
  All phone: Mon., Tues., Wed. All telegraph: Thursdays. Amateur: Daily except Thurs.

New York, New York, 748 Federal Building, 641 Washington St.
  Amateur: Tues., Thurs., Sat. Commercial: Mon., Wed., Fri. Schenectady: March, June, September, December.

Philadelphia, Pennsylvania, Room 1200, Customhouse, 2nd and Chestnut St.
  All telegraph: Wednesdays. All phone: and Amateur Class A: Daily. Amateur Class B: Wed. and Sat.

Baltimore, Maryland, Fort McHenry.
  All classes: Wednesdays. Telegraph: Wed. Other days by appointment. Amateur: Sat. Phone: Daily.

Norfolk, Virginia, Room 402, New P.O. Bldg.
  Phone 3rd and Amateur Class A: Daily. All classes: Fridays. Amateur Class A and

1 C	2 O	3 D	4 E		5 S	6 T	7 A	8 N	9 D
10 A	C	O	R	11 N		12 E	L	E	C
	13 T	P	T	G		14 L	I	D	S
15 S	A	E				16 E	G	A	D
17 P	L		18 E	S		19 V	N		
E			C		20 H	I		21 R	22 A
23 A	C	24 H	O	O		25 S	26 T	A	R
K		O			27 F	I	S	T	
28 E	29 R	O	30 S		31 M	O		32 E	33 D
34 R	A	D	I	O		35 N	O	D	E

Answer to the radio crossword puzzle which appeared on page 75 of the January RADIO.

B: Saturdays. Winston-Salem, N.C.: Feb. 7, May 2, Aug. 1, Nov. 7.

Atlanta, Georgia, 411 Federal Annex.
All classes: Tuesdays and Fridays. Amateur only: Saturdays. Nashville, Tenn.: Feb. 20, May 20, May 15, Aug. 21, Nov. 20.

Miami, Florida, Room 314 Federal Bldg., P.O. Box 150.
All classes: Tuesdays. Restricted Phone Permit: Daily. Amateur: Tuesdays and Saturdays. Jacksonville: May 16, Nov. 21.

New Orleans, Louisiana, 308 Customhouse.
All classes: Mondays. Other days by appointment. Little Rock, Ark.: April 14, Sept. 15.

Galveston, Texas, 404 Federal Bldg.
All classes: Wednesdays and Fridays. Amateur: Saturdays. All phone: Daily.

Dallas, Texas, 500 U. S. Terminal Annex, P.O. Box 5373.
All classes: Tuesdays. Restricted Phone: Daily. Amateur only: Saturdays. Oklahoma City: Commercial; Jan. 23, April 24, July 24, Oct. 23. Amateur; Jan. 24, April 25, July 25, Oct. 24. San Antonio: Commercial; Feb. 20, May 22, Aug. 21, Nov. 20. Amateur; Feb. 21, May 23, Aug. 22, Nov. 21. Albuquerque: March 21, Sept. 16.

Los Angeles, California, 539 U.S. P.O. and Court House Bldg., Temple and Spring Streets.
All Telegraph: Thursdays. All phone: Daily. Amateur: Wed. and Saturdays. Phoenix, Arizona: April and October, 2 days.

San Francisco, California, 328 Customhouse, Washington and Battery Streets.
All phone and Amateur Class A: Daily. All telegraph: Tuesdays. Amateur Class B: Mondays and Saturdays.

Portland, Oregon, 805 Terminal Sales Bldg.
All phone: Daily. All telegraph: Tuesdays and Thursdays. Amateurs. Fridays and Saturdays. Boise, Idaho: April and October.

Seattle, Washington, 808 Federal Office Bldg.
Phone and telegraph 1st and 2nd: Tuesdays. Restricted phone and telegraph: Wednesdays. Amateur Class A and B: Fridays. Billings, Mont.; Butte, Mont.; Spokane, Wash.: May and Nov.

Denver, Colorado, 504 Customhouse.
All commercial: 1st and 2nd Friday. All amateur: 1st and 2nd Saturday. Salt Lake City, Utah: March and Sept.

St. Paul, Minnesota, 208 Uptown P.O. and Federal Courts Bldg., 5th and Washington Streets.

Commercial: 1st and 3rd Thursdays. Amateur: 1st and 3rd Saturdays.

Kansas City, Missouri, 809 U.S. Courthouse. Commercial: Fridays. Amateur only: Saturdays. Other days by appointment. Des Moines, Iowa: Commercial; Jan. 9, April 10, July 10, Oct. 9. Amateur; Jan. 10, April 11, July 11, Oct. 10. St. Louis, Missouri: Commercial; Feb. 13, May 8, Aug. 14, Nov. 13. Amateur; Feb. 14, May 9, Aug. 15, Nov. 11.

Chicago, Illinois, 246 U.S. Courthouse Bldg. All commercial: Thursdays. All Amateur: Saturdays.

Detroit, Michigan, 1025 New Federal Bldg. All Commercial: Fridays. All amateur: Saturdays. Other days by appointment. Cincinnati. Ohio: Feb., May, Aug., Nov. Columbus, Ohio: March, June, Sept., Dec.

Buffalo, New York, 518 Federal Bldg. All commercial: 1st and 3rd Fridays. Amateur: 1st and 3rd Saturdays. Pittsburgh: Jan., April, July, Oct.

Honolulu, T. H., Aloha Tower Commercial: Wednesdays. Amateur: Mondays and Saturdays. Hilo: Jan. 24, Aug. 17. Lihue: Feb. 13, Aug. 26. Kaunakakai: Aug. 3. Lanai City: Aug. 4. Wailuku: Aug. 5.

San Juan, Puerto Rico, 322 Federal Bldg., P.O. Box 2987.
Examinations given at convenience of the Inspector. Arrangements should be made by corresponding with the office.

Juneau, Alaska, 7-8 Shattuck Bldg., P.O. Box 1421.
Examinations given at convenience of the Inspector. Arrangements should be made by corresponding with the office.

Washington, D.C., F.C.C. Headquarters.
All classes: Thursdays. Other days by appointment.

Savannah, Georgia, Sub-Office 6, 208 P.O. Bldg., P.O. Box 77.
Examinations given at convenience of the Inspector. Arrangements should be made by corresponding with the office.

Tampa, Florida, Sub-Office 7, 203 P.O. Bldg. Examinations given at the convenience of the Inspector. Arrangements should be made by corresponding with the office.

Beaumont, Texas, Sub-Office 9, 329 P.O. Bldg., P.O. Box 1527.
All classes: 1st and 3rd Thursdays. Other days by appointment.

San Diego, California, Sub-Office 11, 301 Customhouse and Courthouse Bldg.
Examinations given at the convenience of the Inspector. Arrangements should be made by corresponding with the office.

Cleveland, Ohio, Sub-Office 19, 541 Old P.O. Bldg.
All commercial: 1st and 3rd Fridays. All Amateur: 1st and 3rd Saturdays. Restricted

[*Continued on Page 62*]

Q. & A. Study Guide

[*Continued from Page 20*]

Refer to diagram 100.

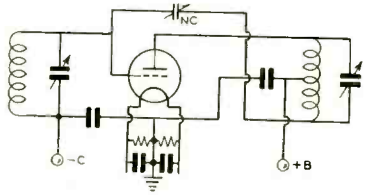
(101) Draw a simple schematic circuit diagram of a radio frequency amplifier, employing a triode vacuum tube and making use of plate neutralization.

Refer to diagram 101.

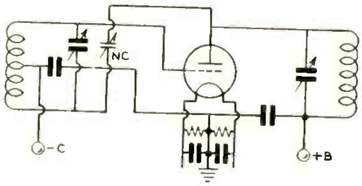
(102) Draw a simple schematic circuit diagram of a radio frequency amplifier, employ-

[*Continued on Page 54*]

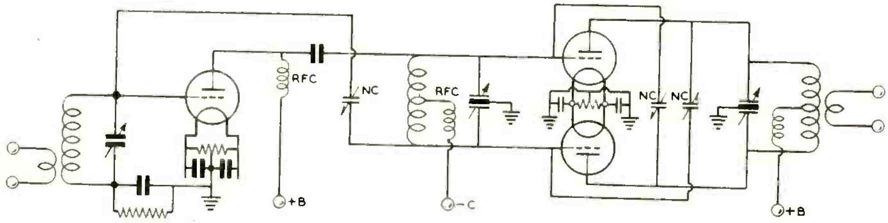
(101)



(102)



(100)



Hi-Fi Phono Amplifier

[*Continued from Page 10*]

quency response. The one with the largest output transformer went lowest in frequency—as would naturally be expected—and the one with the highest plate supply voltage delivered the greatest power output. The three tested had actual plate supply voltages of 330 volts—power output 7 watts, 365 volts—power output 9 watts, and 400 volts—power output 11 watts. It will be noted that these power output figures are slightly lower than would be expected from reference to the published tube characteristics. This discrepancy is due to the fact that the power output was actually measured at the voice coil winding of the output transformer so that the insertion loss in the transformer was subtracted from the actual power output at the plates of the tubes. Published tube data gives the power output at the plates of the tubes, not at the secondary of the output transformer.

Pickup Equalization Circuits

Since phonograph records are not flat in frequency response, that is they are not cut either constant amplitude or constant velocity throughout their range, it is necessary to equalize the phonograph pickup if substantially flat frequency response is desired. Records are cut constant amplitude up to a crossover frequency (from 200 to 1000 cycles depending upon the manufacturer and upon the date when the record was recorded) and substantially constant velocity above that point. Since a crystal pickup has a voltage output dependent upon the amplitude of displacement, its response will be satisfactory on the low frequencies but it will have to have an equalizer which will build up the high frequency response. A magnetic pickup, in which the output voltage is dependent upon the velocity of displacement, will have to be equalized so that its low frequency response is built up. The point at which this equalization should begin to take place is dependent upon the crossover point used in making the recording.

The input condenser and resistor R_1-C_1 in the main circuit diagram serves to equalize the high frequency response of the conventional crystal pickup, using 750 cycles as the average crossover frequency. The additional small circuit diagram is for bass boost when using a crystal pickup, with high frequency compensation, or this input circuit can be used with a magnetic pickup to obtain the low frequency equalization required. When using a magnetic pickup the small condenser C_2 may be removed if too much record scratch is apparent.

Q. & A. Study Guide

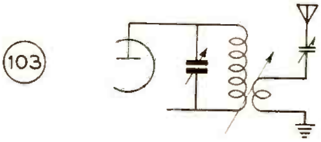
[*Continued from Page 52*]

ing a triode vacuum tube and making use of grid neutralization.

Refer to diagram 102.

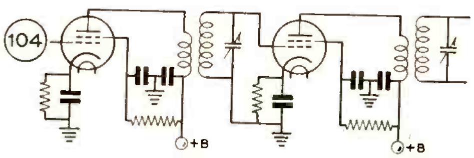
(103) Draw a simple schematic diagram showing a method of coupling the radio frequency output of the final power amplifier stage of a transmitter to an antenna.

Inductive coupling to a Marconi antenna is illustrated in diagram 103.



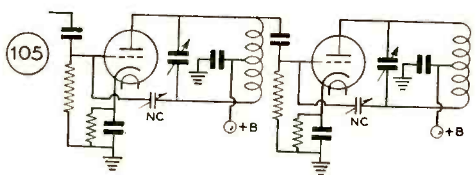
(104) Draw a simple schematic diagram showing a method of coupling between two tetrode vacuum tubes in a tuned radio frequency amplifier.

Refer to diagram 104.



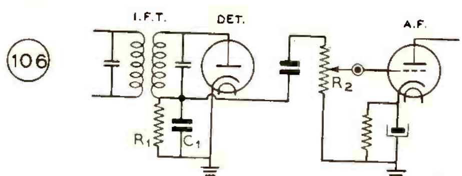
(105) Draw a simple schematic diagram showing a method of coupling between two triode vacuum tubes in a tuned radio frequency amplifier, and a method of neutralizing to prevent oscillation.

Refer to diagram 105.



(106) Draw a simple schematic diagram of a diode vacuum tube connected for diode detection, and showing a method of coupling to an audio amplifier.

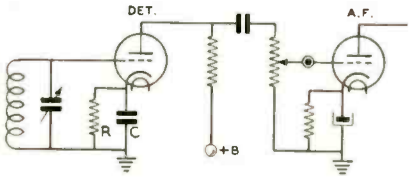
Refer to diagram 106. To avoid a.c. shunt loading, the value of C_1 should be small, and the resistance of R_2 should be much greater than that of R_1.



(107) Draw a simple schematic diagram of a triode vacuum tube connected for plate or "power" detection.

Refer to diagram 107. The value of detector cathode resistor, R, is considerably higher (3 to 10 times) than commonly employed for the same tube in a resistance coupled amplifier.

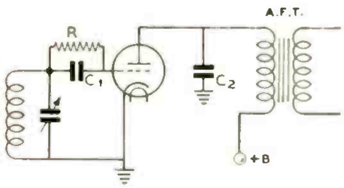
107



(108) Draw a simple schematic diagram of a triode vacuum tube connected for grid-leak-condenser detection.

Refer to diagram 108. The resistance of R should be at least several times the resonant impedance of the grid tank circuit, the reactance of C1 should be considerably higher than the resistance of R at the highest modulation frequency, and the reactance of C2 should be higher than the effective plate resistance (dynamic plate resistance while detecting) of the detector tube at the highest modulation frequency. The plate voltage should be high enough that the tube draws appreciable plate current with no signal, but not so high that plate current is sufficient to damage the tube or endanger the primary winding of a.f.t. These conditions will permit maximum selectivity, sensitivity, fidelity, and power handling capability.

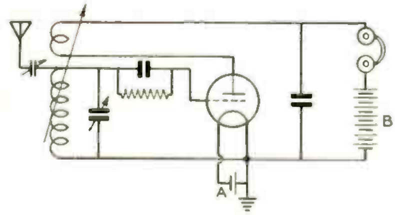
108



(109) Draw a simple schematic circuit of a regenerative detector.

Refer to diagram 109.

109



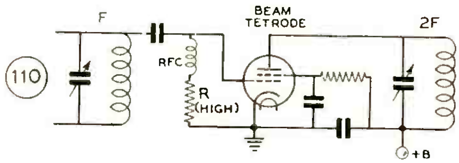
(110) Draw a simple schematic circuit diagram of a radio frequency doubler stage, indicating any pertinent points which will distinguish this circuit as that of a frequency doubler.

Refer to diagram 110. For maximum efficiency, the grid bias should be sufficient to cut down the excitation pulses to 90 degrees or less. The grid (driver) tank should have sufficient Q to maintain good waveform (low harmonic content), as flat topped excitation pulses will increase further the amount of bias required for good efficiency.

To run normal grid current at such a high value of bias (5 or more times cutoff) requires a large amount of excitation power, and therefore pentodes or beam tetrodes often are utilized in doubler stages in order to minimize the excitation requirements.

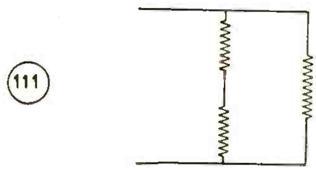
When triodes are used, ones having a high amplification factor and high transconductance are to be preferred in order to minimize the excitation voltage and excitation power required.

When very high efficiency is not required in a doubler stage, two or three times cut-off bias often is found sufficient. This amount of bias greatly reduces the excitation power required.



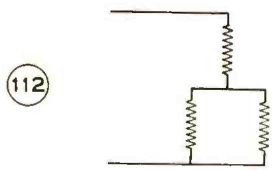
(111) Draw a schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be two thirds the resistance of one unit.

Refer to diagram 111.



(112) Draw a simple schematic diagram showing the method of connecting three equal resistors so that the total resistance will be one and one-half times the resistance of one unit.

Refer to diagram 112.



(113) Draw a simple schematic diagram to indicate how a 60 cell bank of lead-acid storage batteries may be connected to permit charging in parallel from a 110-volt d.c. source and discharging in series, including necessary switches.

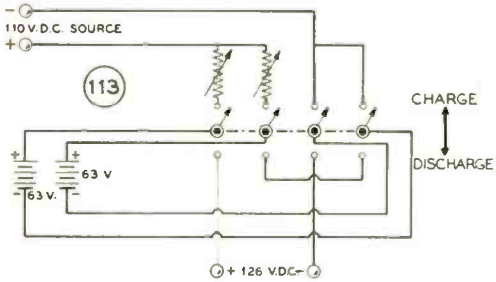
Refer to diagram 113.

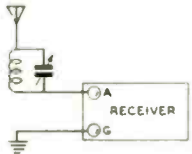
(114) Draw a diagram of a simple shunt rejector wave trap circuit, in series with a receiving antenna circuit, designed to suppress an undesired signal.

Refer to diagram 114.

(115) Draw a diagram of a simple series wave trap circuit, connected in shunt with the input terminals of a radio receiver and designed to by pass an undesired signal.

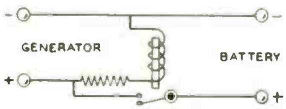
Refer to diagram 57.



114


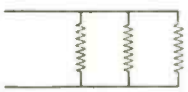
(116) Draw a simple schematic diagram of an underload circuit breaker as used with battery charging circuits.

Refer to diagram 116.

116


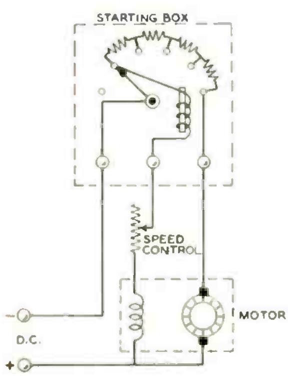
(117) Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be one third of one unit.

Refer to diagram 117.

117


(118) Draw a simple schematic diagram of a shunt wound, self-excited, d.c. motor, with provision for starting and regulating speed, including indication of d.c. source.

Refer to diagram 118.

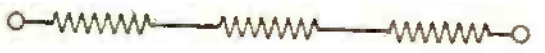
118


(119) Draw a simple schematic diagram showing the method of connecting three resistors of

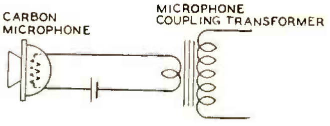
equal value so that the total resistance will be three times the resistance of one unit.

Refer to diagram 119.

(119)



(120)



(120) Draw a diagram of a single button microphone circuit, including microphone transformer and source of power.

Refer to diagram 120.

(121) What is meant by a "soft" vacuum tube?

A "soft" vacuum tube is a tube in which the vacuum is not of a high degree.

(122) What is meant by a "thyratron."

"Thyratron" is the trade name for one make of grid controlled, hot cathode, mercury vapor rectifier. These tubes have many industrial applications, often being used to convert d.c. to a.c.

(123) Describe the physical structures of the triode, tetrode, and pentode on a comparative basis.

Refer to answer 126 for a description of the triode.

The tetrode resembles the triode except for the interposition of an extra grid, called the screen or accelerator grid, between the control grid and plate. Also, the control grid is well shielded from the plate (both elements and leads) when the tube is designed for radio frequency service.

The pentode resembles the tetrode except for the interposition of a "suppressor" grid between the screen grid and the anode. This grid reduces secondary emission from the anode.

(124) Describe the electrical characteristics of the pentode, tetrode, and triode on a comparative basis.

The triode normally has a plate resistance of from 700 to 75,000 ohms when drawing normal plate current, and an amplification factor of from 3 to 100. The triode requires neutralization when used as a tuned amplifier at radio frequencies. When used as an audio frequency amplifier the second harmonic distortion limits the undistorted output to about 20 per cent of the d.c. input when the tube is used in a single ended stage. Therefore, for high a.f. output from triodes they usually are operated in push pull.

The tetrode (old type) has much higher plate resistance and amplification factor than a triode. The amplification factor and plate resistance both go down as the screen voltage is raised, until the screen voltage approaches the plate potential. However, the plate resistance goes down faster than the amplification factor, and therefore the transconductance goes up with an increase in screen voltage (within the aforementioned limits).

Tetrodes designed for r.f. use are well screened, and in most applications do not require neutralization. Older type tetrodes exhibit bad secondary emission, which limits the plate voltage swing. When the plate voltage is somewhat lower than the screen voltage, early type tetrodes have negative transconductance, which makes them well suited for use in the dynatron oscillator.

Beam tetrodes are similar to ordinary tetrodes except for the interposition of "beam forming plates" between the screen and plate. This virtually eliminates secondary emission, and such tubes act very much as pentodes except for somewhat lower screen current and slightly higher transconductance. Beam tetrodes can, so far as electrical characteristics are concerned, be classed with pentodes.

Pentodes are similar to tetrodes so far as amplification factor, screening, and plate resistance are concerned, but secondary emission is practically eliminated. This permits the screen to be run at the same d.c. potential as the plate, since the plate voltage swing is not limited by the dynatron effect.

Pentodes are widely used as class-A single ended output stages in audio frequency amplifiers, as they deliver more undistorted output than a triode running at the same plate input.

Pentodes designed for a.f. use have lower plate resistance and amplification factor, and the screening is not sufficiently good to obviate the necessity for neutralization when the tube is used as an r.f. amplifier.

R.f. power amplifier pentodes have comparatively low plate resistance and amplification factor, and thus are similar to a.f. pentodes. However, the screening is much better.

R.f. pentodes for receiver use have very high amplification factor and plate resistance, and are very well screened.

(125) What are the visible indications of a "soft" tube?

A soft tube usually exhibits a bluish haze between the cathode and other elements. In many instances the plate current will tend to increase, particularly if the tube is run with fixed bias.

(126) Describe the physical structure of a triode vacuum tube.

The conventional triode consists of a cathode, surrounded by a fine wire grill or helix which serves as the grid, which in turn is surrounded by a mesh or solid anode. The structure is supported by mica, ceramic, or glass spacers and braces, and is contained in a glass or metal envelope which is pumped to a high degree of vacuum.

The cathode may be of either the directly heated or indirectly heated type. The former consists of a wire or ribbon filament which emits electrons when it is heated by passing a current through it. The latter type consists of an oxide coated sleeve or cylinder which is heated by an insulated heater element placed inside.

(127) Describe the physical structure of a tetrode vacuum tube.

A tetrode is similar to a triode in physical construction except for the addition of a grid between the control grid and plate, and, in the case of tubes designed for r.f. use, electrostatic screening between grid and plate leads and element structures.

(128) Does a pentode vacuum tube usually require neutralization when used as a radio-frequency amplifier?

This depends entirely upon whether the pentode was designed for r.f. use or primarily for a.f. use. If the pentode was designed for r.f. use, it probably will not require neutralization.

(129) What is the meaning of "plate impedance"?

The plate impedance is the dynamic plate resistance of a tube. It is ratio of a small change in plate voltage to the resulting change in plate current. The plate impedance of a tube is not a fixed characteristic, but depends upon the operating voltages.

(130) What is the meaning of "mutual con-

ductance"? "Transconductance"?

These two terms mean the same thing when applied to a vacuum tube, and are a measure of the power sensitivity or goodness of a vacuum tube. They combine the plate resistance and amplification factor in a single term, being the ratio of the amplification factor to the plate resistance in ohms.

Transconductance also may be defined as the ratio of a small change in plate current to the change in grid voltage required to produce the change, all other electrode voltages remaining constant.

(131) What is the meaning of "secondary emission"?

When electrons strike the screen or plate of a vacuum tube with sufficient velocity, other electrons are released by the impact, thus making the screen or plate an emitter of electrons. This produces undesirable effects in the tube for most applications, and therefore these secondary electrons are prevented from traveling from screen to plate or vice versa by the insertion of beam forming plates, by spacing the screen much closer to the control grid than to the plate, or by inserting a suppressor grid between screen and plate.

(132) What is the meaning of "amplification factor"?

Amplification factor is the maximum theoretical voltage amplification of a tube. In practice it may be approached, but never reached, because it is impossible to work a tube into an infinitely high load resistance. It is the ratio of a change in plate voltage to the change in grid voltage required to produce the change in plate voltage, assuming that the plate current remains constant.

(133) What is the meaning of "electron emission"?

The free electrons in certain materials are released when energy is applied to the surface. When the energy is heat, as in the case of a vacuum tube, it is known as "thermionic emission."

(134) Describe the characteristics of a vacuum tube operating as a class C amplifier.

The operating bias exceeds cutoff, the plate current flows for less than 180 degrees of each cycle of excitation, and the efficiency is high. If the bias exceeds twice cutoff, the excitation heavy, and the loading not too heavy, then the r.f. output voltage varies almost linearly with plate voltage over wide limits.

To obtain sine wave output from a class C amplifier, a tuned output tank having reasonably good Q when loaded is required. This makes the class C amplifier unsuited to wide-band (voice) audio amplification.

(135) During what approximate portion of the excitation cycle does plate current flow when a tube is used as a class C amplifier?

The plate current flows for less than 180 degrees of the excitation cycle. A class C amplifier usually is so biased and so excited that plate current flows for about 120 degrees of the excitation cycle.

[*Note: Element II questions will be continued next month.*]

• • •

The use of high frequency radio waves in diathermy equipment to produce artificial fever is not news. However, 300 kw. of 1,500,000-cycle current is now being "broadcast" through 14-inch thick piles of 4 feet x 8 feet plywood to set the glue between the sheets of wood, in perhaps the first industrial production use of this process. The plywood is now bonded in 5 to 10 minutes as against 8 hours in the former cold press method.

The Ohmite News.

Field-Strength Meter

[*Continued from Page 33*]

of the EF portion of the curve, assuming that the (grid) rectification efficiency is constant. The latter asumption is safe to make so long as the grid leak resistance is sufficiently high that the grid is allowed to assume a bias substantially equal to the contact potential for the negative end of the filament.

So that F will fall on the straight portion of the curve as illustrated, and not on the knee represented by the dotted line, the plate voltage should be at least as great as the amplification factor of the tube, times the filament-voltage-plus-the-contact potential. As the latter voltage is small, it is sufficient to say that the plate voltage should be "somewhat greater than the filament voltage times the amplification factor."

The only effect then of the curvature caused by filament bias is to reduce the effective transconductance on strong signals. As sensitivity is of importance only when dealing with the weakest signals, this is nothing to worry about. In fact, it increases the useful db range of the meter slightly, which may in some cases be an advantage.

A comparison of the curvature of AE with that of BD will show why an indirectly heated cathode type tube is desirable for maximum sensitivity to weak signals when using a bias type ("power") detector regardless of the value of plate voltage.

• • •

Design Precaution For Oscillators Employing Filament-Type Tubes

From RCA Application note no. 117

Experience with filament-type acorn tubes as oscillators in transmitting equipment has shown that, under some conditions of operation, oscillation may continue after the filament voltage has been removed unless the plate voltage is also removed. When the filament voltage is removed from an oscillator tube having particularly low filament power consumption, continued oscillation frequently takes place because of continued heating of the filament by the plate current.

Continued oscillation has been found most likely to occur (1) with a tube having high emission capability, (2) with an exceptionally well-designed oscillator circuit, and (3) with a high value of oscillator plate current; it has been observed with oscillator tubes operated at moderate values of plate voltage and current.

Because of these results in the laboratory and in the field, it is recommended that both the filament voltage and the plate voltage of filament-type miniature, GT, and acorn tubes used for transmitter purposes be removed when equipment employing these types is "shut down." Usually, a convenient method is to break the minus filament and the minus plate supplies with a single, double-pole switch.

The recommended procedure insures that the oscillator will always stop functioning in the "off" position, saves power, and avoids interference with reception in combined transmit-receive equipment.

New Books and Catalogues

[*Continued from Page 44*]

These are, in order: Introduction to Amateur Radio, Fundamental Electrical and Radio Theory, Vacuum Tube Theory, Radio Receiver Theory, Radio Receiving Tube Characteristics, Radio Receiver Construction, Transmitter Theory, Radiotelephony Theory, Frequency Modulation, Transmitting Tubes, Transmitter Design, Exciters and Low Powered Transmitters, Medium and High Power R.F. Amplifier, Speech and Modulation Equipment, Power Supplies, Transmitter Construction, U.H.F. Communication, U.H.F. Receivers and Transceivers, U.H.F. Transmitters, Antenna Theory and Operation, Directive Antenna Arrays, U.H.F. Antennas, Transmitter Adjustment, Test and Measuring Equipment, Workshop Practice, Broadcast Interference, and Radio Mathematics and Calculations. There are the three additional sections in the back of the book devoted to Appendix, Buyer's Guide, and Index.

This year the price of the Radio Handbook has been increased 10 per cent to offset the increase in the price of paper and printing, and to cover the fact that the Eighth Edition contains 32 pages more text than the previous edition. This increase in the size of the book represents a much more than proportionate increase in the editorial content since a type face somewhat more compact than that in the previous edition has been used.

R.C.P. 1942 Test Instrument Catalog

The 1942 line of radio and electrical test instruments manufactured by Radio City Products Co., Inc., 88 Park Place, New York City, is presented in a 20-page, illustrated catalog just released. This new line includes more than 40 models of 22 basic test instruments. In this new Catalog No. 125 each of these models is illustrated and its specifications presented in concise, timesaving form.

Copies of the new catalog are now available from RCP distributors throughout the country, or from the manufacturer direct.

New Thordarson Book for Servicemen

Transformer Replacements for over 4000 receivers are given in Thordarson's new edition of the Replacement Encyclopedia, No. 352-F, available free to servicemen. Receiver types have been carefully arranged to enable quick and accurate selection of power transformer, filter choke, audio or output transformer. A special feature of the Encyclopedia is the addition of electrical and physical characteristics of recommended replacement types listed in the book.

Ask your distributor for this new 32 page book, No. 352-F or write direct to Thordarson for your copy. Address, Thordarson Electric Mfg. Co., 500 W. Huron Street, Chicago, Illinois.

Postscripts and Announcements

[*Continued from Page 51*]

phone: 1st and 3rd Fridays at 1 P.M.

Note: All examinations begin promptly at 9:00 A.M. local time except at New Orleans, La., and Honolulu, T.H., at 8:30 A.M.

Only Amateur examinations may be started on Saturdays at Des Moines, St. Louis, and Kansas City. Date of examination days at Bismarck, North Dakota, and Pittsburgh, Pennsylvania, can be determined bv corresponding with the Inspectors in Charge at St. Paul, Minnesota, and Buffalo, New York, respectively.

Balboa, Canal Zone, commercial examinations by appointment with District Communications Officer, Navy Dept.

No examinations on National holidays or State holidays.

Where dates are not shown, obtain information from the Inspector in Charge of the District.

All classes of examinations will be given at each point, except when otherwise indicated.

U.H.F.

[*Continued from Page 36*]

Ranger"; 6QLZ likes the name "Desert Rat," Bill Conklin and the local Washington round-up are calling themselves "Jerks," while the W1 squires are "Hoss Thieves." Oh my, what next?

W6SLO and W6OVK worked W6QLZ/6 and 112-Mc. out to 210 miles about a week before band closing. 6SLO was using an 8-element W1HDQ vertical array and getting R3 to 4 reports with a pair of 76's in a parallel rod job.

W6QLZ was also hearing W6OZM's transceiver. Jim was using one of his super-infra receivers that appear to be becoming popular, with a 1232 mixer, 6C5 h.f. oscillator, 6J5GTX super-regen second detector. Clyde, 6QLZ, seems to think that this is normal ground wave due to lack of QSB on the signals he was hearing. Although this might appear that way, in a number of reception tests using FM extended ground waves, it was found that very little fading existed, if the signal was heard at all, when distances of 160 miles or more had been reached.

Card from W1JFF, Newport, R.I., says he worked W1MEP (Vermont) on December 3rd at 10:10 p.m. for first Rhode Island to Vermont contact. Nine states on 2½ is Fred's claim from fixed location. Not bad!

Question and Answer Department

Q. "I live quite a distance from the nearest FM broadcasting station and since I would like to have some real FM reception, the receiver gain necessary would probably be accomplished only by using some of those "pipes" you keep mentioning. Just how would they work out?"

A. Undoubtedly the gain in our so-called "pipes" is just what you need. Roughly speaking a line about fifteen inches long with a 4 to 1 ratio, with a small condenser across the hot end to set you back on 5 when the mess is over or the Civilian Defense perks up, would probably work out excellently with an acorn, or better a 9001 or 1204 r.f. tube. Only one r.f. stage would be needed, but care must be exercised in building FM receivers so that no regeneration occurs, since even a little will sharpen selectivity and ruin a major part of the noise reducing qualities. Otherwise, there is no reason why a good "hot" FM receiver could not be built up with even a 1282 (7W7) as mixer if inexpensive parts are needed.

Q. "Although I cannot divulge the reasons, I need this information. I wish you would supply me data on the possibilities of building a mobile c.w. transmitter operating from a six-volt auto battery, and a very small dry-cell-supplied receiver capable of operating a relay instead of phones, with a maximum range of 25 miles."

A. One cannot guarantee a reliable 25-mile range from such simple equipment, especially if mobile and without any elevated location for either the receiver or transmitter. Suggestion is that you look over the past 18 months of RADIO or in the new RADIO HANDBOOK for transceiver diagrams, certainly not using a smaller tube than an HY75. The receiver is the difficult item. You might possibly get along with a finely adjusted super-regen (using a 1201 or Acorn) since a change in plate current will be needed to operate a relay. Using a tone in the transmitter and a rectifier on the relay might work well enough. Considerable data can be obtained from past issues of RADIO and *QST* that describe receivers for controlling model aircraft. Small relays are readily available. Whether they can stand considerable bouncing around and how they will react to the staccato auto ignition is another question determined only by experiment.

Q. "As a W6 I protest against the lack of aurora DX. Is there any geophysical reason for this?"

A. Theoretically, yes, since aurora does not occur simultaneously over all sections of the country, but instead follows a band of maximum frequency (measured in geomagnetic latitude) which places the region of maximum intensity 400 miles closer to W3 than even the Nevada W6's.

The Marketplace

Classified Advertising

(a) Commercial rate 10c per word, cash with order; minimum, $1.00. Capitals: 13c per word. For consecutive advertising, 15% discount for 3d, 4th, and 5th insertions; 25% thereafter. Break in continuity restores full rate. Copy may be changed as often as desired.

(b) Non-commercial rate: 5c per word, cash with order; minimum, 50c. Available only to licensed amateurs not trading for profit; our judgment as to character of advertisement must be accepted as final.

(c) Closing date (for classified forms only): 25th of month; e.g., forms for March issue, published in February, close January 25th.

(d) No display permitted except capitals.

(e) Used, reclaimed, defective, surplus, and like material must be so described.

(f) Ads not relating to radio or radiomen are acceptable but will be grouped separately.

(g) No commissions nor further discounts allowed. No proofs, free copies, nor reprints sent.

(h) Send all Marketplace ads direct to Santa Barbara accompanied by remittance in full.

SUPREME MODEL—500 deluxe series, automatic tube tester and analyzer. Meter not burned out but rest of instrument needs repair. Price, $12.50 f.o.b. Parts alone worth much more. Editors & Engineers, Ltd., Santa Barbara, Calif.

HAVE several reconditioned guaranteed JRA3. 400 watt A.C. Light Plants at $45, ideal for amateurs. Write Katolight, Inc., Mankato, Minn.

COMPLETE PHONE TRANSMITTER, in cabinet, very conservatively rated at 150 watts carrier, excellent fidelity. Originally designed for amateur bands from 3500 to 30,000 kc., but with few coil alterations will work on any frequency between 2000 and 33,000 kc. Makes excellent police transmitter. Described on page 357 of 1942 RADIO HANDBOOK. Price, less tubes, crystal and microphone, $200.00 f.o.b. Editors & Engineers, Ltd., Santa Barbara.

COME WHAT MAY—we will continue to serve you with the world's most complete stock of shortwave receivers and radio supplies of all sorts. Amateurs, Government, Police, Broadcast, Schools, NYA, and all other services get whatever radio equipment you need from us promptly. You get lowest prices, best terms (financed by us), quickest delivery, best trade-in. We have everything radio: 2½ meter and emergency equipment. Vibrapacks, Signal Shifters, hundreds of Communications receivers. SX-32s, NC-200s, HQ-120Xs, SX-28s, SX-25s, S-29s, etc., positively in stock. Write, telephone, telegraph us 24 hours a day 7 days a week for anything radio. Bob Henry, Butler, Missouri, or Ted Henry, 2335 Westwood Blvd., West Los Angeles, Calif.

KATOLIGHT—350 watt model JR35, 110 volts a.c. or 6 volts at 20 amps. d.c. Ignition completely shielded, including special plug. Self-starting with 6 volt battery (not included). Used very little; both gas engine and generator in excellent shape. Price $50 f.o.b. Editors & Engineers, Ltd., Santa Barbara, Calif.

WE PAY CASH—for used Communications receivers. Also give best trade-ins. Bob Henry, Butler, Missouri, or Ted Henry, 2335 Westwood Blvd., West Los Angeles, Calif.

MICROPHONES: (All complete with desk stand.) Amperite PGH. $12.50; RCA Aerodynamic (low impedance) $10.00; Astatic type JT, $4.50. Can't be told from new. Editors & Engineers, Ltd., Santa Barbara.

RECONDITIONED—Guaranteed communications receivers and transmitters. All makes and models cheap. Free trial. Terms. List free. Code machines rented. Bob Henry, Butler, Mo., or Ted Henry, 2335 Westwood Blvd., West Los Angeles, Calif.

PLATE TRANSFORMERS: Three special Inca 1.5 kva 110 or 220 v. pri., various taps up to 4000 v. each side c.t. sec. Price $20 each f.o.b. Also various smaller transmitter plate transformers and chokes at reasonable price. Editors & Engineers, Ltd., Santa Barbara.

HOWARD 435-A RECEIVER—used very little, perfect shape. $35.00 f.o.b. K. V. R. Lansingh, Santa Barbara, Calif.

PANELS—Chassis. Racks. Cabinets. Specials. R. H. Lynch, 970 Camulos St., Los Angeles, Calif.

TRANSMITTER COMPONENTS: Some new, some used but in perfect condition. Too many to list. First come, first served. Write your needs and we will quote when can supply. Editors & Engineers, Ltd., Santa Barbara, Calif.

VIBRAPACK, 300 VOLT Mallory type 552, case a bit rusty but unit electrically OK. $6.00 f.o.b. Editors & Engineers, Ltd., Santa Barbara, Calif.

How We Speak and Hear

[*Continued from Page 31*]

bination, vary quite widely in their output powers: from about 100 microwatts as the average power for one instrument to about 65 or 75 watts as the average for a symphony orchestra. The power in a particular case and at a particular time depends upon the number and kind of instruments in use and upon the musical piece being played. Distribution of the sound power over the frequency range of an instrument depends upon the instrument in use and the fundamental frequency being played, with the greater power being produced on the lower notes in most instruments.

Each of the present day instruments can be placed in one of four classifications: *wind, string, percussion,* and *electronic,* according to the method used to produce musical tones. The wind group is divided into the woodwinds, which include the clarinet, bassoon, oboe, flute, and English horn, and the brasswinds, which include the piccolo, tuba, bass tuba, French horn, trombone, trumpet, and cornet. The sound is produced in these instruments by the vibration of a reed or the lip of the player, and the pitch of the sound is changed by opening or closing holes along the length of the tube, or by changing the length of the tube. A pipe organ is a wind instrument in which the pipes are made to "speak" by admitting wind to the lower ends.

In the string classification are the violin, viola, cello, base viol, and harp. These are sounded by drawing a bow across the strings or by plucking the strings. The piano is a stringed instrument played by percussion methods. All forms of drums, cymbals, chimes, triangles, bells, xylophones and the celesta are true percussion instruments, sounded by being struck with sticks, hammers, or the hands of the performer.

By electronic instruments is meant those that *produce* their tones electrically, rather than electrically operated instruments. Among these are the Hammond organ, Novachord, Solovox, and numerous others built by Everett, Miessner, etc. An instrument whose tones are picked up by some form of microphone, amplified and fed into a speaker cannot be considered as a true electronic instrument. Various tone generating methods are used in electronic instruments, but the two most important types are the alternator and the vacuum tube oscillator. In addition to these there are the photo-electric, electrostatic, vibrating reed and many others.

Scales

The scale used in the diagram illustrating the range of various instruments, voices, and equipment is known as the philosophical or scientific scale, and is based upon a middle C frequency of 256 cycles per second. The scale used by musicians is based upon a frequency of 440 cycles per second for A above middle C.

The subject of musical scales is far too comprehensive to cover in detail in a short article; so to those interested in knowing more about this or the other topics discussed here we suggest consulting one of the many books available in most libraries.

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