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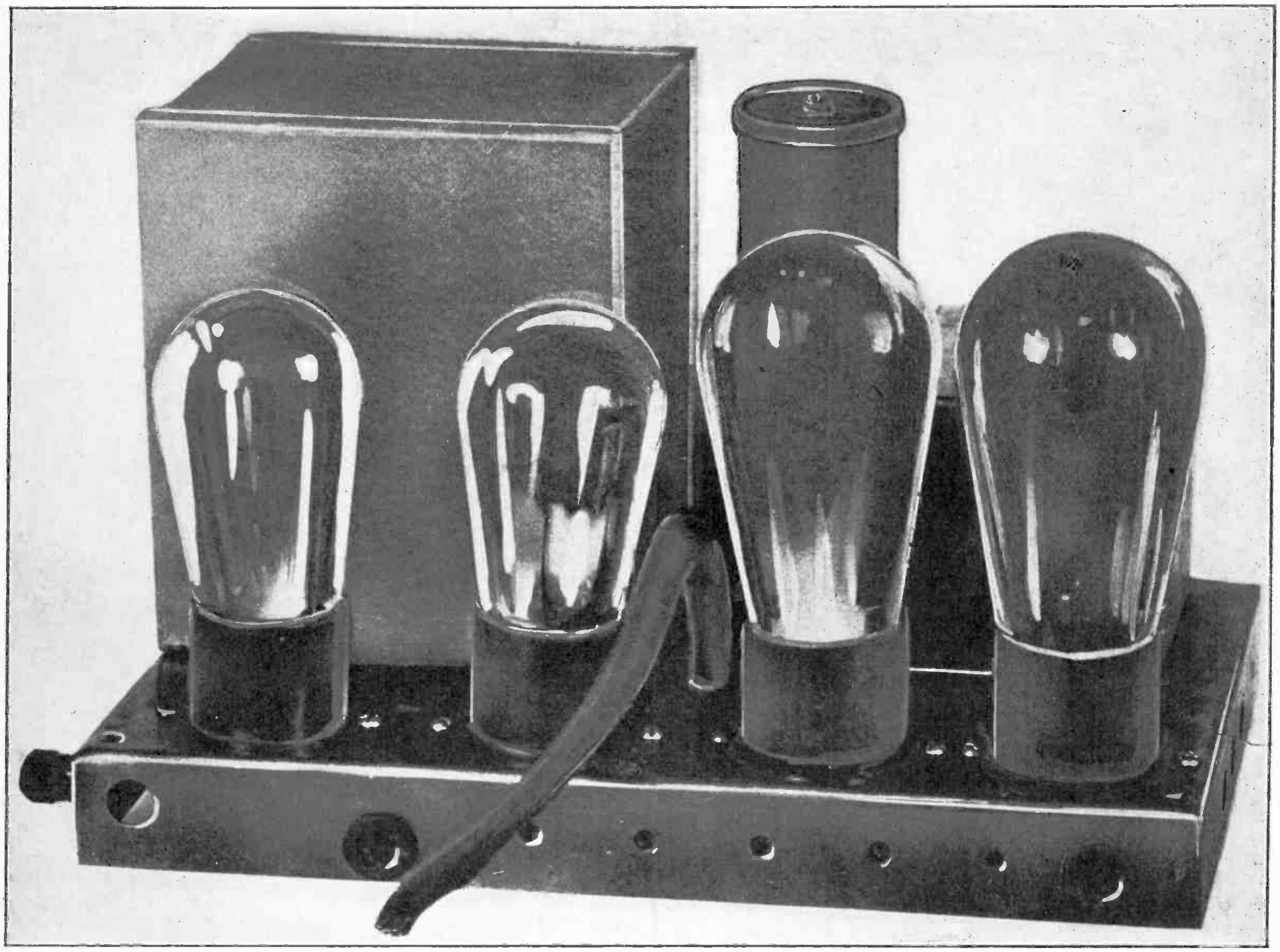

A three-stage resistance-coupled audio power amplifier can be built for $15 on a 6 1/4 x 9 3/4 x 1 3/16-inch steel chassis. See page 3.

RADIO WORLD, Published by Hennessy Radio Publications Corporation; Roland Burke Hennessy, editor; Herman Bernard, managing editor and business manager, all of 145 West 45th Street, New York, N. Y.

BOOKS FREE!

"AUDIO POWER AMPLIFIERS"

by J. E. Anderson and Herman Bernard, begins with an elementary exposition of the historical development and circuit constitution of audio amplifiers and sources of powering them and proceeds to an exposition of circuit laws, including Ohm's laws and Kirchhoff's laws. The determination of resistance values to produce required voltages is carefully expounded. All types of power amplifiers are used as examples: AC, DC, battery operated and composite. But the book treats of AC power amplifiers most generously, due to the superior importance of such power amplifiers commercially. Full technical data on tubes, 193 pages..(APAM)

"FOOTHOLD ON RADIO"

In English that any one can understand, the technical side of radio is presented by Anderson and Bernard. It is intended for the sheer novice. The treatment is non-mathematical. The origin of the broadcast wave, its radiation, reception, amplification and rectification are set forth in clear language. Published June, 1930; 59 pages..........................(FOR)

"THE SUPERHETERODYNE"

This is a volume by Anderson and Bernard, published July, 1930, dealing with the principles and practice of the Superheterodyne method of receiving. It explains the function of the oscillator, the modulator, the pre-modulator selector, and the intermediate frequency amplifier. It explains the cause of repeat points and gives methods for avoiding them or minmizing their effect. It expounds the relative advantages and disadvantages of high and low intermediate frequencies, and shows the effect of selectivity on the quality. Constructional circuits included, 112 pages ....(ABSH)

115 LATEST COMMERCIAL SET DIAGRAMS

Compiled by John F. Rider. Contains, each on separate 9 x 12" sheet, schematics of Audiolas 30B and 230; Balkite F; Crosley 41A, 42 A.C., 609, 600 A.C., 20, 21, 22, 18, 30S, 33S, 804 A.C., 40S, 41S, 42S, 82S, 60S, 61S, 62S; Sonora 7P, A30, A32, B31, A30, A40, A44; Kennedy 80, 10, 20; Stewart-Warner 900 A.C., 950 battery, 950 A.C., 950 D.C., Model B; Radiola 44, 47, 66; Majestic 90, 9P6 power unit, 9P3 power unit; Stromberg-Carlson 641, 642, 846; Edison R1, R2, C2 (50 and 25 cycles), R5 and C4, C1; American Bosch 54 D.C.; Victor R32 and RE45; Grebe SK4 A.C. (early model), SK4 A.C. (late model), SK4 D.C., 428; Traveler A.C. power pack; Erla 224 A.C. screen grid; Silver-Marshall 30B, 30C, 30D, 30E; Eveready 1, 2 and 3, Series 30, Series 40, Series 50; Steinite 40, 50 and 102, 50 power unit; All American Mohawk 96 (60 cycle), 90 (25 cycle), 90 (60 cycle), 70, 73 and 75; Gulbranson Model C (early model), Model C (late model); Bremer-Tully 7-70 and 7-71, 81, 82; Earl 21, 22, 31, 32, 41, 42; Philco 65, 76, 87, 95 screen grid; Peerless Electrostatic series, screen grid; Fada 20, 20Z, 22 battery, 25, 252, 25, 25Z, M250, M250Z, Electric units, 35, 35Z, 75, 77; Brunswick 5 NC8 Radio Chassis Schematic, NC8 Audio Chassis Schematic, NC8 and 3 NC8, Audio Chassis Schematic, 5 NC8 cabinet wiring, 3 NC8 Radio Chassis Schematic, 3 NC8 cabinet wiring, S14, S21, S31, S81, S82 screen grid Radio Chassis Schematic, S14, S21, S31, S81, S82 screen grid Radio Chassis Actual, S14, S21, S81, S82 Audio Chassis Schematic (25 cycle), S14, S21, S81, S82 Audio Chassis Schematic (60 cycle), S14, S21, S81, S82 Audio Chassis Actual (25 cycle), S14, S21, S81, S82 Audio Chassis Actual (60 cycle), S31, Audio Chassis Schematic (60 cycle) S31, Audio Chassis Actual (60 cycle), 3 KR8 cabinet wiring, 3 KR8 Radio Chassis, 3 KR8 Audio Chassis Schematic, 3 KR8 Audio Chassis Actual, 5 NO Radio Chassis Schematic, 5 NO Socket Power Schematic, 5 NO Socket Power Actual, 3 KRO and 3 KR6 Radio Chassis, 3 KRO and 3KR6 Socket Power, 5KR, 5KRO, 2KRO Socket Power, 5KR, 5KRO, 3KRO, 2KRO, 5KR6 Socket Power, 5KR, 5KRO, 2KRO, 5KR6 Radio Chassis; Amrad Bel-Canto series; Spartan 89, 89A, 49, ensemble, 931, 301 D.C., 931 A.C., 110 A.C., 301 A.C...............(SUPP. NO. 1)

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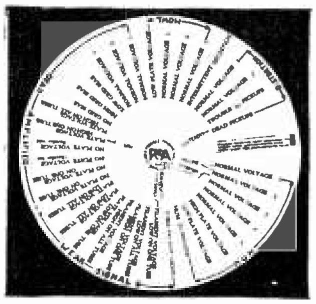

Here is an 8" diameter dial that you slide around to shoot trouble in an audio circuit or B supply or power amplifier. Trouble is divided into five groups: distortion, howl, dead amplifier, weak signals and hum. By sliding the dial to one of fifty different positions the cause of the trouble is read in the slotted opening. Invented by John F. Rider. Send 50 cents for four weeks subscription for Radio World and get a Trouble-Finding Dial free with instructions on back. If extending an existing subscription please so state.

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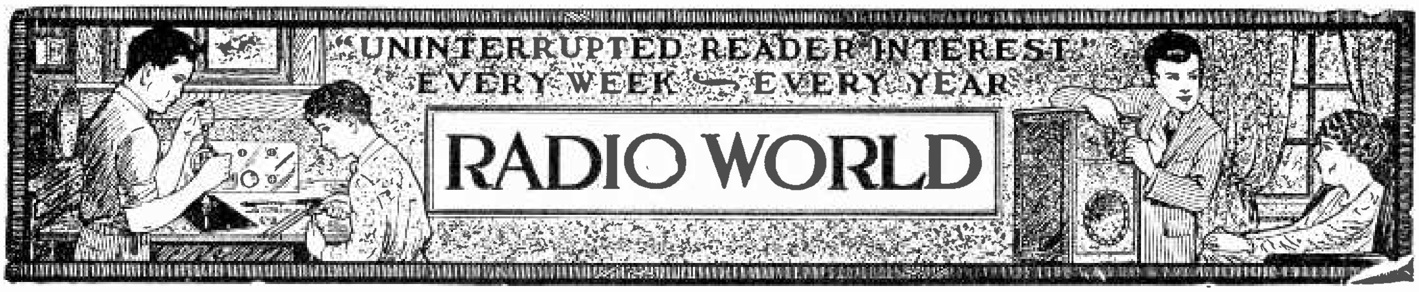

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NINTH YEAR

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A $15 Power Amplifier

By Herbert E. Hayden

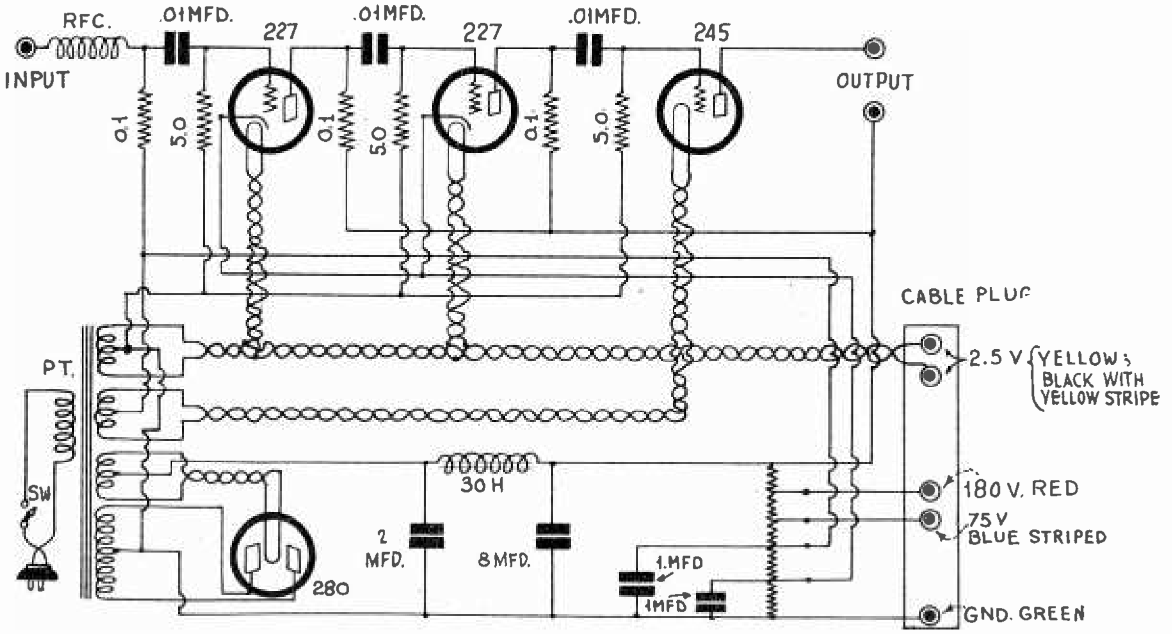

FIG. 1
CIRCUIT DIAGRAM OF A POWER AMPLIFIER THAT CAN BE BUILT FOR $15. THE VOLTAGE DIVIDER MAY CONSIST OF A TOTAL OF 26,500 OHMS, WITH 150 OHMS FROM GROUND TO THE FIRST TAB, 1,000 OHMS FROM FIRST TO SECOND TAB, AND 25,000 OHMS FROM SECOND TAB TO THE HIGH VOLTAGE END.

AN AUDIO power amplifier, with three stages of resistance coupling, and with enough power to spare to work a tuner of the AC type, up to six extra tubes, either 224 or 227, may be built on a 6¼ x 9¾ x 1 3/16 inch chassis, at a cost not exceeding $15. This is a quality power amplifier, one that will reproduce faithfully, and will afford adequate volume.

The audio amplifier consists of two stages of 227s and a 245 output. No output filter is shown, as a dynamic speaker probably would be used, and this has an output transformer built in; or, if a magnetic speaker is used, an output filter, either a transformer or a choke-condenser combination, may be built into the speaker; or, indeed, as to many magnetics, the 32 milliamperes may be passed through the speaker winding without much danger of burnout, although there might be a little danger.

Cable Leads Identified

There are five sockets in the subpanel. One is for a cable plug, so that when the plug is inserted in this five-prong socket it picks up the voltages and delivers them to the five leads of the cable. These five voltages and their color designations on the cables follow:

(1), (2)—Yellow; black, with yellow marker—2.5 volts AC for heaters of tubes in the tuner (heater prongs of socket). (3)—Green—ground lead, connected to subpanel, and to ground post of receiver (cathode prong of the socket).

(4)—Blue with white marker—B plus 75 volts, for screen grids of the tuner (grid prong of socket).

(5)—Red—B plus 180 volts, for plates of tubes in tuner (plate prong of socket.)

While the quality and the volume are good, what particularly commends this power amplifier is the fact that it will fit into the smallest space you would consider for the purpose. A total overall height of 6½ inches will clear everything nicely, so consider

LIST OF PARTS

One drilled steel subpanel 6¼x9¾x1 3/16 inches
One shielded RF choke, 50 millihenries
One .00025 mfd. fixed condenser, mica dielectric
Three 0.1 meg. plate resistors with mounts
Three 5.0 meg. grid leaks with mounts
Three .01 mfd. fixed condensers, mica dielectric
Three binding posts (input, speaker, speaker)
One power transformer: 110 v., 50-60 cycle primary; 2.5 volts high current secondary, center tapped; 2.5 volts 3 ampere secondary, center tapped; 5 volts 2 amperes, center tapped; high voltage secondary, center tapped
One 30 henry choke
One 2 mfd. 500 v. AV condenser, paper dielectric
One dry electrolytic condenser, 8 mfd.
One AC cable
One AC switch
Three UY (five-prong) and two UX (four-prong) sockets
One 5-lead cable plug
One voltage divider: 150 ohms, 1,000 ohms, 25,000 ohms, or other values to afford the 6, 50 and 250-volt distribution
Two 1 mfd. 200-volt condensers, paper dielectric
Two 227 and one 245 tubes

Resistance AF Analyzed

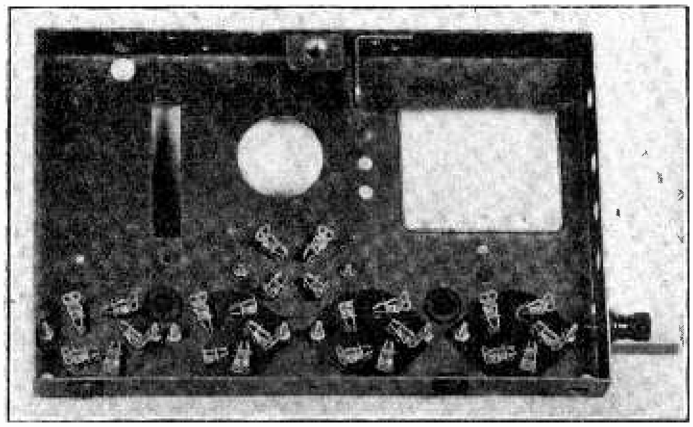

FIG. 2
VIEW OF CHASSIS BOTTOM, WITH SOCKETS IN PLACE. THE DISTRIBUTION OF SOCKETS WAS CHANGED A LITTLE AFTER THIS PHOTOGRAPH WAS TAKEN. SEE TEXT FOR TUBE ARRANGEMENT.

the total dimensions ofthe finished product as not exceeding 6¼ x 9¾ x 6½ inches, which is about the smallest power amplifier in point of size, that you have ever seen.

Arrangement of Tubes

Considering the steel chassis from the row of tubes, which we will call the front of the chassis, the first and second audio tubes are in that order at left, the 245 is next and the rectifier tube is last, at extreme right. The in-beween socket, at center, but farther back, is for insertion of the plugged cable.

The tubes used ahead of the output are 227s because of the greater stability resulting, and the absence of any requirement of more gain per stage, that might be afforded by a screen grid tube with consequent instability troubles always looming.

The resistors in the plate circuits are 100,000 ohms (0.1 meg.) each, while those in the grid circuits are 5,000,000 ohms (5.0 meg.) each. The values in the grid circuit should not be increased, although they may be decreased to 2 or even 1 meg., in any one stage, it matters not which, should any tendency toward instability arise. This refers particularly to motorboating, a trouble which was not experienced at all in the laboratory model, and which need not be expected to develop, since the filter capacities total 10 mfd., enough of a safeguard for this outfit. However, in the event of any possible trouble like that, you have your remedy.

When to Expect No Reading

The power transformer has five windings: primary and four secondaries: 2.5 volts for the 245 filament, 2.5 volts for the two 227s, which voltage is serviceable for heaters of tubes in the tuner; and a secondary winding, which, when used with a 280 rectifier and about 400 ohms DC resistance of choke coil, will afford 300 volts DC total filtered output.

In testing the power amplifier, due consideration should be paid to the fact that resistance coupling is used, the plate load resistors being of high value, and the plate current being low. Therefore the plate current may not do more than trivially budge the needle of a milliammeter of a 20 ma full-scale deflection, as that current would be around 1 ma. Particularly if the detector tube (not shown) is of the negative bias type, will the plate current be unreadable, unless the meter has a sensitivity of 1 ma at full-scale deflection (0-1 ma), or better sensitivity.

Capacities for Stopping

The stopping condensers of .01 mfd., used for keeping the positive plate voltages off the grids, but not used, as many mistakenly suppose, as coupling condensers, should not have a lower value than specified, although the capacity may be greater, if you desire. The choice depends largely on the proportion of this capacity to the grid circuit resistor, as these two are in series. The general rule is, use .01 and 1 meg. as minima, for tonal reasons, so that if a higher leak value is used, a lower capacity is passable. Nevertheless, it is just as well not to go below .01 mfd., and particularly since mica dielectric condensers of this capacity, but scarcely much higher, are on the market It is favorable to use mica dielectric condensers because of the necessity of avoiding so far as possible all leakage across the dielectric.

As for hum, that should be low, and will be, if the design is carefully followed. The resistors have no interacting fields that cause trouble between the power transformer and the interstage coupling media. Nevertheless, low-note reproduction is good in this amplifier, hence hum, which is in the low-note region, if it gets into the amplifier, will receive considerable amplification.

The causes of hum are many, and some are assocated with the tuner, but as the power amplifier alone is under consideration, hum reduction may be effected by raising the bias on the first and second audio stages, by connecting cathodes to a point higher up on the voltage divider. The bypass connection, shown at the voltage divider, would be moved up with the common cathode lead.

Effect of Voltage Divider

The signal does not have as much of an unbalancing effect on the total applied plate voltages as it does in some other power amplifiers, because the voltage divider's bleeder current is a steadying influence. In general, as the signal amplitude rises, the plate current rises, hence the total B current, but when a steady value of bleeder is introduced, the change is relatively reduced, hence the cathodes of the first and second audio tubes are connected to a point on the voltage divider, and indeed, so is the filament center tap of the 245.

Some may wonder how the 245 gets its bias, or whether it does get any at all. The bias would result only from a potential difference between the filament and the grid return. The filament is connected to the B plus detector lead in the diagram, from the center tap of the 2.5 volt 3 ampere winding of the power transformer, to the second highest tap used on the voltage divider. If this is 50 volts, as intended, and since the grid is returned to ground B minus, the potential difference is 50 volts. The grid return, hence the grid, is 50 volts negative in respect to the filament center. Since the 245 tube has a filament fed from a separate winding, the same 50 volts may be used on the detector plate, since the applied voltage also would be 50 volts above B minus.

Higher Detector Voltage

It is not highly advisable to standardize on 50 volts for the detector, since that voltage is suggested only if the tuner has a grid leak and condenser detector. Should negative bias detection be used, then a higher plate voltage would be preferable, in which case the 75-volt tap or the 180-volt tap would be used instead. The B lead coming from the binding post next to the plate input, second from top in upper left of diagram, instead of going to the center of the 245 filament, would go to the higher post chosen on the voltage divider.

Twisted pair wire should be used for the heaters. It is a good plan indeed to run each pair directly from the 2.5-volt high-current leads of the power transformer to the intended socket, not so much because there is a great deal of current drawn by two heaters, but because any trouble arising in a particular tube circuit is more readily traced. Suppose a piece of solder slips off the iron, falling between the heater prongs of the sockets, unknown to you. When you turn on the set there will be a little smoke, due to the short, but the winding will have a higher resistance than will the twisted pair going to one particular socket, and even though you turn off the set quickly, as a safeguard, you can put your finger on the trouble immediately, since the twisted pair to the troublesome socket or tube will be hot, yet the other leads from the same winding will be cool. Then look for the piece of solder or other cause of short, which indeed may be an internal short in the tube itself.

If the 2.5 volt high current winding, the one with the thick lead-out wires, equivalent to No. 9 wire, is to be used for a tuner, do not run leads from the power amplifier to the tuner, to carry this current, unless those leads are at least No. 14 wire or stranded equivalent. See that the wire is well insulated. Twisted pair, in stranded equivalent of No. 14, is on the market.

If you have a dynamic speaker of the DC type, for around 40 milliamperes, you may cut it in between the high end of the B line and the voltage divider. You see in Fig. 1 a line running from B plus speaker to the voltage divider and choke and an 8 mfd. The line between the top of the voltage divider and the lead running on to the speaker would be represented by the field coil of the DC dynamic. While the useful voltage for the power amplifier would be reduced, the convenience of being able to run a DC dynamic, if you have one, is well worth considering.

Resistance Values

What the voltage divider resistance should be may be determined by yourself, if you are able to make the calculations. The negative bias value for the two 227s may be as much as 11 volts, for highest permissible voltage swing in the grid or plate circuit, but it is not necessary to use as much bias as that, as swings of that order are never encountered in practice in the first audio stage, anyway, and almost never in the second (certainly not here). In the present circuit, if you go as far as 6 volts negative bias, that is plenty. You have your choice of biases from the voltage divider. Figure on 1 ma for each 227 in the power amplifier. has 6 volts negative; 32 ma for the 245 at 250 plate volts, 50 volts bias. You can adjust by plate current-voltage reading, if you like.

The August "Proceedings"

W. W. BROWN, of the General Electric Company, Schenectady, N. Y., discusses Mycalex in a paper in the August "Proceedings" of the Institute of Radio Engineers entitled, "Properties and Applications of Mycalex to Radio Apparatus." Mycalex is a new insulating material formed from ground mica and lead borate. The mixture is heated to the softening point of lead borate, and the mass compressed while plastic. It is also cooled while under compression.

The material is either molded into special shapes by intricate molds or into standard shapes, such as slabs and rods, which may be sawed, turned, drilled, ground, or polished. Carborundum wheels are used for sawing and grinding and tungsten-carbide alloy for turning and drilling.

Mycalex has a dielectric constant of 8 a power factor at 100,000 cycles of 0.2, a phase angle of 69 minutes, a loss factor of 1.6, and a dielectric strength of 120,000 under conditions giving fused quartz 100,000 and porcelain 90,000. Its mechanical characteristics compare favorably with fused quartz and porcelain and are superior to those of many other insulating materials.

The material will undoubtedly be used widely in radio because it combines electrical and mechanical characteristics in a favorable manner not equalled by any other insulating material. It has already gone into the equipment of many broadcasting stations.

Talking Picture Technique

Porter H. Evans, chief engineer, Eastern Studios, Warner Brothers-Vitaphone Corporation, contributes a paper entitled "A Comparison of the Engineering Problems in Broadcasting and Audible Pictures."

The problems of broadcasting and talking pictures are compared and the differences pointed out, and attention is called to the principal difference between the present successful talking pictures and the failures that preceded them. Some advantages of disk recordings are pointed out and fidelity measurements of recording stages, theatres, and systems are given. The elements in greatest need of improvement are pointed out.

For improvement of the reproduction from wax records the most important factors seem to be:

(A) The frequency-response characteristic of the loudspeaker
(B) The frequency-response characteristic of the reproducer
(C) The surface noise of the record.

The limiting factors in the film method of recording appear to be:

(A) The frequency-response charactertistic of the loudspeaker
(B) The frequency-response characteristic of the light valve
(C) The frequency-response characteristic of the sound-track reproducer
(D) The elimination of speed variation in the sound-track reproducer.

Other improvements needed are:

(A) A silent camera which need not be enclosed in a sound-proof booth.
(B) A microphone which could be placed at a greater distance from the action and which could be focused on the set in the same manner that a camera is focused on a set and which would collect the sound equally well from a restricted angle.

Test Apparatus

"Problems Involved in the Design and Use of Apparatus for Testing Radio Receivers" are discussed by Paul O. Farnham and Alfred W. Barber, Radio Frequency Laboratories, Inc., Boonton, N. J.

The paper deals with the desirable characteristics of measuring equipment used in making the usual tests on radio receiver performance and a description of the apparatus and technique used in carrying out special tests such as measurement of hum, tube and circuit noises, modulation distortion, intermodulation, audio harmonic analysis, and volume control. Illustrative curves are included.

Dry Electrolytics

"Dry Electrolytic Condensers" are discussed in a brief paper by P. E. Edelman, electrical engineer, Chicago, Ill.

"Operating characteristics of compact, dry, electro chemical, high voltage filter condensers, comprising a dielectric plated sheet electrode contacting with gummed spacer rolled with an untreated electrode sheet, show that such condensers are in all respects suitable for power-pack filter service and effect large reduction in costs."

Condensers of this type are made to withstand DC voltages of 350 and 700 volts in large capacities. The leakage current is very small and for an 8 mfd. section rated at 350 volts will not exceed ½ milliampere at the rated voltage. This is only 1/16 milliampere per microfarad. At lower voltages the leakage will be less. The leakage current decreases during continuous operation so that at the end of 41 days it reaches a minimum of 10 per cent. of the current obtained on intermittent operation. The conclusion is that there is an irreducible minimum current, which may be due to small molecular pores in the lattice structure of the anode coating.

Message Center

There is a brief description, illustrated with photographs, of the "War Department Message Center," contributed by Frank E. Stoner, Signal Corps, War Department, Washington, D. C.

The Message Center is in direct communication hourly, day and night, with the following points: Seattle, Washington; San Francisco, California; Manila, Philippine Islands, Hawaii; Panama, Canal Zone; San Antonio, Texas; Omaha, Nebraska; Chicago Illinois; Atlanta, Georgia; Columbus, Ohio, and Boston, Massachusetts.

Noise in Sets

"Fluctuation Noise in Radio Receivers" is a mathematical paper by Stuart Bailantine dealing with shot and thermal effects in radio-frequency receivers. The shot effect, also called the "Schrot" or Schottky effect, is a hissing noise due to irregular emission of electrons from the cathode or filament.

A method is also outlined whereby the noise may be measured.

Vacuum Tube Voltmeter

"A Screen-Grid Voltmeter and Its Application as a Resonance Indicator" is a paper contributed by Ronold King, Physics Department, Cornell University. It is an instrument of high sensitivity effectively covering a range from 0.1 to 10 volts, r.m.s., at low frequencies. It is also useful at frequencies as high as 100 million cycles per second, especially as a supersensitive indicator for a Lecher wire system. The instrument is compared as to sensitivity with a vacuum tube voltmeter utilizing a triode. Numerous curves are given.

Reflected Waves

"Reflection of Radio Waves from the Surface of the Earth" is the report of theoretical and experimental study of reflection of radio waves from the surface of the earth by Lal C. Verman, Physics Department, Cornell University, Ithaca, N. Y. The paper is largely mathematical and the experimental work has been done as a verification of the mathematical conclusions. Only those who are well versed in mathematics will be greatly interested in this paper.

The Dewey System

"Classification of Radio Subjects: An Extension of the Dewey Decimal System," second edition, prepared by J. H. Dellinger and C. B. Jolliffe, appears in full.

This is a systematic scheme of classification of subjects in radio science and engineering of interest mainly to librarians, and to those who make frequent use of material in libraries. The system makes it easy to place books on related subjects near together on the shelves, or to file references on the same subject all in the same group and not in the order of their addition to the collection or file.

Standard Tests

The August issue of the Proceedings also contains proposed standard tests of broadcast radio receivers. Due to the importance of such tests to experimenters and radio engineers the article is published in full text elsewhere in this issue.

Coil Data

If a metal subpanel or cabinet is used the mounted coils should not be close to the metal. This difficulty is avoided by using extension bushings to hold the coil receptacle at least 1½-inch from the metal. Then the coil will not be nearer than 2 inches to the metal, which is satisfactory.

If you have .0005 mfd. SFL tuning condensers and desire to cover from 15 to 130 meters you may do so with two pair of coils, assuming two tuned circuits, one pair for each. Use 3-inch diameter and No. 22, 20 or 18 insulated wire, even bell wire, the so-called annunciator type. In the first pair wind 3 turns primary, space ¼ inch, then wind 3 turns secondary. For the other coil, wind 7 turns primary, space ¼ inch, and wind 17 turns secondary. If regeneration is desired, a fixed winding of one-half the number of secondary turns may be added, for plate circuit connection, regenerating with a small vanable condenser, 50 or 100 mmfd. maximum, from plate to ground. If regeneration fails, reverse connections to this plate coil.

New Standards Proposed

[The following copyrighted articles, reprinted in full from the August "Proceedings" of the Instutute of Radio Engineers, by special permission, constitutes a committee report, and has not yet gone before the Institute's Board of Direction. Hence the standards are proposed ones, not enacted ones. Any criticisms or suggestions regarding standards should be forwarded to Technical Editor, Radio World, 145 *West* 45*th Street, New York, N. Y.*]

PROPOSED STANDARD TESTS OF BROADCAST RADIO RECEIVERS

Introduction

DURING the past year and a half, the Committee on Standardization of the Institute of Radio Engineers, and the four Technical Committees of the Committee on Standardization have been busily engaged in bringing the past standardization reports of the Institute up to date by adding new material and by making such alterations in the past reports as have become desirable. The committees have based their work principally upon the "Report of the Committee on Standardization for 1928," as published in the 1929 Year Book of the Institute of Radio Engineers.

The four Technical Committees, under the Committee on Standardization, have been engaged in the more technical and specialized work of enlarging and modernizing the "Report of the Committee on Standardization for 1928." When necessary, subcommittees of the Technical Committees have been appointed to work out even more specialized definitions than are originated by the Technical Committees. The work of the subcommittees and the Technical Committees has been practically completed and their reports are being forwarded to the Committee on Standardization for its approval, or revision if this is necessary.

The Committee on Standardization is concerned with the matter of correlating the reports of the Technical Committees to make sure that the recommended definitions, nomenclature, and tets methods will not be duplicated in the various sections of the 1930 standardization report; of making all definitions consistent in grammatical structure; of securing comments, criticism, and suggestions concerning the reports of the Technical Committees, and of recommending to the Board of Direction of the Institute that its own report be adopted and published as the "Report of the Committee on Standardization for 1930."

There are forty-five members of the Committee on Standardization of the Institute of Radio Engineers under the chairmanship of J. H. Dellinger to whom the responsibility of working out a satisfactory standardization report is delegated. The members of this Committee are scattered throughout the United States, Canada, England, Germany, France, Japan and Italy.

The following report of the "Proposed Standard Tests of Broadcast Radio Receivers" by the Technical Committee on Radio Receivers and its subcommittees is being circulated for comment and criticism before being brought before the Committee on Standardization. Comments, criticisms, and suggestions from members of the Institute concerning this report will be appreciated so that any new or important ideas on the subject may be considered by the Committee on Standardization. Communications should be addressed to the Secretary, Committee on Standardization, Institute of Radio Engineers, 33 West 39th St., New York City.

I. General

The purpose of the standard tests here proposed is to provide by general agreement a basis upon which the complete normal performance of any broadcast radio receiver may be reasonably predicted. It is believed that no simple "figure of merit" can be properly derived that will by itself give an index of complete performance. This follows from the varying weights that may be applied at different times and in different services, to the fundamental properties of Sensitivity, Selecivity and Fidelity. Consequently it is believed to be essential to define and to provide for the separate measurement of each of these fundamental proprties. Such information is of somewhat too highly technical nature to appeal directly to the average user of broadcast radio receivers, but is thought to be useful to radio distributors and dealers in guiding their selection of apparatus for specific service conditions, and to engineers and manufacturers in aiding the comparison and improvement of their products.

It is recognized that the tests do not comprehend the entire range of service conditions that may be met in practice, and that peculiarities of design not reflected in the test data may in special cases affect the deductions to be made properly from the test results. It is also recognized that the three basic properties of Sensitivity, Selectivity, and Fidelity are in some radio receivers dependent upon adjustments that will change the relative prominence of each. and consequently the three factors should be invariably measured at the same settings of the radio receiver adjustments. Nevertheless, it is thought that acceptance of the procedure outlined, together with proper interpretation and correlation of the results obtained by the tests, will serve to permit a standard comparison of normal radio receiver performance.

II. Definition of Terms

A. Sensitivity—Sensitivity is that property of a radio receiver which enables it to respond to a small input voltage of the frequency to which it is tuned. It is measured quantitatively in terms of the input voltage required to give a standard output.

B. Selectivity—Selectivity is that property of a radio receiver which enables it to differentiate between the desired signal and signals of other carrier frequencies. This characteristic is not expressible by a single numerical value, but requires one or more graphs for its expression.

C. Fidelity—Fidelity is that property of a system, or a portion of a system, which enables it to reproduce accurately at its output the signal which is impressed upon it. As applied to a radio receiver, fidelity is measured by the accuracy of reproduction at the output terminals of the modulation of the received wave.

D. Normal Test Output—As applied to the testing of a broadcast radio receiver, the term represents an audio-frequency power of 0.05 watt in a noninductive resistor arranged to carry alternating current only and connected across the output terminals of the radio receiver (usually the loud-speaker terminals), the resistance of the resistor having been adjusted to that value recommended by the tube manufacturer to give maximum undistorted output power for the type of vacuum tube intended to be used in the output of the radio receiver, with normal adjustments of this vacuum tube. If the radio receiver is not arranged to filter out direct current from its output circuit, then an external filter system shall be employed, of such character as to introduce negligible resistance to direct current, to have negligible loss and to have negligible shunt admittance and negligible series impedance relative to the output resistor.

E. Normal Radio Input Voltage—As applied to the testing of a broadcast radio receiver, this term represents the r.m.s. voltage of a received signal, modulated 30 per cent at 400 cycles per sec., which results in Normal Test Output (definition **D**, section **II**) at resonance. If the radio receiver does not include a self-contained antenna, then the signal is to be impressed on a real or artificial Standard Antenna* (see definition **F**, section **II**).

For data on various methods of measuring the percentage modulation, the reader is referred to "The use of the electron tube peak voltmeter for the measurement of modulation" by C. B. Jolliffe, Proc. I.R.E., 17, 660-669; April, 1929. The method described in this article has much to recommend it from the point of view of simplicity, and with proper care the method is sufficiently accurate and reliable for general use. The method involves calculation of the pecentage modulation from measured values of the peak voltage of the radio-frequency oscillator output under modulated and unmodulated conditions. The voltage measurements are made with a vacuum-tube peak voltmeter. The paper indicates that this method is capable of giving results accurate to within about 5 per cent. For use in calibrating the percentage modulation of a radio-frequency oscillator for radio receiver measurement work, however, this accuracy is generally sufficient.

F. Standard Antenna. (Real or Artificial)—As applied to the testing of a broadcast radio receiver not having a self-contained antenna, this term represents an artificial antenna having in series a capacity of 200 uuf, a self-inductance of 20 uh, and a resistance of 25 ohms.

G. Standard Test Frequencies—In the testing of a broadcast radio receiver, the five standard carrier frequencies are 600, 800, 1000, 1200 and 1400 kc per sec. When tests are required at only three carrier frequencies, the values 600, 1000, and 1400 kc per sec. are recommended.

III Requirements and Characteristics of Testing Apparatus

The apparatus employed in testing radio receivers should be as simple as is consistent with accurate performance of the necessary functions. As far as possible, the same apparatus should be ued in the different tests. The values of the electrical quantities and the calibrations should not change with time, or if some change is unavoidable, means for checking should be provided.

The required apparatus for Tests of Sensitivity, Selectivity, and Fidelity, is indicated schematically in Fig. 1. Both frequency sources should be calibrated so that separate measurement of frequency is not needed. The requirements of the separate elements are stated in the following paragraphs:

A. Audio-Frequency Source.

For Sensitivity and Selectivity Tests this may be a mechanical oscillator of fixed frequency (400 cyles per sec.), but a vacuum tube oscillator having a frequency range at least from 40 to 10,000 cycles per sec. is preferred and for the Fidelity Test is

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*Experience has indicated that with some radio receivers, an artificial antenna adversely affects the stability. In such cases it is necessary to employ a real antenna.

for Tests of Receivers

necessary. The total harmonic content in the output of this oscillator should not exceed 5 per cent. The audio-frequency oscillator is arranged to modulate the radio-frequency oscillator by a known amount and preferably should furnish the same degree of modulation without readjustment at all carrier frequencies and all modulation frequencies. Means should be provided for adjusting the degree of modulation for at least the normal value of 30 per cent.

B. Radio-Frequency Source.

This consists of a vacuum tube oscillator supplied preferably from batteries, either fully shielded in itself or so shielded from the radio receiver under test that there is no direct radiation to the receiver. If the power supply is external to the shielding system which encloses the oscillator all ungrounded leads to the oscillator should pass through shielded low-pass filters. The frequency should be adjustable by an external control to any desired value between 500 and 1,500 kc per sec., and the frequency should not be affected by changes in output power. Means should be provided for varying the frequency in small steps immediately on each side of any specified frequency. A second external control should be provided for varying the modulated radio-frequency output supplied to the transfer circuit, and an instrument should be provided which indicates the effective value of this output. The oscillator in conjunction with the transfer system used (see part **C** below) should be capable of supplying in series with the receiving antenna system at least 200,000 μv at all carrier frequencies.

C. Transfer Circuit.

The radio receiver under test is provided with a local antenna circuit consisting of either a loop antenna (which may be self-contained) or an artificial antenna. In determining the significant characteristics, as outlined in the preceding sections, modulated radio-frequency voltages of known value are impressed in the local antenna circuit through the transfer circuit which should assume one of two forms as follows

1. A coupling coil fed from the radio source and mounted in inductive relation with the loop antenna or with the 20-μh inductance coil of the artificial antenna. In the latter case the coupling coil is used as the primary of a calibrated mutual inductor, the secondary of which is the 20-μh coil.

2. A calibrated attenuator of the resistance type terminating in a low impedance of known value (usually a resistance of about one ohm) which may be inserted in series with the artificial or loop antenna. This attenuator should be so constructed that all attenuation ratios are substantially independent of frequency within the broadcast band. It is preferably made variable in steps with additional provision for continuous variation between the steps. As an alternative to continuous variation within the attenuation network, provision may be made for continuously varying the measured current or voltage supplied from the source to the attenuator over a sufficient range to cover all values of receiver input voltage which lies between the steps of the attenuator. Design details of attenuators fulfilling these requirements are available in the literature. The combined range of ratios on the attenuator and variable currents from the source should be such as to allow a range of voltage across the terminal unit which feeds the receiving set of 1 μv to 200,000 μv.

D. Output Measuring Circuit.

The components of the output measuring circuit should be as follows:

1. A nonconductive load resistor adjustable to any desired value between 1 and 20,000 ohms and capable of dissipating 10 watts at any setting.

2. An output filter to be used with radio receivers normally having direct current in their outputs. This filter should fulfill the requirements given under definition **D**, section **II**, and a recommended form consists of an inductance of not less than 100 h (with 50 ma direct current in the winding) and a capacitance of not less than 8 μf arranged as shown in Fig. 5.

3. A vacuum-tube voltmeter or an equivalent device which will accurately measure the r.m.s. values of output voltage. At Normal Test Output the voltage is of the order of from 10 to 20 volts for ordinary output vacuum tubes. For the Sensitivity and Selectivity Tests the output meter need be calibrated only at these values. For the Fidelity Test continuous calibration is required, and for Overload Level Test calibration for much higher values is needed.

IV. Test Procedures

A. Preliminary.

The present-day radio receivers vary so greatly in their manner of operation that it is difficult to set down a single test procedure for each fundamental characteristic and have the procedure include all the allowances that should be made for the peculiarities of different sets. It is simpler to describe in general the test set-ups and adjustments of input and output; the operating conditions; and the radio receiver adjustments as applied to any type of receiver. Then standard procedures for measuring Sensitivity, Selectivity, and Fidelity, can be outlined.

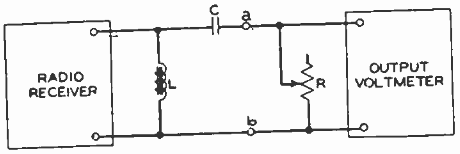


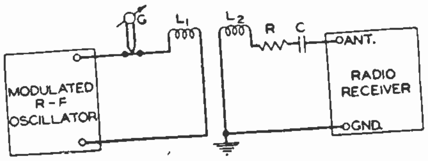
FIG. 1—SCHEMATIC ARRANGEMENT OF APPARATUS USED IN TESTS OF RADIO RECEIVERS.

B. Input Measurements.

1. Radio Receiver Without a Self-Contained Antenna

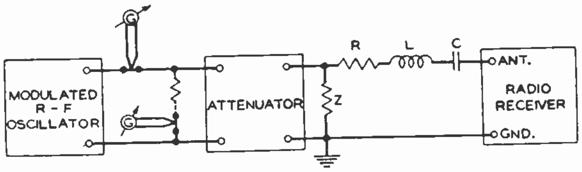
Standard input circuits are shown in Figs. 2 and 3. Either circuit may be used depending on whether an impedance device or a mutual inductance (see section **III**) is used to attenuate and introduce the radio-frequency voltage in the artificial antenna circuit.

The mutual inductor is used as shown in Fig 2. The input to the receiving set is controlled by adjustment of either the coupling between coils L_1 and L_2 or the current through L_1. The value of radio-frequency voltage impressed on the artificial antenna is determined from the formula,



Artificial antenna
$L_2 = 20\ \mu h$
$C = 200\ \mu\mu f$
$R = 25$ ohms

FIG. 2—STANDARD INPUT CIRCUIT—MUTUAL INDUCTIVE COUPLING.



Artificial antenna
$L = 20\ \mu h$
$C = 200\ \mu\mu f$
R+Resistance component of L = 25 ohms
Z = Coupling Impedance

FIG. 3—STANDARD INPUT CIRCUIT—IMPEDANCE COUPLING.

$$E = 2\pi\ fMI$$

where
E is the radio-frequency input voltage in microvolts
f is the carrier frequency in kilocycles per sec.
M is the mutual inductance between L_1 and L_2 in millihenries
I is the current through L_1 in microamperes.

The circuit for use with an impedance coupling device is shown in Fig. 3. The voltage impressed in series with the artificial antenna is brought to the desired value by selecting the proper degree of attenuation and accurately adjusting either the current or the voltage input to the attenuator. The value of Z should be small compared with that of the circuit to be connected to it. If the attenuator is calibrated in terms of current, the radio-frequency voltage impressed on the artificial antenna may be expressed as

$$E = KZI \qquad (2)$$

where
E is the radio-frequency input voltage in microvolts
K is the attenuation factor
Z is the impedance of the coupling device in ohms
I is the measured value of current fed to the attenuator in microamperes.

(Continued on next page)

(*Continued from preceding page*)

If the attenuator is calibrated in terms of voltage and includes the impedance Z, **then**

$$E = KV \tag{3}$$

where

E is the radio-frequency input voltage in mocrovolts
K is the attenuation factor
V is the measured input voltage in microvolts.

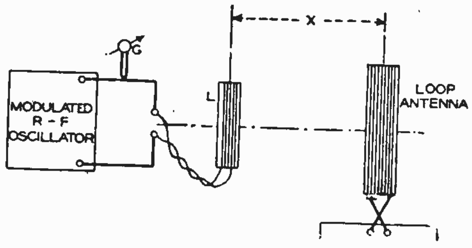


FIG. 4.—RADIO RECEIVER WITH LOOP ANTENNA.

2. Radio Receiver with a Loop Antenna

There are two methods by which such receivers may be measured. The first method consists of inducing a known voltage in the loop antenna, while the second method introduces the known voltage in series with loop antenna.

a. For the first of these methods an arrangement of apparatus as shown in Fig. 4 is suggested. The voltage induced in the loop antenna is

$$E = eQ \tag{4}$$

where

E is the radio-frequency input voltage in microvolts
e is the field strength in microvolts per meter at the loop antenna
Q is the effective height of the loop antenna.

The values of e and Q may be calculated as follows:

$$e = \frac{18850 N_1 A^2 I}{(A^2 + X^2)^{3/2}} \cos B \tag{5}$$

where

N_1 is the number of turns in the coupling coil L
A is the radius of the coupling coil in centimeters
I is the ammeter reading in microamperes
X is the distance in centimeters between the center of the coupling coil and the center of the loop antenna
B is the angle, if any, between the axis of the loop antenna and the line between the coil centers

and

$$Q = 2N_2 h \sin \frac{fs}{300{,}000} \tag{6}$$

where

N_2 is the number of turns in the loop antenna
h is the height of the loop antenna in meters
s is the length of the loop in meters
f is the frequency in kilocycles per second.

The induced voltage in the loop antenna may be adjusted by varying the distance X and the current through the coil L. The distance X should always be large as compared with the dimensions of the loop antenna. The axis of the coupling coil L should always pass through the center of the loop antenna. Equation (6) applies only to rectangular loops.

b. In the second method of test, the radio-frequency voltage may be introduced in the loop antenna by inserting the terminal impedance of a resistance type attenuator in series with the loop at a point of ground potential in a manner similar to that shown for an artificial antenna in Fig. 3. In this case the loop takes the place of the artificial antenna and the radio-frequency voltage is measured across the impedance which should be kept low in comparison with the impedance of the loop.

C. Output Measurements.

1. Radio Receiver with Direct Current in its Output

If the radio receiver is not equipped to filter direct current from its output, the circuit which should be used in making output measurements is shown in Fig. 5. The specifications for the components of the above circuit are given in section **III**.

The value for R is dependent on the operating conditions of the output tubes used in the radio receiver. Its value is arbitrarily taken (from the specifications of the tube manufacturer) as that resistance which gives the maximum undistorted power output under the given operating conditions.

In the case of a radio receiver having an output transformer, the load resistance R_L to be used across the output terminals is taken as the transferred value of the resistance R as specified above. That is,

$$R_L = \frac{R}{A^2} \tag{7}$$

where

R_L is the load resistance actually connected across the output terminals
R is the load resistance recommended by the manufacturer for maximum undistorted output. (In the case of push-pull operation this value is the sum of resistances for the individual tubes.)
A is the transformer ratio of the total primary-to-secondary turns. The voltage across R for Normal Test Output is

$$V = \sqrt{0.05R}.$$

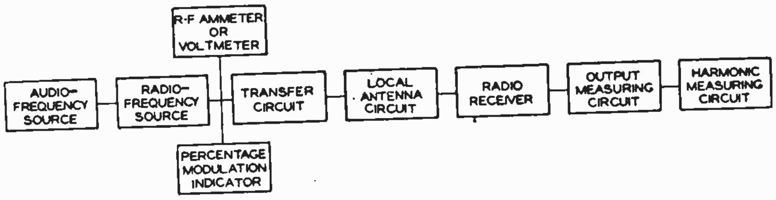


FIG. 5.—RADIO RECEIVER WITH DIRECT CURRENT IN ITS OUTPUT.

2. Radio Receiver with no Direct Current in Output

If the radio receiver has a device eliminating direct current from its output, (referring to the circuit of Fig. 5) L and C are removed and the points a and b connected directly to the output terminals of the receiver.

3. Radio Receiver with Extraneous Voltages in the Output

The voltages due to a-c hum, tube noises, etc., that may exist across the output of some radio receivers must be considered where the output voltage to be measured is small. For example, if these voltages are comparable with the Normal Test Output Voltage, let the voltage across the resistor R for Normal Test Output be.

$$V_1 = \sqrt{V_1^2 + V_2^2}, \tag{8}$$

where

V_1 is the r.m.s. voltage due to extraneous effects
V_2 is the value for Normal Test Output Voltage which gives 0.05 watt power in R.

In any case, if the extraneous voltage is appreciable, the measured voltage across R (see Fig. 5) should be considered as the vector sum of the extraneous voltage and that due to the desired signal.

D. Operating Conditions.

1. Battery Operated Radio Receivers

The "A" and "B" battery voltages supplied to the radio receiver should be held constant at the values specified for the receiver. If a battery cable is not furnished with the receiver, the leads to the batteries should be as short as possible. The batteries used should be in good condition.

2. Socket-Powered and Electric Radio Receivers

The a-c or d-c voltage input to the radio receiver should be held constant at the value specified for the set or at 115 volts. If the receiver is provided with adjustments for reducing hum or ripple in the output, such adjustments should be made.

3. Tubes

The tubes used should have characteristics which represent the arithmetical mean value as regards filament emission, plate current, plate resistance, amplification factor, and mutual conductance for that type of tube.

E. Radio Receiver Adjustment.

1. General

The Test Frequency adjustment is normally obtained by adjusting all the external tuning and volume controls, with which a radio receiver is equipped, until maximum response is had at its output for a given signal impressed on its input.

2. Regenerative Radio Receivers

All tests should be made for each of the following conditions:

a. With the radio receiver adjusted as in part 1 without causing oscillation at radio or audio frequencies to occur within the receiver.

b. With the receiver adjusted as in part 1 with the minimum of regeneration that can be obtained by adjustment of the external controls only.

3. Stabilized Radio Receivers

If a radio receiver is provided with external stabilization controls that are to be used in the normal operation of the receiver, it should be tested as a regenerative receiver. No other modifications of the general instructions of part 1 are necessary for the testing of stabilized radio receivers.

4. Super-Heterodyne Radio Receivers

If a super-heterodyne radio receiver has a separate control of its oscillator frequency all tests should be made with the oscillator adjusted to the higher frequency above the signal, unless the instructions accompanying the receiver specify other conditions for operation. Selectivity tests should include the response at the lower frequency. In making selectivity tests the radio-frequency oscillator should be moved over twice the intermediate frequency. If this falls outside the broadcast band it should not be ignored. Otherwise, tests are to be in accordance with part 1.

F. Sensitivity and Tuning Range Tests.

1. SENSITIVITY TEST

The sensitivity is determined by impressing a radio-frequency voltage, with 400 cycles, 30 per cent modulation, in series with a standard antenna (definition **F**, section **II**), or by inducing a known radio-frequency voltage in the self-contained antenna, if the radio receiver is so provided, and adjusting the intensity of the input voltage until Normal Test Output is had under conditions stated in **D** and **E**, section **II**, for carrier frequencies between 550 and 1,500 kc per sec.

A graph is plotted with Normal Radio Input Voltage as ordinates and carrier frequency as abscissas. A uniform scale should be used for the abscissas and either a uniform or logarithmic scale may be used for ordinates.

2. TUNING RANGE TEST

In conjunction with the Sensitivity Test it is convenient to make a test of the tuning range of the radio receiver. Using the same test conditions as for the Sensitivity Test, the radio receiver tuning adjustment should be set for the lowest carrier frequency it is capable of receiving under normal operation. The radio-frequency oscillator is then adjusted in frequency until it is at that frequency which gives maximum output in the output meter. The output signal used should be approximately Normal Test Output, to avoid inaccuracies due to over-loading. The radio-frequency setting of the oscillator is then recorded as the lower frequency limit of the tuning range. If the radio-frequency oscillator is incapable of reaching the low-frequency limit of the receiver, the oscillator should be set at its minimum frequency and the receiver tuned to it. The dial scale reading of the radio receiver is then recorded for that frequency. The process is then repeated at the high-frequency limit of the range. The maximum and minimum frequency settings of the tuning control will generally correspond to the maximum and minimum dial scale markings. If they do not, the dial settings corresponding to the limit frequency settings should be recorded.

If a calibration of dial setting versus carrier frequency is desired, it can be obtained by adding to the limit values, a set of readings of the dial settings for each of the Standard Test Frequencies used in the Sensitivity Test. The dial calibration is plotted in the form of a graph with carrier frequency as abscissas and dial setting as ordinates, both to a linear scale.

G. Selectivity Test.

The selectivity is determined by tuning the radio receiver to each Standard Test Frequency (definition **G**, section **II**) in succession, with the receiver in the same condition as in the Sensitivity Test, and measuring the radio-frequency input voltage necessary to give Normal Test Output at a series of carrier frequencies in steps not greater than 10 kc per sec. at least up to 100 kc per sec. on either side of resonance or until the radio input voltage has increased to at least 1,000 times its value at resonance (and preferably 10,000 times or more if the measuring equipment permits).

The conditions of modulation of the radio-frequency oscillator are to be the same as given under the definition for Normal Radio Input Voltage (definition **E**, section **II**). For each Standard Test Frequency a graph is plotted with carrier frequency as abscissas and the ratio of input off resonance to the input at resonance, as ordinates. The scale of ordinates should be logarithmic and the most accurate representation is secured by plotting the graphs for selectivity with separate enlarged frequency scales, which should be uniform and alike.

On some receivers the volume control setting has an effect on the selectivity, and this fact should be considered when making this test. (See, Effect of Volume Control on Selectivity, section **V**, for outline of test for this performance characteristic.)

H. Fidelity Test.

This is determined by tuning the radio receiver to each Standard Test Frequency (definition **G**, section **II**) in succession, with the receiver in the same condition as in the Sensitivity and Selectivity Tests, adjusting the impressed voltage to the Normal Radio Input Voltage, (definition **E**, section **II**) and then varying the modulation frequency from 40 to 10,000 cycles per sec. at 30 per cent modulation and constant radio-frequency input voltage throughout, taking readings of relative output voltage at convenient modulation frequencies. For each Standard Test Frequency, a graph is plotted with modulation frequency as abscissa, and as ordinate, the ratio of the output voltage at the modulation frequency of measurement to the output voltage at the modulation frequency of 400 cycles per sec. A logarithmic scale should be used for the abscissas and a uniform scale for the ordinates.

It is often useful to make Fidelity Tests at output levels higher than Normal Test Output. The output levels to be used are left to the discretion of the test engineer and should be stated in the results.

Certain types of volume controls have an effect upon the fidelity of the receiver and this fact should be considered when making this test. (See Effect of Volume Control on Fidelity, part **B**, section **V**, for outline of test for this characteristic.)

V. Additional Tests

The tests outlined in this section are to be regarded as tentative only. They are included for the purpose of bringing before the industry the need for tests of certain other factors of performance, in addition to major radio receiver tests which have been outlined in the preceding sections.

In some of the following tests, limits have been set in a somewhat arbitrary manner for the purpose of providing a basis for experimentation and further development. After some general experience has been had in making these additional tests, it is intended that definite standards for procedure in investigating these factors of radio receiver performance shall be drawn up. The Committee will be greatly assisted to this end if those laboratories finding a use for such tests will try out the methods outlined, and send in their comments and criticisms.

The tests which have appeared necessary thus far under this heading include:

A. Tests of radio receivers at high output levels.*
B. Tests for volume controls of radio receivers.
C. Tests for hum produced in radio receivers.

A. Tests of Radio Receivers at High Output Levels.

1. OVERLOADING OF RADIO RECEIVERS

It is conceded that the effect of distortion on the human ear is highly variable, and dependent upon many conditions which cannot be specified in any manner which shall be standard practice for any length of time. There is a basis on which overloading can be defined from the technical viewpoint, however, that may be used for the purpose of comparing radio receivers with respect to this factor of performance. A radio receiver can be said to be overloaded when distortion is manifested in the output, i.e., when the electrical output differs in wave form from the electrical input by a specified amount. The output of the radio receiver should be tested for the introduction of spurious frequencies, that is, those not present in the input.

The test apparatus will be that used for the Fidelity Test, except that a harmonic measuring instrument is to be connected across the standard output load, and this instrument so chosen as to constants, that it exerts negligible effect on the load circuit. For this purpose the instrument described in "The alternating current bridge as a harmonic analyzer"*

The radio-frequency input (with modulation adjusted to 30 per cent at 400 cycles) is to be increased in steps until a value is reached which causes the output voltage to contain 10 per cent of total harmonics.

When this input value has been reached, the output voltage is to be measured (as in Fidelity Test) and the power in the output circuit calculated. The overload level of the radio receiver shall then be considered to be that value of power output.

2. OVERLOAD CURVES

Curves showing the radio-frequency input in microvolts as abscissas, and the corresponding audio-frequency output in watts, as ordinates, furnish valuable data on the overloading of a radio receiver, especially if taken at lower percentage of modulation, as well as at 30 per cent. The same arrangement of apparatus can be used as in measuring the overload level. is recommended.

Observations at 30 and 10 per cent modulation at 400 cycles are usually sufficient, although other values may be used at the discretion of the test engineer. It is suggested that the test be made at 1000 kc although other Test Frequencies may be used if desired. The radio frequency and percentage modulation should be designated on each curve. Logarithmic scales should be used for both ordinates and abscissas.

3. SENSITIVITY AT MAXIMUM UNDISTORTED POWER OUTPUT

In view of the output power capabilities of present-day broadcast receivers, it is felt desirable to have a test for sensitivity at an output power greater than the Normal Test Output. For this purpose it is suggested that the input radio-frequency voltage necessary to produce maximum undistorted output in the load resistor be determined. The value of output may be determined as described in the preceding section on Overloading of Radio Receivers, or if it is not desired to make this test, that value may be used which is given by the tube manufacturer for the particular output tube and voltage conditions in the receiver. It is realized that this output may not be the maximum undistorted output as defined in part 1 above, but it is felt that some useful information will, nevertheless, be obtained by such a test.

The data obtainable from these measurements should be

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*In the opinion of the Committee, tests at high output levels are considered worthy of a place among the preceding standard tests, but it is felt that there has not been sufficient experience with this test by various laboratories to warrant the setting up of a definite standard test for this characteristic of radio receivers. The following paragraphs on "Tests at High Output Levels" are therefore placed in the section on "Additional Tests," pending the collection of further data. It is expected that the material will be revised in further editions of this report.

* Irving Wolff, "Alternating current bridge as a harmonic analyzer" *Jour. Opt. Soc. Am. and Rev. of Sci. Inst.*, 15, No. 3, 163-170; September, 1927.

(Continued on next page)

(Continued from preceding page)

plotted in the same form as for sensitivity measurements except that the ordinate values should be the radio-frequency input voltages for maximum undistorted output instead of the normal radio-frequency input voltages, and the power output obtained should be noted on the graph sheet.

In cases where the power output varies for the different carrier frequencies, note of this should also be made.

B. Volume Control Tests of Radio Receivers.

Briefly, the most important of these are:

1. Tests of the effect of the volume control on the sensitivity, selectivity, and fidelity of the radio receiver.
2. Tests of the effect of the radio-frequency field to which the radio receiver is exposed (input signal not subject to the volume control adjustment).

1. Tests of the Effect of the Volume Control on the Sensitivity, Selectivity, and Fidelity of the Radio Receiver

a. Effect of Volume Control on Sensitivity.

The radio input voltage required to produce Normal Test Output should be measured at various volume control settings. These can be plotted in the form of a graph using percentage of maximum setting of volume control as abscissa, and Normal Radio Input Voltage in microvolts as ordinate. This graph can be plotted on the same type of paper used for selectivity graphs with the logarithmic axis as ordinate. The graph should be taken all the way to the minimum end of the volume control unless this is impossible with the equipment available. In the latter case the graph should be taken to a radio-frequency input of at least 200,000 μv. This graph can be taken at any one or more of the Standard Test Frequency settings desired, and enough points should be taken to show the graph shape accurately.

b. Effect of Volume Control on Selectivity.

In addition to the usual inverse resonance graphs, a selectivity graph should be taken with a radio-frequency input at resonance of 5000 μv. This signal is to be reduced by means of the volume control until it gives Normal Test Output at the receiver output. One or more such selectivity graphs should be taken at reduced volume control as required in the opinion of the test engineer, and in cases of apparent erratic behavior of the volume control, graphs may be taken at higher values of radio-frequency input voltage.

c. Effect of Volume Control on Fidelity.

In addition to the usual Fidelity graphs, one should be taken with a radio-frequency input of 50,000 μv, with the radio receiver output reduced by means of the volume control to give Normal Test Output at 400 cycles. Such curves should be taken at 600 and 1400 kc, and at other standard test carrier frequencies if thought desirable.

d. Test of Automatic Volume Control Characteristics.

Curves of audio-frequency output against radio-frequency input voltages, modulated 30 per cent at 400 cycles, are taken for several settings of the manual volume control. The radio-frequency input voltages should be varied over a range of at least 100 to 1. The audio-frequency output voltages or currents are plotted as ordinates and the radio-frequency input voltages as abscissas. Logarithmic scales should be used for both ordinates and abscissas.

2. Tests of the Effect of the Radio-Frequency Field to Which the Radio Receiver is Exposed (Input Signal Not Subject to the Volume-Control Adjustment)

It is intended that this test evaluate the pickup by the radio receiver circuit, of radio-frequency fields through unshielded or poorly shielded coils or wires within the radio receiver, and through the power line in the case of radio receivers deriving part or all of their power supply from that source, under conditions where the volume control is set at minimum. Such a test appears desirable, but the Committee knows of no satisfactory way of making such a test quantitatively at the present time, and recommends that the various laboratories keep in mind the need for such a test. If a method is later developed which permits results of a useful quantitative nature to be obtained, it is requested that this be brought to the attention of the Technical Committee on Radio Receivers.

C. Test for Hum Produced in Radio Receivers.

Radio receivers of the type which derive their power from an a-c supply generally produce in the output circuit a certain amount of audio-frequency voltage composed of a combination of various harmonics of the a-c supply frequency and occasionally containing the fundamental. This voltage is commonly called the a-c hum voltage, and this section is intended to outline certain tests for evaluating it.

A measure of the r.m.s. hum voltage across the output terminals of the radio receiver is not an indication of its quantitative effect on the ear, since the audio response characteristics of audio-frequency amplifiers and loud speakers, and of the human ear, cause the higher harmonics of the a-c power supply to result in more sound response from the loud speaker than do the lower harmonics or the fundamental. Therefore it is desirable to evaluate the various harmonic components of the hum voltage in order to obtain a useful conception of the degree of unpleasantness which the hum from a particular radio receiver will create. A simple way of doing this would be to construct a filter net-work having an attenuation characteristic which would take account of the dropping off in loud speaker response and ear response below 1500 cycles. (It is felt that frequencies above 1500 cycles can be disregarded in the hum measurement.) This network should be connected between the radio receiver output and the output voltmeter. If the voltmeter is calibrated in r.m.s. volts it will then measure the square root of the sum of the squares of the various hum harmonic voltages, each harmonic being attenuated to a percentage of its actual value corresponding to its importance from the point of view of the loud speaker and ear response characteristics. Thus, a single voltage measurement is made to give a measure of the degree of unpleasantness which the hum from a particular radio receiver would create with an average loud speaker. From this voltage measurement and the value of the radio receiver output resistance the hum power should be calculated.

While the ear characteristic is fairly well known, the preparation of a network which would include the response characteristic of an average loud speaker would, of course, necessitate the measurement of all the loud speakers upon the market at the present time and for some time past. It would also require the use of the sound measuring equipment and measurement conditions whose absolute accuracy has been proved. These requirements are impossible of complete realization at the present time, but it is felt that some valuable experience in the field of hum measurement can be obtained by the adoption of an arbitrary network, having characteristics which appear, in light of present knowledge, to be of the general order of magnitude of the frequency attenuation factors involved, and to approximate an average loud-speaker characteristic. A possible attenuation characteristic for such a network is shown in Fig. 6, and a network having approximately this characteristic is shown in Fig. 7.

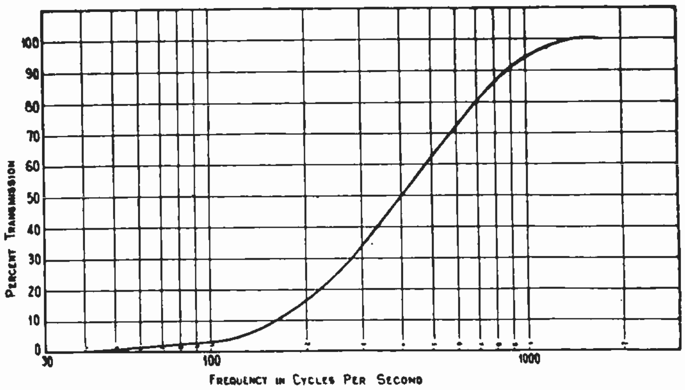
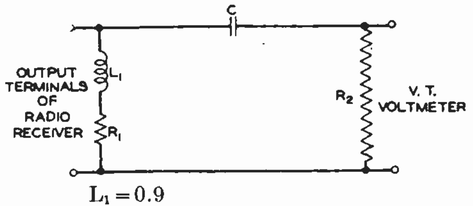


FIG. 6—POSSIBLE ATTENUATION CHARACTERISTIC OF ARBITRARY NETWORK FOR USE IN HUM MEASUREMENT.



$L_1 = 0.9$
$R_1 = 180$ ohms (including $R_{eff.}$ of L_1)
$R_2 = R_p$ of output tube
$C = 0.045$ μf for 5000 ohm R_2
$C = 0.065$ μf for 2000 ohm R_2

FIG. 7—NETWORK INTENDED TO APPROXIMATE AN AVERAGE LOUD-SPEAKER CHARACTERISTIC.

It should be emphasized that the graph of Fig. 6 is not intended to include an accurate representation of an average loud speaker frequency response characteristic. The network characteristic is only tentative, and has been prepared as a guide for those desiring to make investigations in the field of hum measurement.

Other conditions which must be considered in connection with the measurement of hum from a radio receiver are:

1. Use of an a-c power supply having known and definitely limited harmonic characteristics.
2. Adjustment of any devices provided on the receiver for hum regulation, such as filament mid-tap potentiometer, for minimum hum.

In connection with condition 1 above, it is suggested that use be made of the differential distortion factor circuit, which has been used in the past in the electrical art in evaluating the harmonic content of a-c power supplies. The circuit is shown in Fig. 8. The constants of the circuit are governed by the relation

$$R = \frac{1}{2\pi f C} \qquad (9)$$

where f is the fundamental frequency of the a-c line. The value of R can be chosen to suit the particular thermocouple meter available. The resistance of the thermocouple should be, of course, small compared with R.

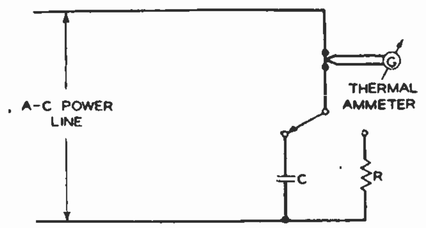


FIG. 8—DIFFERENTIAL DISTORTION FACTOR CIRCUIT.

The differential distortion factor is then given by the following relation

$$d.\,d.\,f. = \frac{I_c}{I_r} \qquad (10)$$

where I_c is current through the condenser and I_r is current through the resistor.

It is recommended tentatively, in making measurements of hum on a-c radio receivers, that the power supply have a differential distortion factor not greater than 1.05.

It should be noted that in some radio receivers, more hum will be produced when a carrier is tuned in. On this account it is necessary to measure the hum under two conditions of the radio receiver unless only the value of the worst hum condition is desired, in which case that one of the following receiver adjustment conditions should be used which gives the greater hum:

a. No incoming carrier frequency and no other voltages such as static, induction, etc., in the output circuit. In radio receivers where the position of the volume control does not affect the hum (with no incoming carrier), the last condition may be most easily complied with by setting the volume control to zero.

b. With an incoming unmodulated carrier having a radio-frequency input of 50,000 μv impressed on the radio receiver input circuit, and with the volume control so set that, were the incoming carrier to be modulated 30 per cent at 400 cycles, it would give normal output power in the radio receiver output circuit. Here, as in condition a, static and induction voltages in the output voltage should be reduced to a negligible percentage.

VI. Receiver Performance Graph Sheets

In an engineering analysis of general trends in receiver design and performance, it is necessary to consider data on a large number of receiver designs, and on a large number of particular receivers of each design, for it is well known that the performance of a random sample of a type of receiver may be far from representative of the type as a whole. In order to facilitate such analyses, and to aid in the evaluation of a particular design relative to the field, the Receiver Performance Graph Sheets to be described below were developed. They have been found so helpful by those who have used them in experimental forms that in more finished form, as prepared by the I.R.E. Technical Committee on Radio Receivers, they are here published for the information of the membership. It is hoped that they will be found useful and freely used. The Committee will welcome any comments or suggestions of the members relative to their improvement.

Great accuracy is not usually justified in plotting typical or average characteristic curves, for large probable errors are inherent in a determination of what is typical or average from the relatively small quantity of data which are usually available. And furthermore, the usefulness of the sheet as a summary for frequent reference would be decreased by including too much detail. Therefore, in the form shown in Fig. 9, advantage has been taken of these facts by making the sheet small—standard Lefax size, 3¾ in. x 6¾ in.—thus gaining the utmost in compactness without sacrifice of needed accuracy.

Curves plotted on this sheet may be easily read to an accuracy of 5 per cent, which should prove sufficient for the original record of many receiver tests which are made with test equipment not of the highest order of accuracy, or which are rapidly made when great accuracy is not required. However, this small sheet has been designed with the principal object in view of providing a means of recording average or typical data in summary form for ready reference. Tests made to disclose small differences in individual receivers, or to discover errors or defects, should be recorded in other ways more suitable for such tests.

The sheet consists of two ruled sections, one with logarithmic abscissas and linear ordinates, for fidelity curves, and the other with linear abscissas and logarithmic ordinates, upon which may be recorded sensitivity and band-width (selectivity) curves. The scales are all properly marked and are so chosen as to be universal, that is, they will be suitable for practically any present or contemplated broadcast receiver, without change.

The use of universal scales is considered essential so that different receivers may be compared at a glance by noting the shape and location of their characteristic curves on the standard sheet, without the necessity of translating the curves back into figures. This requirement necessitates—if undue loss of accuracy is to be avoided—the plotting of the selectivity characteristic by means of the band width, derived from the inverse resonance curves (or measured directly) instead of the inverse resonance curves. It is obvious that to cover all types of receivers, a logarithmic scale for sensitivity and band width is required. Linear ordinates for the fidelity curves are chosen because, on a small sheet, they indicate with greater accuracy the essential fidelity characteristics.

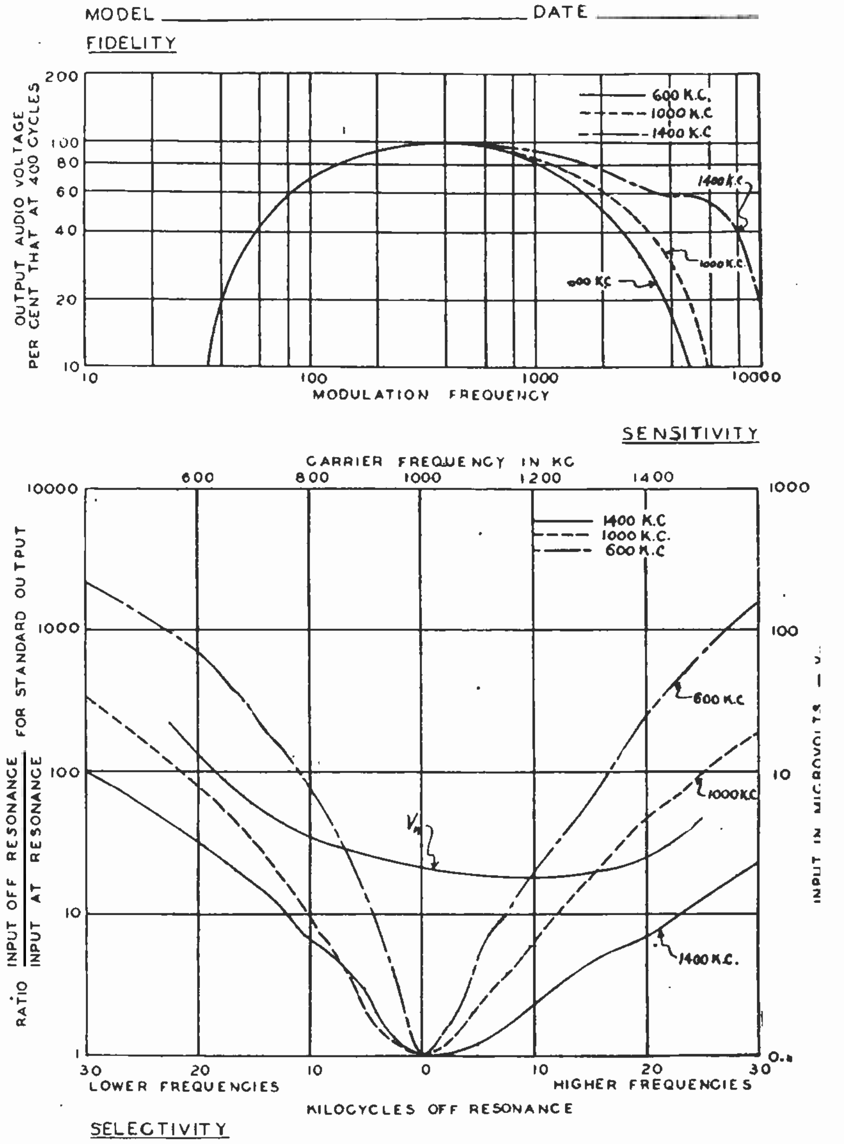


FIG. 9—RECEIVER PERFORMANCE GRAPH SHEET. (FULL SIZE)

Space has been left at the top of the sheet for a title and any general memoranda which may be desirable. The standard Lefax index ruling may be included in the upper right-hand corner of the sheet, if desired, subject to any legal restrictions there may be to the use of this ruling. The figure shows the proposed sheet, full size, upon which have been plotted, for the purpose of illustration, the basic characteristics of a receiver; sensitivity; band widths at 10, 100, and 1000 times Normal Radio Input Voltage at resonance; and fidelity, measured at the three standard test frequencies of 600, 1000 and 1400 kc per sec.

For those who prefer to plot complete selectivity curves, instead of band-width data, a different form has been prepared, and is shown in Fig. 10. This form is designed for standard letter size paper 8½ in. x 11 in.

The lower part of the form provides for plotting complete selectivity curves, and also provides for a sensitivity curve. As in the smaller form, the upper section of the form is for fidelity curves. Logarithmic ordinates are provided for the fidelity curves, as many engineers consider these show the fidelity more nearly as it sounds.

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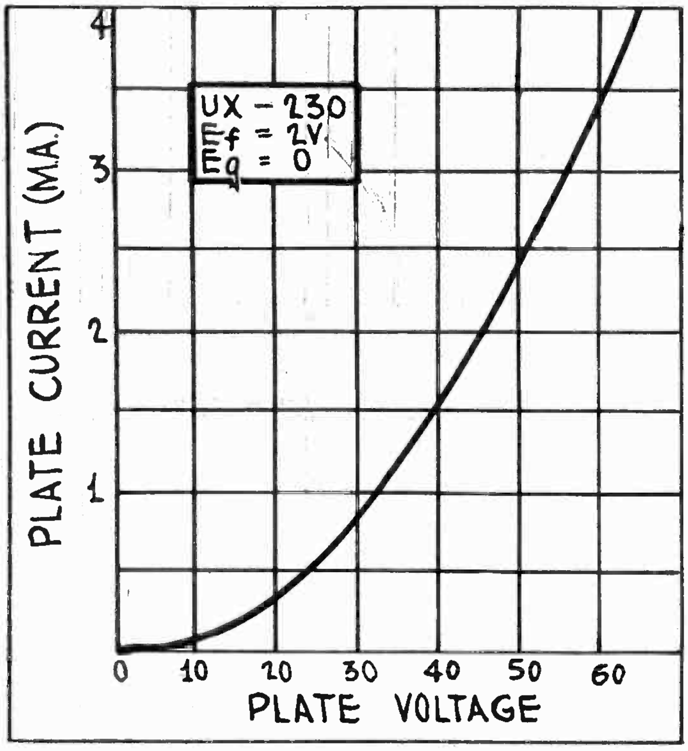

FIG. 52

PLATE VOLTAGE, PLATE CURRENT CHARACTERISTIC OF A 230 TUBE WITH ZERO GRID BIAS.

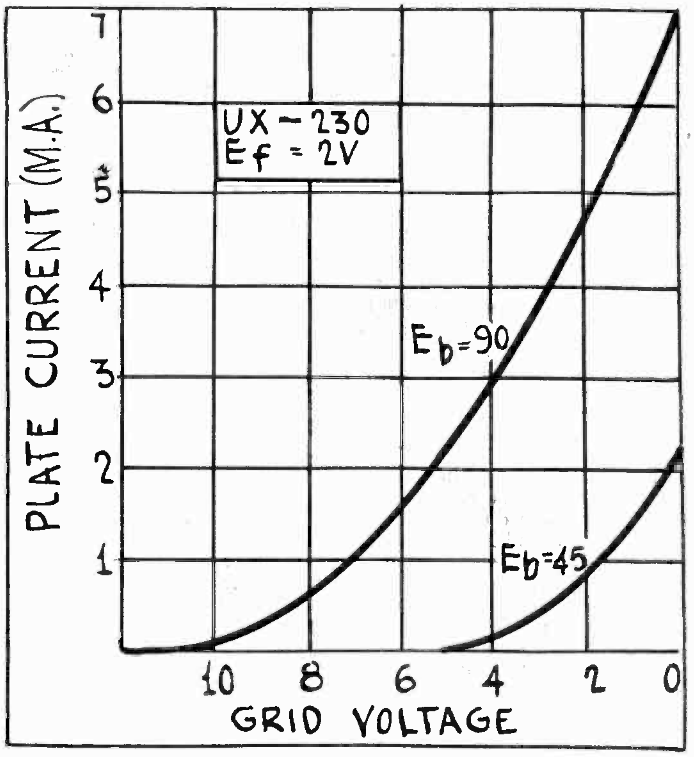

FIG. 53

GRID VOLTAGE, PLATE CURRENT CHARACTERISTICS OF THE 230 TUBE FOR PLATE VOLTAGES OF 45 AND 90 VOLTS

[*This is the fifth weekly instalment of "Modern Radio Tubes." The first appeared in the August 9th issue. Previous discussions have deal with the WD*11, *WD*12, *UV*199, *UX*199, 120, 201*A*, 240, 20J*A*, 112*A*, *and* 171*A*. *Next week the* 232 *and* 222 *screen grid tubes will be discussed.—Editor.*]

Fig. 52 gives the plate voltage, plate current relationship at zero grid bias for the 230 tube up to about 65 volts in the plate circuit. As has been stated in connection with preceding tubes. this curve is mainly useful for determining the plate voltage when the grid bias is zero and the plate current is known from a measurement. It is always possible to get a zero bias by merely returning the grid to the negative end of the filament, and hence the only measurement that is necessary to that of the plate current.

Grid voltage, plate current curves for the 230 tube at plate voltages of 45 and 90 volts are given in Fig. 53. When the grid bias is zero and the plate voltage is 90 volts, the plate current is 7 milliamperes. At the recommended grid bias of 4.5 volts, the plate current is 2.6 milliamperes. The nominal value is 2 milliamperes. The difference may be accounted for by the fact that 2 milliamperes is the average while the curve in Fig. 53 is for a particular tube. It will be noted that if the grid bias is 4.5 volts and the signal swings the grid 4.5 volts either side of the bias, the plate current varies between 7 and 0.25 milliamperes.

When the plate voltage is 45 volts, the plate current rises to 2.2 milliamperes when the bias is zero and falls to 0.25 milliampere when the bias is 3.5 volts. Since it is desirable to avoid entering the region of sharp curvature it is best not to allow the grid to swing more than 3 volts negative, that is, making the bias 1.5 volts.

Even when the plate voltage is 90 volts it is not necessary to use the recommended bias of 4.5 volts. Somewhat less harmonic distortion will result if the bias is only 3 volts, but at this bias the mean plate current will be 3.8 milliamperes. If it is necessary to conserve the life of the tube and the B supply, the higher bias should be used. but if quality is paramount and if the signal swing is small, the lower bias should be used.

A Family of Curves

In Fig. 54 is a family of plate voltage, plate current curves of the 230 tube over the usual operating range of grid bias voltages. There are also two load lines across the curves, one for 25,000 ohms, which is twice the value of the internal plate resistance, and the other for 100,000 ohms. The 25,000-ohm load line can be used for calculating the output power of the tube and also the amplification when the tube is used as a resistance coupled voltage amplified with 25,000 ohms in the plate circuit. The 100,000-ohm load line can be used for calculating the voltage amplification when the load resistance has this value.

Let us first estimate the output power. We note that when the bias is zero the plate current is 3.7 milliamperes and the effective plate voltage is 63.75 volts. If we take the minimum permissible plate current to be 0.4 milliampere we note that the load line crosses this current line at 150.675 volts on the plate and 15 volts on the grid. Thus we have a current change of 3.3 milliamperes and a plate voltage change of 87 volts. Thus the output power is 35.9 milliwatts.

In the case of resistance coupling with 25,000 ohms in the load circuit, we can use the same figures for determining the voltage amplification. We found that the plate voltage change was 87 volts and that this change followed a change of 15 volts on the grid. Hence the voltage amplification is 5.8. In order to obtain this voltage amplification it is necessary to make the plate battery voltage about 160 volts, and the grid bias must be 7.5 volts. The steady plate current will be 2 milliamperes.

Resistance Coupled Voltage Gain

The 100,000-ohm load line has been drawn for a plate battery voltage of 180 volts. In this case let us assume that the minimum current is 0.25 milliamperes. The load line cuts the 0.25-milliampere line at a grid bias of 16.6 and a plate voltage of 157.5 volts. The plate voltage at zero bias is 38.75 volts. Hence the voltage amplification is 7.15. The grid bias must be 8.3 volts, at which value the steady plate current is about 0.8 milliampere.

If we make the bias 7.5 volts the steady plate current will be 0.9 milliamperes and the voltage amplification 7.35. Not only will the amplification be higher with the lower bias but the quality will be better. However, the output voltage will not be quite so high. Still the amplitude of the output voltage under these conditions will be 7.45 volts, which is much more than the input required to load up any power output tube with the exception of the 250.

It is interesting to note that the curves in Fig. 54 can be used

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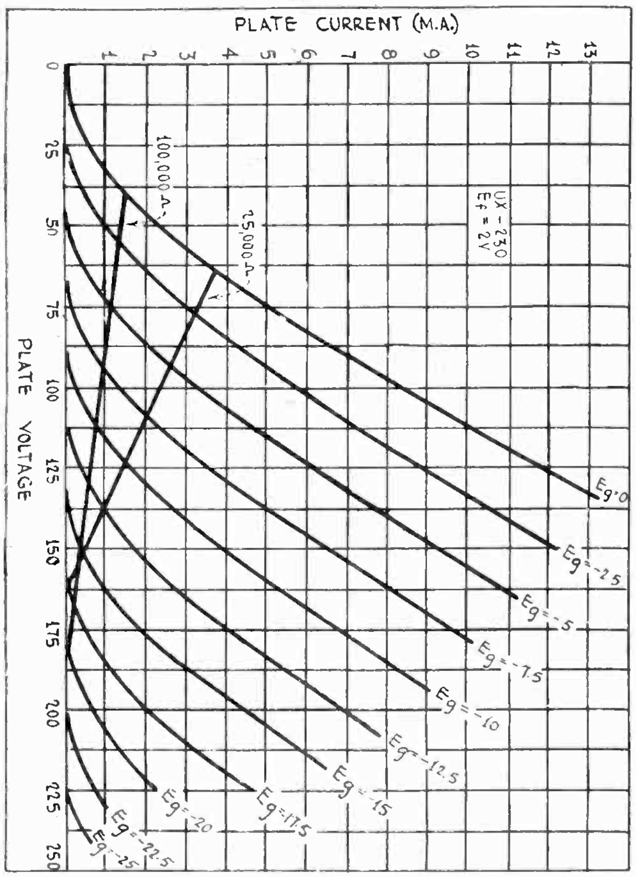

FIG. 54

A FAMILY OF PLATE VOLTAGE PLATE CURRENT CURVES FOR THE 230 TUBE OVER THE USUAL OPERATING GRID VOLTAGE RANGE. ONE LOAD LINE IS DRAWN ACROSS THE CURVES FOR 25,000 OHMS AND ANOTHER FOR 100,000 OHMS.

to determine the amplification constant of the tube. When the plate and grid voltages are zero, the plate current is also zero. Again, when the plate voltage is 22.5 volts and the grid bias is 2.5 volts, the plate current is zero. The ratio of 22.5 to 2.5 is the amplification factor. This ratio is 9, whereas the rated amplification factor is 8.8. A closer determination can be obtained by taking another constant plate current other than zero. Take, for example, 10 milliamperes between bias voltages of zero and 5 volts. The zero bias curve crosses the 10-milliampere line at 112.5 volts and the 5-volt bias curve crosses the same current line at 156.25 volts. Thus 5 volts on the grid produces a change in the plate voltage of 43.75 volts, keeping the plate current constant. Hence the amplification factor is 43.75/5, or 8.755. This is very close to the rated value. The amplification constant of any other tube for which a family of plate voltage, plate current curves is available can be determined in the same manner.

The curves in Fig. 53 show that if the 230 tube is to be used as grid bias detector, the bias should be 4.5 volts when the plate voltage is 45 volts, and 10 volts when the plate voltage is 90 volts.

The plate voltage, plate current characteristic of the 231 power tube for the conditions specified is given in Fig. 55. We note that when the plate voltage is 60 volts and the bias is zero the current is 11 milliamperes. It is not advisable to apply a higher voltage without grid bias, and for that reasn the curve is not extended above 60 volts.

231

THE 231 tube is the power tube in the new series of 2-volt tubes. Its external characteristics are like those of the 230 or the 120 and it has a small standard UX base fitting into a standard UX socket. It has a more rugged filament than the other tubes in the series and takes a current of 0.130 ampere.

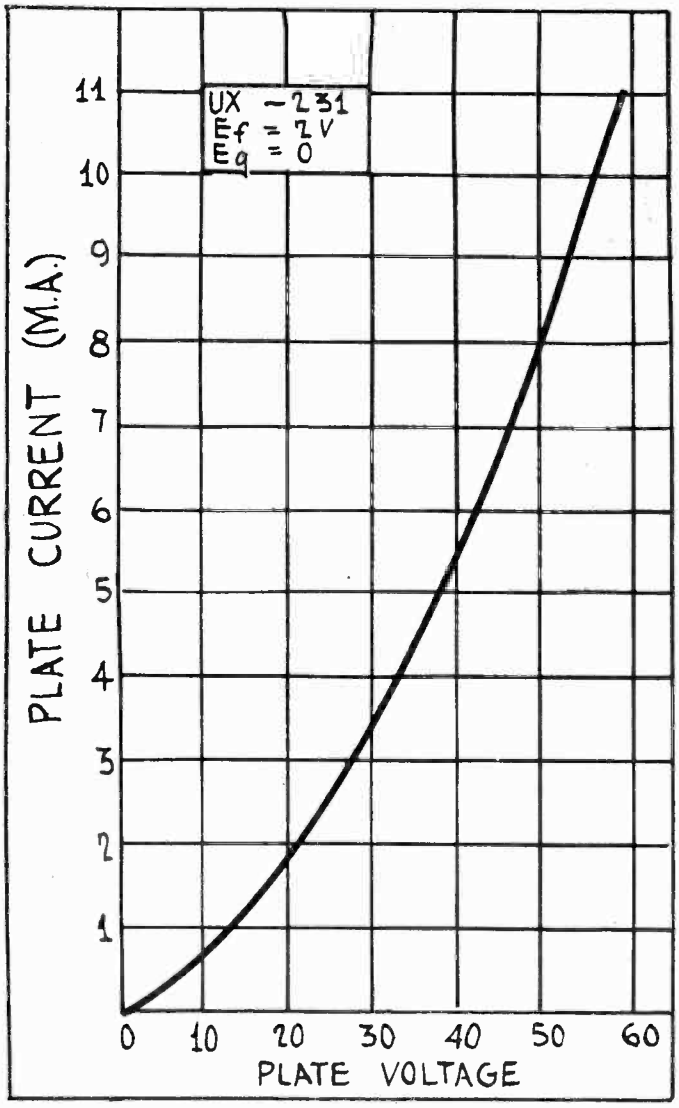

FIG. 55

PLATE VOLTAGE, PLATE CURRENT CHARACTERISTIC OF THE 231 POWER TUBE FOR ZERO GRID BIAS AND UP TO 60 VOLTS ON THE PLATE

CHARACTERISTICS OF 231

Filament voltage	2.0
Filament current, amperes	0.130
Filament power, watts	0.26
Plate voltage, maximum	135
Grid bias, volts	—22.5
Plate current, milliamperes	8.0
Plate resistance, ohms	4,000
Amplification factor	3.5
Mutual conductance, micromhos	875
Undistorted power output, milliwatts	170
Grid-plate capacity, mmfd.	6.0

Since this power tube has an output resistance of 4,000 ohms, the load impedance should be 8,000 ohms for greatest undistorted power output. This should be the effective impedance of the loudspeaker if one is connected directly in the plate circuit, or of the primary of the output transformer if one is used.

The maximum and recommended plate voltage on this tube is 135 volts, and the corresponding grid bias should be 22.5 volts. A lower bias will limit the undistorted output power and at the same time it will cause excessive plate current, thus shortening the life of the tube.

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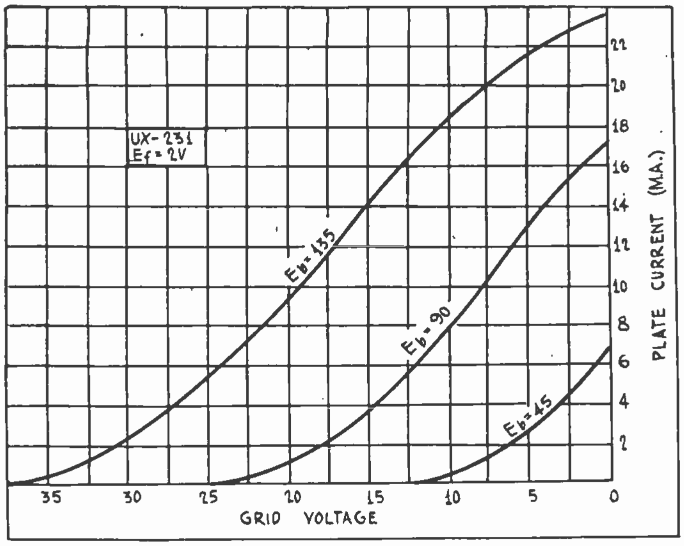

FIG. 56

THREE GRID VOLTAGE, PLATE CURRENT CURVES FOR THE 231 POWER TUBE AT PLATE VOLTAGES OF 45, 90 AND 135 VOLTS

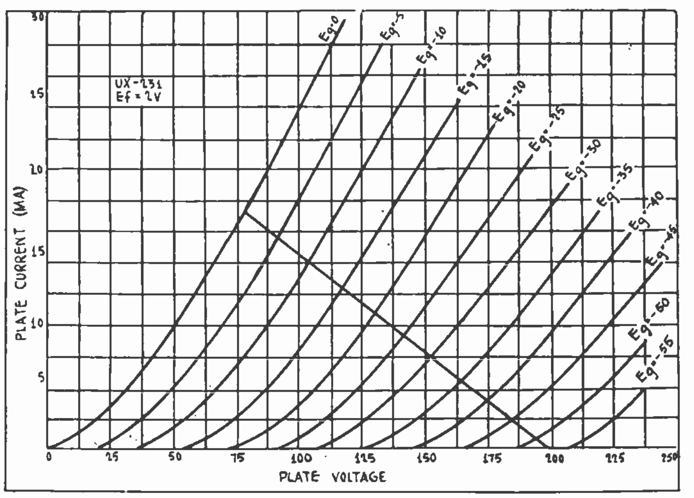

FIG. 57

A FAMILY OF PLATE VOLTAGE, PLATE CURRENT CURVES FOR THE 231 POWER TUBE FOR GRID VOLTAGE BETWEEN ZERO AND MINUS 55 VOLTS. THE LOAD LINE IS DRAWN FOR 8,000 OHMS, TWICE THE VALUE OF THE INTERNAL PLATE RESISTANCE OF THE TUBE

(*Continued from preceding page*)

The tube should be used only in the last stage for its amplification factor is so low that it cannot be used advantageously as a voltage amplifier. The connections of the tube as single-sided power amplifier are shown in Figs. 49 and 50, and in Fig. 51 they are shown for a push-pull amplifier. This push-pull amplifier is capable of putting out an undistorted power of 370 milliwatts or more, but this requires that the amplitude of the signal voltage across the secondary of the push-pull input transformer be 45 volts. If the total step-up ratio of the transformer is 1-to-5 this will be given if the amplitude of signal voltage on the preceding tube is about 1.5 volts.

Grid voltage, plate current curves for the 231 power tube for three different plate battery voltages are given in Fig. 56. In each of these curves the plate current is reduced to zero when 45-volt curve goes to zero when the grid bias is 12.5 volts, the 90-volt curve when the bias is 25 volts, and the 135-volt curve when the grid bias is 37.5 volts. Theoretically, this ratio is the amplification constant of the tube. The rated value of the constant is 3.5, and therefore the check is satisfactory. Later we shall determine the constant from the family of plate voltage, plate current curves for the tube.

Saturation Effects

Two of the curves in Fig. 56 show decided saturation effects, which indicate that the filament emission is not sufficient to support the demand for current. The saturation effect on the 135-volt line is quite great, while that for the 45-volt line is imperceptible.

The fact that saturation effects are appreciable imposes certain conditions on the grid bias that should be used on the tube. For example, on the 135-volt curve the optimum operating point is approximately at a bias of 16.5 volts. If this bias is used, the maximum grid voltage will be 33 volts, provided the amplitude of the signal is equal to the bias. This will make the minimum plate current one milliampere, which is about correct. At 16.5 volts the steady plate current is 11.5 milliamperes.

The recommended bias of 22.5 volts seems to be too high, for it does not permit of a grid signal amplitude greater than about 10.5 volts if the minimum current is not to be less than one milliampere. However, it must be remembered that the curves in Fig. 56 is for a particular tube, which may be inferior to the average.

When the recommended bias of 22.5 volts is used the plate current is 7.2 milliamperes, which is less than the rated current of 8 milliamperes.

The optimum bias voltage for the 90-volt curve is 7.5 volts. If the signal amplitude is equal to this bias the maximum grid voltage will be 15 volts, where the plate current is 3.7 milliamperes. A bias as great as 10.5 volts may be used when the plate voltage is 90, and this bias permits a signal swing of 21 volts. When the grid voltage is 21 volts the plate current is about 0.6 milliampere. Thus there will be considerable harmonic distortion when the higher bias is used.

45 Volts on Plate

At 7.5 volts on the grid the plate current is 10.3 milliamperes and when 10.5 volts is used the plate current is 7.3 milliamperes.

Since this is a power tube it will not often be used with a plate voltage as low as 45 volts. However, it may be that the tube will be used for earphone reception, when it is inadvisable to use a higher voltage. With this voltage in the plate circuit the bias may be as high as three volts, giving a plate current of about 4 milliamperes.

It is well to note that if the tube is operated at the optimum grid bias for either 135 or 90 volts in the plate circuit, the saturation effect partly prevents the generation of even order harmonics. Each curve is nearly symmetrical about its optimum bias point, which is characteristic of the curve obtained from a push-pull amplifier, that is, the curve showing the relationship between the grid bias and the total voltage drop across the load impedance with the voltmeter connected from the plate of one tube to the plate of the other.

A family of plate voltage, plate current curves for the 231 power tube is given in Fig. 57, together with a load line for 8,000 ohms, twice the internal plate resistance of the tube. This line is drawn through the 200-volt point on the voltage axis, which indicates that if the load is a pure resistance the battery voltage should be 200 ohms. The line passes through the 22.5 volt bias curve at 135 volts so that the effective voltage on the plate when the bias is 22.5 volts is 135 volts. This is the recommended condition of operation of the tube. Let us try to find the approximate value of the output power.

The load line crosses the curve for zero bias at 77.5 volts and 15.4 milliamperes. Now if the signal amplitude is equal to the bias, the grid swings to 45 volts negative. The 45-volt bias curve crosses the load line at 185 volts and 2 milliamperes. Hence we have a plate voltage change of 107.5 volts and a plate current change of 13.4 milliamperes. The product of these two is eight times the output power expressed in milliwatts. Hence the power is 180 milliwatts. The rated output is 170 milliwatts. Note that the steady plate current at the recommended bias is 8.2 milliamperes, whereas the rated current is 8 milliamperes. The agreement is satisfactory.

Use of Optimum Bias

We concluded from the study of the grid voltage, plate current curve for an effective plate voltage of 135 volts that the optimum bias was 16.5 volts. Let us see what output power is when this bias is applied, still using the 8,000-ohm load, and assuming again that the amplitude of the signal voltage is equal to the bias.

We found previously that the load line crosses the zero bias line at 77.5 volts and 15.4 milliamperes. We now have to find the corresponding values for the intersection of the load line and the 33-volt bias curve. The 33-volt curve is not given so we have to interpolate between the curves for 30 and 35 volts. To find our desired point we divide the distance along the load between the two curves into five equal parts and locate the point two-fifths of the way from the 35-volt curve. We find a voltage of 160 volts and a current of 6.1 milliamperes. Hence the power is 106 milliwatts.

This power is much less than that which may be obtained when the bias is 22.5 volts so it is plain that by optimum is not meant the bias which gives greatest undistorted output but rather the bias which gives least distortion whatever the signal voltage may be so long as it is less than the applied bias.

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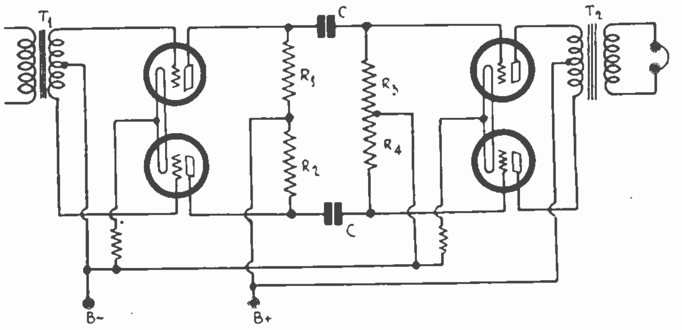

FIG. 844
A BALANCED CIRCUIT UTILIZING RESISTANCE-CAPACITY COUPLING BETWEEN THE TWO STAGES. A CIRCUIT OF THIS TYPE IS ONLY PARTLY PUSH-PULL.

Screen Voltage Requirements

I HAVE experimented with screen grid tubes in resistance coupled circuits and have found that it is impossible to get good results if the screen voltage is as high as has been recommended for the tubes. Invariably the required voltage for best amplification is much less than the recommended values. I should like to have an explanation for this condition. Why do the manufacturers of the tubes specify screen voltages that will not give results?—R. C. J.

The manufacturers specify plate voltages, not applied voltages in the plate circuits. If you boost the voltage in the plate circuit until the actual voltage on the plate is that specified by the manufacturers, then the tubes will function with the screen voltages specified. If you are using a voltage in the plate circuit equal to the recommended plate voltage then you must decrease the screen voltage considerably. For example, if the voltage in the plate circuit is 200 volts, the screen voltage must be reduced to about 16 volts if the tube is to amplify well on a bias of 1.5 volts on the control grid and a 250,000 ohm resistor in the plate circuit. If the screen voltage is higher than 16 volts it is necessary to increase the control grid bias.

* * *

Variation of Screen Current

HOW DOES the screen current vary with changes in grid bias when the plate circuit voltage and the screen voltage remain constant? Or does it remain constant?—T. G. H.

Experimental curves taken on a 224 under the specified conditions were published in the Aug. 30th issue of RADIO WORLD and these curves show that the screen and the plate currents vary in the same manner over the range covered in the experiment. Both decrease as the bias increases. This law of variation does not necessarily hold true for other bias ranges. If the bias is decreased still more the voltage drop in the load resistance becomes so great that the net voltage on the plate becomes less than the voltage on the screen. Then the plate current will stop increasing. The screen current will continue to increase under these conditions.

* * *

Choice of Grid Bias Resistor

WILL you kindly explain how to compute the grid bias resistor needed for a screen grid tube in detector circuits, in radio frequency amplifiers, and in resistance coupled audio amplifiers? What current is used in calculating the value?—W. A. S.

In all of these cases the sum of the plate and screen current is taken, that is, the sum of the currents flowing at the bias desired. Consider first the case of a radio frequency amplifier in which the DC voltage drop in the plate circuit is negligible. The plate current will be about 4 milliamperes when the plate voltage is 180 volts, the grid bias is 1.5 volts, and the screen voltage is 75 volts. Under the same conditions the screen current will not be more than one-third as great as the plate current. It is reasonable to assume that it will be one milliampere. Thus the total current flowing through the grid bias resister will be 5 milliamperes. Now this current is to cause a drop of 1.5 volts. Hence the resistance should be 1.5-.005, or 300 ohms. This value is usually recommended and it works all right. In the case of grid bias detector working into a high resistance of the order of 250,000 ohms, with an applied plate voltage of 200 volts, and a screen voltage of 45 volts, the grid bias should be 4.5 volts. But at this bias the sum of the plate and the screen currents will be very small, say about .035 milliampere. This would require grid bias resistor of something like 130,000 ohms, which is not practical at all. Hence we have to provide another arrangement. One method is to connect a resistance of suitable value from the screen voltage supply post to the cathode and then a grid bias resistor from the cathode to the grid return. We may arbitrarily select such values that the current through this shunt will be about one milliampere, which is so large that we may neglect the screen and plate currents in comparison, at least at first. Let us take a 5,000 ohm resistance for the grid bias and then find what the resistor from the 45 volt tap to the cathode should be to give a bias of 4.5 volts. Obviously, the current through the bias resistor should be 4.5/5,000 ampere. We have used up 4.5 volts of the 45, so we have only 40.5 left for the screen. Then the resistance we are looking for is determined by dividing 40.5 by 0.9 milliamperes, since that is the current. Hence we get a resistance of 45,000 ohms. That is, we use a total resistance of 50,000 ohms and connect the cathode 5,000 ohms from the grid return end. We might now take the plate and screen currents into consideration to see what the actual bias will be. In one case the current measured actually .035 milliampere. But the current through the 45,000 ohm resistor also flows through the bias resistor. Hence the total current will be .935 milliampere and the bias will be 4.675 volts. We could also make the two resistances 5,000 and 50,000 ohms. If we do, we get a bias of 4.265 volts. This is not quite high enough for best detection under the conditions imposed. In the case of a resistance coupled amplifier, the sum of the screen and plate currents will be slightly higher, using the same plate circuit adjustments, but still the total current will not be enough to provide a suitable bias a simple bias resistor alone. We could well use a grid bias of 3 volts, provided that we reduce the screen voltage to about 16 volts. If we connect a 50,000 ohm potentiometer from the screen supply post to the grid return and connect the cathode to the slider we have a means of adjusting simultaneously the screen and grid voltages so that the best amplification results.

* * *

Effectiveness of By-pass Condenser

WILL you kindly give a formula showing how to determine the effectiveness of a by-pass condenser when connected across a resistance. I understand that the larger the resistance the greater the by-passing effect of a given capacity. I presume there is a formula connecting the resistance, the capacity and the frequency.—H. A. C.

If R is the resistance, C the capacity, and w, 6.28 times the frequency, the effective resistance of the condenser and the resistance connected in parallel is $R1\div(1+R^2C^2w^2)$. The fact that the resistance squared enters the denominator proves that the effective resistance decreases rapidly as the resistance across the condenser increases. Since both the capacity and the frequency also enter as squares in the denominator the effective resistance of the combination also decreases rapidly as either the capacity or the frequency increases. Let us illustrate the use of the formula. Suppose we have a grid bias resistor of 5,000 ohms and a condenser of 2 mfd. across it. What is the effective resistance at 25 cycles. RCw is then equal to 1.5708, the square of which is 2.47. Hence the denominator is 3.47 and the effective value of the resistance is 1.442 ohms. If we make the condenser 8 mfd., RCw becomes 6.28, the square of which is 39.45, and the denominator in the formula becomes 40.45. Hence the effective resistance is 5,000/40.45, or 123.8 ohms. This shows the importance of using a large by-pass condenser across the grid bias resistor in an audio frequency amplifier.

* * *

Unit of Force

IN one of your recent issues you defined pressure as so many dynes per unit area, but you did not say what a dyne is. This is not a familiar term and I would appreciate a definition of it.—W. H. S.

The dyne is the unit of force in the centimeter-gram-second system of measurement, the system used in all scientific work. The centimeter is the unit of length and is one one-hundredth of one meter. The gram is the unit of mass, and is the mass of one cubic centimeter of distilled water at 4 degrees centigrade, or it is one one-thousandth of a kilogram. The second, of course, is the unit of time and is 1/86.400 part of the mean solar day. The dyne is defined in terms of these three fundamental units. It is that force which when acting on one gram of mass cause an acceleration of one centimeter per second every second. For example, if the gram mass starts from rest a dyne causes the gram mass to move with a velocity of one centimeter per second at the end of one second. At the end of two seconds the gram mass is moving two centimeters per second. The force of gravity in latitude 45 degrees north or south of the equator and at sea level is about 980 dynes.

* * *

Tapping Storage Batteries

I UNDERSTAND that it is not good practice to tap the cells of a storage battery to get a lower voltage. I have a six-volt battery and I want to operate a receiver built with the new two-volt tubes, as soon as I can get the tubes. If I tap in on the battery so as to use one cell at the tap and use each cell the same length of time, will it ruin the battery?—C. G. B.

While it is not good practice to tap a six-volt battery in this manner it will not ruin the battery. If the battery is overcharged a little each time it is charged the three cells will tend to become equally charged. Moreover, if you have a hydrometer you can always test the condition of charge and use that cell which shows the highest charge.

* * *

Pure Wave Oscillator

I AM looking for a source of radio frequency voltage with as pure wave as possible. Would it be possible to hook up a push-pull circuit and using a push-pull radio frequency amplifier following the oscillator for producing the wave?—W. W. A.

Yes, it is possible, but it is hardly necessary to go to this trouble. A sharply tuned circuit purifies the wave better than a push-pull amplifier and oscillator would do it. However, if all trace of harmonic is to be removed both methods might be used. The back coupling in the push-pull oscillator should be as loose as possible, that is, as loose as can be used and still have oscillation. Then the coupling between the oscillator and the push-pull amplifier should be sharply tuned and the tubes in the push-pull stage should be power tubes operated with as high load impedance as possible. Tuning in the plate circuit is suggested. It is possible to make a practical single tube oscillator giving a feeble oscillation which is very pure and a push-pull oscillator will improve the purity.

* * *

Output of Power Tubes

THE claim that so-called power output tubes give louder signals does not seem to hold true. I have substituted 245s for 171-As and I don't get any more than I did before. Previously I had the same experience when I changed from 112As to 171As. In fact, when I made this change I did not get nearly as much as I did with the 112As. How do you reconcile the facts with the claims?—J. J. McC.

There is no discrepancy at all between the facts and the claims. Your interpretation of the situation is faulty. When a circuit has been designed for 112A tubes and then 171A tubes are substituted, the output for the same input will be less, because the amplification factor of the 171A is much less than that of the 112A. The 171A should be operated with a higher plate voltage and a greater grid bias. If the proper values are applied to the tube and the signal input boosted to the maximum the tube will stand, the output from the 171A will be much greater. You have to boost the input in the ratio of about one to three. A 245 cannot be substituted directly because the filament supply voltage must be changed. The grid bias and the plate voltage must also be increased. When this tube has been put in the proper setting and the required signal input has been applied, the output of this tube will be much greater than that of the 171A tube. In order to get a large power out of the tube it is necessary to put a lot into it.

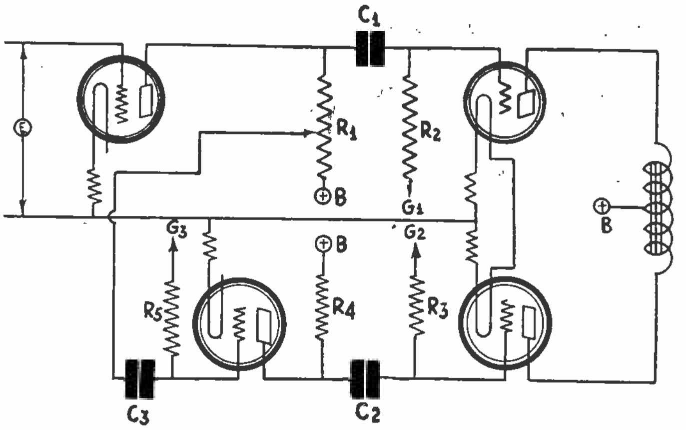

FIG. 845
THIS CIRCUIT UTILIZES A PHASE INVERTER TUBE FOR THE PURPOSE OF COUPLING A PUSH-PULL OUTPUT STAGE TO A SINGLE-SIDED AMPLIFIER WITHOUT THE THE USE OF A COUPLING TRANSFORMER

* * *

Total Applied Voltage

IN many amplifiers utilizing 245 tubes the plate voltage is specified as 300 volts but the recommended voltage is 250 volts. Frequently the description of the circuit emphasizes the plate voltage should not be greater than 250 volts, yet the circuit diagram calls for 300 volts. What is the reason for the inconsistency?—J. A. B.

There is nothing inconsistent at all. The tube requires a plate voltage of 250 volts and a bias of 50 volts. These two voltages add up to 300 volts. Since the bias for the 245 is invariably obtained from a drop in resistance in the plate circuit the total applied voltage must be 300 volts if the plate is to get 250 volts and the grid 50 volts. The bias resistor is selected so that the plate current produces a drop of 50 volts and then the total applied voltage divided automatically between the plate and grid circuits in the proper ratio.

* * *

Calibrating a Tube Voltmeter

WHAT is needed for the calibration of a first class vacuum tube voltmeter, that is, what instruments?—J. C. V.

First, a source of radio frequency current, which may be a vacuum tube oscillator. Then a means for measuring the voltage drop produced by the current flowing through a known resistance. Then a means of varying the current and hence the voltage drop. If a thermo-couple type voltmeter is available this is the best to use. If one is not available thermo-couple type milliammeter and a known resistance should be used. Known values of AC voltages are impressed on the grid of the voltmeter tube and the corresponding readings in the plate circuit of that tube are recorded on a graph.

* * *

Push-Pull Resistance Coupled Circuits

WILL you please publish a circuit of two-stage, push-pull amplifier using resistance coupling between the two stages. Please give the values of the elements of the coupler. I should also appreciate a circuit diagram of a direct coupled circuit in which a phase inverter tube is used so that the resistance push-pull amplifier can be coupled to an ordinary detector. Please give values.—W. A. J.

The circuits you request are given in Figs. 844 and 845. The stopping condensers in these circuits should be .01 mfd. or larger and they should be of the mica dielectric type. The two condensers in either circuit should be as nearly equal as possible. The two plate resistances in Fig. 844 should be 0.1 megohm each and the two grid leaks one megohm each. The grid leaks in Fig. 845 should have the same values. R4 in Fig. 845 might have a value of 250,000 ohms and R1 should be a potentiometer having the same value.

Short-Wave Set Tips

By *John C. Williams*

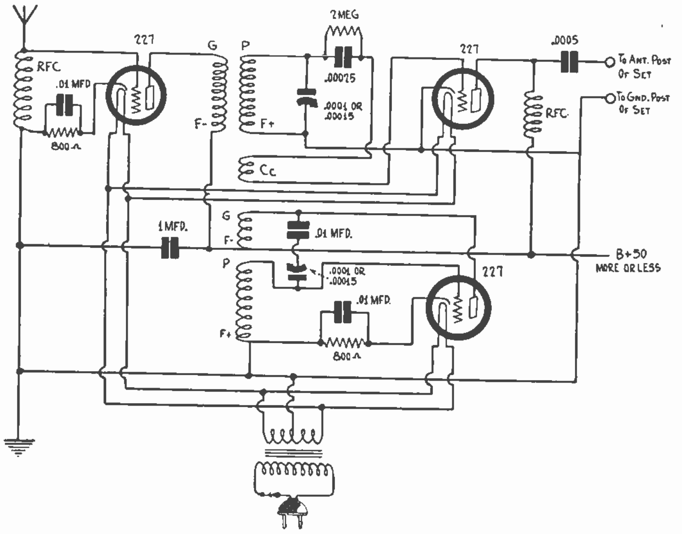

FIG. 1
SHORT WAVE ADAPTER WITH A TUNED PLATE, TUNED GRID CIRCUIT THAT WORKS WELL BUT HAS SOME HAND CAPACITY EFFECT

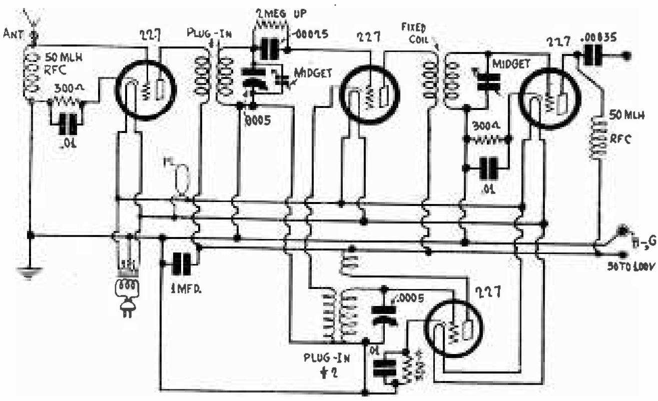

FIG. 2
IMPROVED SHORT WAVE ADAPTER CIRCUIT WITH A TUNABLE INTERMEDIATE STAGE

THOSE who like to construct some of their own short-wave receiver parts, particularly the coils, frequently need constructional information.

Some state that they have certain left-over parts, or that they have certain wire sizes insulated with silk or cotton coverings in single or double layers. Others have enamel covered wires with and without extra insulation.

Successful operation of a given short-wave receiver does not depend on the kind of insulation used. It is also noticed that there is some doubt or uncertainty regarding the influence of the size (or shape) of the conductor with which the coil is wound.

It is felt that short-wave sets are very different fundamentally from the regular broadcast receivers.

That there are differences, there is no doubt, but at the same time there is no valid reason for believing that the designs of short-wave receiving circuits have to be so exact that any slight deviation, electrical or constructional, is bound to render the circuit inoperative.

When the Converter "Won't Work"

Suppose a man builds a short-wave converter, but gets no signals. After the adapter has been in operation, say, for 20 minutes, during which time the tubes have warmed up, and the adapter's tuning condenser dials have been rotated, what's the next step? It is to determine whether the converter's oscillator tube is indeed oscillative.

Next test for all plate and screen electrode voltages.

If they are not alive the cause must be found.

If they are alive, then the common return-wire between the converter and the set must be found and a 0-20 or 0-100 range milliammeter placed in this return circuit. The load current is read, if there is any. If there is no deflection you must get at the converter circuit proper and test for a short across the grid bias resistors, with the tubes not lighted. Use a continuity tester. If the tester has a lamp across 1½ volts, the lamp won't light with 300 ohms in series. If the resistor is open there will be no plate current in that tube. Place the voltmeter prods on plate and B minus, and while reading the plate voltage, short-circuit the grid bias resistor. If the tube is good the voltage at the plate will drop.

Shorts and Opens

Of course in the foregoing case all the likely sources of trouble have been considered on the assumption that wiring is correct.

But there is no reason why a continuity test should not be made on all chokes, especially the RF ones, and on the BF coils when these are plugged into their respective receptacles. Test for continuity with a dry cell and a flashlight lamp. There should be no appreciable diminution in the brilliance of the lamp, due to the few turns on short-wave coils.

If the short-wave circuit should be one that contains as an integral part of its assembly a "B" voltage supply circuit, consisting of either a full-wave or half-wave rectifier, you naturally look here first, if the circuit is inoperative, either when you set it up, or when you have completed assembly.

A requirement of all short-wave converters is that the circuit must oscillate, which is the first thing to look for when there's trouble. The oscillator circuit must oscillate because the functioning of the converter is based on frequency changing, and without local oscillations there can be no frequency changing.

With the circuit connections correct, give the oscillator tube sufficient plate voltage, from 50 to 100 volts. If the tube is weak a higher voltage is necessary to provide oscillation.

Many listeners persistently refuse to allow for the time difference between the different hemispheres, and also do not care to learn enough about the idiosyncrasies of short-wave reception, hence their efforts to "get Europe" come to naught.

But this experience is not likely to be a serious deterrent to the radio enthusiast whose very enthusiasm naturally tends to make him "undefeatable."

Difference in Diagrams

Fig. 1 is the schematic diagram of one of the first universally successful short-wave converter circuits, for which small-sized (tube base) coils were originally designed. The input circuit is untuned and the modulator tube is coupled to the broadcast receiver through the .0005 mfd. fixed condenser located in series in the upper right-hand circuit.

The next step was a modification of this circuit where the principal change was one of constants, and the substitution of a wholly tuned-grid oscillator tube, instead of what's shown in Fig. 1. Body capacity was reduced to the vanishing point.

The type of coil that is most efficient is the solenoid, and better results are obtainable from coils of larger diameter than tube-base size. About 3-inch diameter is a good working rule for short waves.

The converter circuit is "universal" because it's operated on AC for the heaters, and deriving plate voltage from the receiver, it will operate with any broadcast receiver, AC, battery, DC or composite.

Fig. 2, the later form of Fig. 1, includes all the changes previously recorded and uses plug-in coils, but with the addition of a tunable intermediate stage whose purpose is to supply a tuned output, at higher output voltage than the other circuit could. Also, there is a separate heater supply source to avoid the excessive voltage drop that in some cases was prohibitive when a battery-cable was used with Fig. 1 circuit, and finally, Fig. 2 circuit employed a somewhat expanded parts layout plan to achieve better stability.

Affected by Frequency

Regarding comparative coil sizes, a factor that many overlook is the rapid increase of surface resistance of electrical conductors both with decrease of radius and increase of frequency.

Excessive dieletric in the form is to be avoided, without weakening the coil supporting structure unduly. This retention of mechanical strength is usually a manufacturing accomplishment.

The minimum capacities of most present-day variable condensers, other than the straight frequency line type, is higher than 50 mmfd., and therefore if you use the high minimum type it may be necessary to remove secondary turns to cover a predetermined frequency band.

(*Continued from page* 11)

The curves plotted on Fig. 10 are from the same data as those on Fig. 9.

These forms have been prepared in accordance with the revision of the Standard Tests of Broadcast Radio Receivers, as found on the preceding pages.

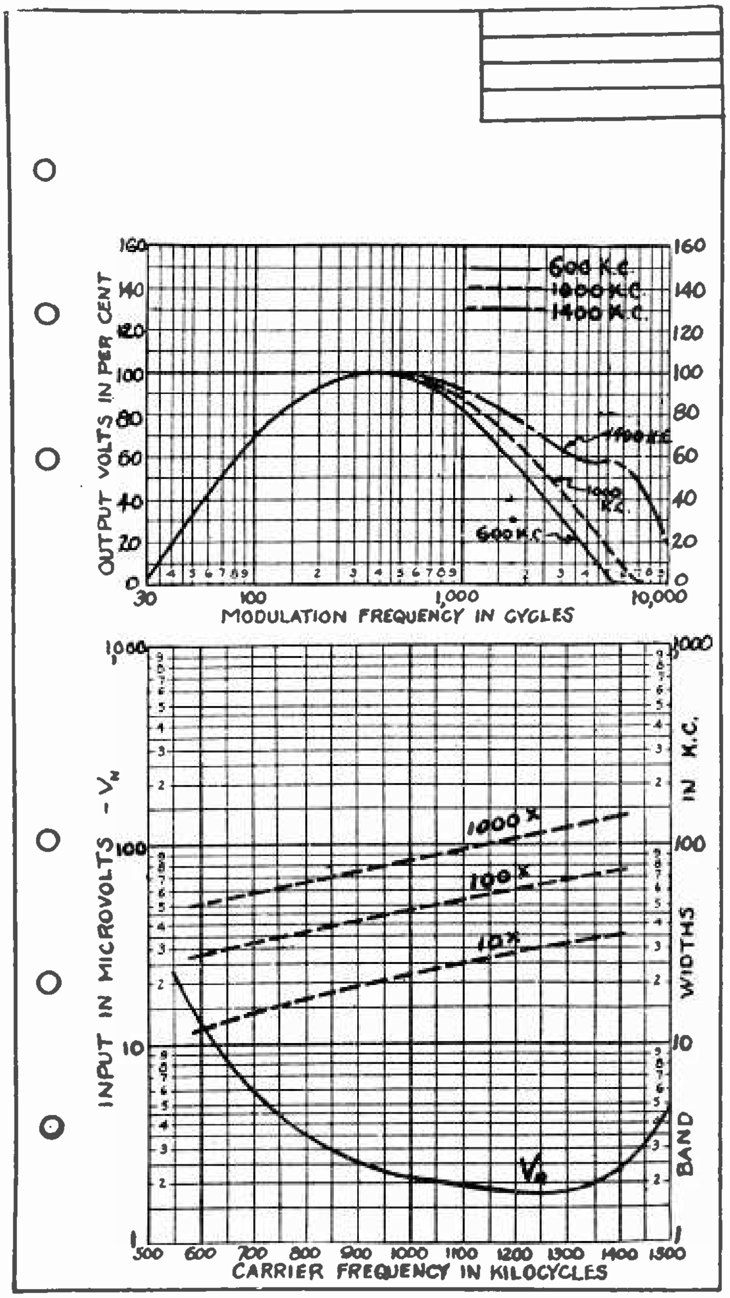

FIG. 10—RECEIVER PERFORMANCE GRAPH SHEET. (HALF SIZE)

Right or Wrong?

QUESTIONS

(1)—The mutual conductance of a tube can be measured by measuring the plate current for two grid bias voltages one volt apart. The difference between the two currents is numerically equal to the mutual conductance.

(2)—The mutual conductance obtained by the method in (1) is the same regardless of the load in the plate circuit.

ANSWERS

(1)—Right. The mutual conductance is the change in the plate current for a change of one volt on the grid. Hence, if the grid voltage is changed one volt and the difference in the two currents is taken that difference is numerically equal to the mutual conductance. If the current change is measured in milliamperes it has to be multiplied by 1,000 to get the mutual conductance in micromhos.

(2)—Wrong. If the method in (1) is to give the mutual conductance of the tube there should be no load on the tube, except the negligible load introduced by the meter. If the tube has a load the result obtained by the method in (1) is the mutual conductance of the tube and the load, which is always less than that of the tube alone.

$15 Amplifier

The same voltage is applied to the plate loads of all three tubes in the audio amplifier. Normally this will be around 300 volts, a little more if only the power amplifier is worked, and perhaps a little less if a large-capacity tuner is fed with B supply from the amplifier.

The Plate Voltages

Thus around 300 volts will afford an effective plate voltage on the first and second audio tubes of about 30 volts, due to the drop in the 0.1 meg. plate resistors, while the drop in the plate load on the last audio tube, the 245, will be inconsiderate.

Of course, the bias voltage is subtracted from the plate voltage in any case, so if the total voltage is 30 from plate to ground on the first and second audio tubes, 24 volts constitute the effective plate voltage and 6 the bias voltage.

Hence it is conceivable that some will use less than 6 volts for biasing these tubes, whereby 100 ohms or even less would be sufficient for this purpose in the voltage divider.

However, the usual recommendations are that the bias be governed by the applied plate voltage, not the effective plate voltage (which is the applied minus the drop in the plate load). Curves for tubes are worked out on the basis of no load, or a transformer load, so that when it comes to resistance coupling one has to solve the problem for himself. Six volts constitute a compromise, for 2 or 3 volts would be sufficient, on the theory that the effective plate voltage is to be considered, which is the viewpoint to which the writer leans.

Plate Resistors 1 Watt

The plate current will be of the order of 3 milliamperes in the resistance plate loads, which is permissible, since the resistors are of 1-watt rating, as generally available commercially, and a little less than 1 watt is dissipated (0.003 x 270, or 0.81 watt).

There is no objection whatever to using a high applied rating plate voltage on these resistors, provided the wattage rating is not exceeded, unless it be that the signal's effect on the bias is to decrease the current, so that the voltage drop is less, and the effective plate voltage is higher.

If this effect were enough to stop the plate current even for an instant, the applied and the effective voltage would be the same. But the effect is to reduce the plate current no more than an average of 10 per cent., so that the drop would diminish, then, to 243 volts, leaving 57 volts effective, for which purpose 2 volts of negative bias permanently steady negative negative bias still would be adequate.

The 245 has an applied plate voltage of actually 250 volts, due to the other 50 volts being used for negative bias.

Unshielded Coils for Short Waves

IS IT PRACTICAL to build short-wave receiver with everything shielded except the coils, that is, so that the coils are outside the shields? I ask this because I have tried shielding the coils without much luck, which I assume to be due to eddy current losses in the shielding.—M. T. S.

Short-wave converters have been constructed this way and they proved to be quite satisfactory. However, the coils had to be mounted so they were at some distance away from the shielding. If the coils are put near the shielding only part of the advantage is gained for there will be eddy currents just the same.

Amplitudes of Sound on Wax Records

IF TWO SOUNDS, one of low frequency and the other of high frequency, are recorded on a wax record and intended for reproduction by means of an electromagnetic pick-up unit, are the amplitudes of the groove the same for the two sounds when the intensities are the same? If not, in what manner does the amplitude vary?—J. C. C. C.

The amplitudes are not the same. The variation of the amplitude is inversely as the frequency. For example, the amplitude of a sound of 5,000 cycles per second is only one per cent. as great as that of a sound of 50 cycles per second. The voltage generated in the pick-up unit is directly proportional to the transverse velocity of the needle.

Since the amplitude varies inversely as the frequency the amplitudes of the very low notes are very great and there is danger of the needle cutting through from one groove to the next.

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* *Channel shared by United States and Canada. The Canadian stations will be found following the United States stations of the same frequency. Expression "Kw" not used for Canada.*

** *Channel exclusively assigned to Canada.*

*** *Frequency change under consideration. See "List of Impending Changes," on page 22.*

CP—Construction permit authorized.

T—Transmitter location, specially given where it differs from main studio location.

Where two powers are given, larger is for daytime use.

Time-sharers are shown in parentheses for U. S. stations.

THE list of stations by frequency published herewith was corrected up to the moment of going to press. The list includes all broadcasting stations in the United States and Canada. The reason for consolidating them is that so many Canadian stations are tuned in that a United States list would require resort to a Canadian list to make the service complete, and that Canadian list might not be at hand.

550 KILOCYCLES, 555.6 METERS

WGR—Buffalo, N. Y. ....1 Kw.
T—Amherst, N. Y.
WKRC—Cincinnati, Ohio........1 Kw.
KFUO—St. Louis, Mo. (KSD)........500, 1 Kw.
KFUO—Clayton, Mo. ....500, 1 Kw.
KSD—St. Louis. Mo. (KFUO)........ 500
KFDY—Brookings, S. D. (KFYR)....500, 1 Kw.
KFYR—Bismarck N. D. (KFDY) 500
KOAC—Corvallis, Ore. ....1 Kw.

560 KILOCYCLES, 535.4 METERS

WLIT—Philadelphia, Pa. (WFI)........500
WFI—Philadelphia ....500-1 Kw.
WQAM—Miami, Fla .... 1 Kw.
KFDM—Beaumont, Texas ....500, 1 Kw.
WNOX—Knoxville, Tenn. ....1 Kw., 2 Kw.
WIBO—Chicago, Ill. (WPCC, WEBW) .. 1 Kw.
T—Desplaines, Ill. ....1½ Kw.
WPCC—Chicago, Ill. (WIBO, WEBW) 500
WEBW—Beloit, Wis. (WIBO, WPCC) 500
KLZ—Denver, Colo. .... 1 Kw.
KTAB—Oakland, Calif. .... 1 Kw.

570 KILOCYCLES, 526.0 METERS

WNYC—New York, N. Y. (WMCA) 500
WMCA—New York City (WNYC)........500
T—Hoboken, N. J.
WSYR—Syracuse, N. Y. (WMAC) 250
WMAC—Cazenovia, N. Y. (WSYR)........250
WKBN—Youngstown, O. (WEAO)........500
WEAO—Columbus, O. (WKBN)........750
WWNC—Asheville, N. C. .... 1 Kw.
WISJ—Beloit, Wis........500
(C. P. for 1 Kw.)
KGKO—Wichita Falls, Tex. 250, 500
WNAX—Yankton, S. D. .... 1 Kw.
KXA—Seattle, Wash. 500
KMTR—Hollywood, Calif. 500

*580 KILOCYCLES, 516.9 METERS

WTAG—Worcester, Mass. 250
WOBU—Charleston, W. Va. (WSAZ) 250
WSAZ—Huntington, W. Va. (WOBU)......250
KGFX—Pierre, S. D. 200
WIBW—Topeka, Kans. (KSAC) ....500, 1 Kw.
KSAC—Manhattan, Kans. (WIBW)..500. 1 Kw.
CHMA—Edmonton, Alberta 250
CJCA—Edmonton, Alberta 500
CKUA—Edmonton, Alberta 500
CNRE—Edmonton, Alberta 500
CJBC—Toronto, Ontario 500
CJSC—Toronto, Ontario 500
CKCL—Toronto. Ontario 500
CKNC—Toronto. Ontario 500

590 KILOCYCLES, 508.2 METERS

WEEI—Boston. Mass. .... 1 Kw.
T—Weymouth, Mass.
WEMC—Berrien Springs, Mich........1 Kw.
WCAJ—Lincoln, Nebr. (WOW) 500
WOW—Omaha. Nebr. (WCAJ) ....1 Kw.
KHQ—Sponkane, Wash........1 Kw., 2 Kw.

*600 KILOCYCLES, 499.7 METERS

WCAC—Storrs. Conn. (WGBS) 250
WCAO—Baltimore, Md. 250
WGBS—New York City (WCAC)........250
T—Astoria, L. I., N. Y......500, LS (Exp.)
WREC—Memphis. Tenn. (WOAN)........500
T—Whitehaven, Tenn. ....1 Kw.
WOAN—Lawrenceburg, Tenn. (WREC)......500
WMT—Waterloo, Iowa 500
KFSD—San Diego, Cal........1 Kw.. 500
CFCH—Iroquois Falls, Ontario 250
CJRW—Fleming, Saskatchewan 500
CJRM—Moose Jaw. Saskatchewan 500

610 KILOCYCLES, 491.7 METERS

WJAY—Cleveland Ohio 500
WFAN—Philadelphia, Pa. (WIP) 500
WIP—Philadelphia, Pa. WFAN) 500
WDAF—Kansas City, Mo. ....1 Kw.
KFRC—San Francisco. Calif. ....1 Kw.

620 KILOCYCLES, 483.6 METERS

WLBZ—Bangor, Maine 500
WFLA—WSUN—Clearwater, Fla..2½ Kw.,1 Kw.
WTMJ—Milwaukee, Wis. ....1 Kw., 2½ Kw.
T—Brookfield, Wis. ....2½ Kw.
KGW—Portland, Ore. ....1 Kw.
KTAR—Phoenix. Ariz. ....1 Kw., 500

*630 KILOCYCLES, 475.9 METERS

WMAL—Washington, D. C........500. 250
WOS—Jefferson City. Mo. (WGBF, KFRU)
1 Kw., 500
KFRU—Columbia, Mo. (WOS, WGBS).....500
WGBF—Evansville. Ind. (WOS, KFRU)......500
CFCT—Victoria, British Columbia........500
CNRA—Moncton. New Brunswick 500
CJGX—Yorkton. Saskatchewan 500

640 KILOCYCLES, 468.5 METERS

WAIU—Columbus. Ohio 500
WOI—Ames. Iowa ....5 K
KFI—Los Angeles, Calif. ....5 Kw.

650 KILOCYCLES, 461.3 METERS

WSM—Nashville, Tenn. ....5 Kw.
KPCB—Seattle. Wash. 100

660 KILOCYCLES, 454.3 METERS

WEAF—New York City ....50 Kw.
T—Bellmore, N. Y.
WAAW—Omaha. Neb. ....500—W

670 KILOCYCLES, 447.5 METERS

WMAQ—Chicago, Ill. ....5 Kw.
T—Addison. Ill.

680 KILOCYCLES, 440.9 METERS

WPTF—Raleigh, N. C. ....1 Kw.
KFEQ—St. Joseph, Mo. ....2½ Kw.
KPO—San Francisco. Cal. ....5 Kw.

690 KILOCYCLES, 434.5 METERS

CFAC, CFCN—Calgary. Alberta 500
CHCA, CJCJ. CNRC—Calgary, Alberta........500

700 KILOCYCLES, 428.3 METERS

WLW—Cincinnati, Ohio ....50 Kw.
T—Mason. Ohio

710 KILOCYCLES, 422.3 METERS

KMPC—Beverly Hills, Cal. 500
WOR—Newark, N. J. ....5 Kw.
T—Kearny. N. J.
KEJK—Beverly Hills. Calif. 500

720 KILOCYCLES. 416.4 METERS

WGN, WLIB—Chicago, Ill. ....25 Kw.
T—Elgin. Ill.

**730 KILOCYCLES, 410.7 METERS

CHLS, CKCD—Vancouver, British Columbia.....50
CKFC. CKMO—Vancouver, British Columbia..50
CKWX—Vancouver, British Columbia.......1000
CHYC—Montreal, Quebec 500
CKAC—Montreal. Quebec 1000
CNRM—Montreal. Quebec 1650

740 KILOCYCLES, 405.2 METERS

WSB—Atlanta. Ga. ....5 Kw.
KMMJ—Clay Center. Neb. ....1 Kw.

750 KILOCYCLES, 399.8 METERS

WJR—Detroit, Mich. ....5 Kw.
T—Sylvan Lake Village. Mich.

760 KILOCYCLES, 394.5 METERS

WJZ—New York. N. Y........30 Kw.
T—Boundbrook. N. J.
WEW—St. Louis, Mo. ....1 Kw.
KVI—Tacoma, Wash. ....1 Kw.
T—Des Moines. Wash.

770 KILOCYCLES. 389.4 METERS

KFAB—Lincoln, Nebr. (WBBM. WJBT)..5 Kw.
WBBM. WJBT—Chicago, Ill. (KFAB)...25 Kw.
T—Glenview. Ill.

*780 KILOCYCLES, 384.4 METERS

WEAN—Providence. R. I. 500, 250
WTAR. WPOR—Norfolk, Va........500
WMC—Memphis. Tenn. ....1 Kw., 500
(C. P. issued to move to Bartlett, Tenn.)
KELW—Burbank. Calif. (KTM)........500
KTM—Los Angeles. Calif. (KELW)........500
T—Santa Monica. Calif........1 Kw.
CKX—Brandon, Manitoba 500
CKY, CNRW—Winnipeg. Manitoba 5000

790 KILOCYCLES, 379.5 METERS

WGY—Schenectady, N. Y........50 Kw.
T—So. Schenectady, N. Y.
KGO—Oakland. Calif. ....7½ Kw.

800 KILOCYCLES, 374.8 METERS

WBAP—Fort Worth, Texas. ....50 Kw.
T—Grapevine. Texas (Licensed for 10 Kw. only at present)
WFAA—Dallas, Tex. (WBAP)........50 Kw.
T—Grapevine, Texas
C. P. to increase pwr. to 50 Kw.

810 KILOCYCLES. 370.2 METERS

WPCH—New York. N. Y........500
T—Hoboken. N. J.
WCCO—Minneapolis. Minn. ....7½ Kw.
T—Anoka. Minn.

***820 KILOCYCLES, 365.6 METERS

WHAS—Louisville. Kentucky........10 Kw.
T—Jeffersontown. Kentucky

830 KILOCYCLES, 361.2 METERS

WHDH—So. Boston, Mass. ....1 Kw.
T—Gloucester. Mass.
WRUF—Gainesville, Fla. ....5 Kw.
KOA—Denver. Colo. ....12½ Kw.

**840 KILOCYCLES, 356.9 METERS

CHCT—Red Deer, Alberta 1000
CKLC—Red Deer. Alberta 1000
CFCA—Toronto, Ontario 500
CJB—Toronto. Ontario 1000
CKOW—Toronto, Ontario 500
CNRT—Toronto. Ontario 500

850 KILOCYCLES, 352.7 METERS

KWKH—Kennonwood. La. (WWL)........10 Kw.
WWL—New Orleans La. (KWKH) ....5 Kw.

860 KILOCYCLES, 348.5 METERS

WABC, WBOQ—New York City........5 Kw.
T—West of Cross Bay Blvd., Queens Co.
C. P. issued to move & incr. pr. to 50 Kw.—LP
WHB—Kansas City, Mo. 500
KFQZ—Los Angeles, Calif. 250
T—Hollywood, Calif.
KMO—Tacoma, Wash. ....1 Kw., 500

870 KILOCYCLES, 344.6 METERS

WLS—Chicago, Ill. (WENR, WBCN) 5Kw., 50 Kw.
T—Crete, Ill.
WENR, WBCN—Chicago, Ill. (WLS).......50 Kw.
T—Downers Grove, Ill.

*880 KILOCYCLES, 340.7 METERS

WGBI—Scranton, Pa. (WQAN)........250
WCOC—Meriden, Miss........500
WQAN—Scranton, Pa. (WGBI) 250
WSUI—Iowa City, Iowa 500
KLX—Oakland, Calif 500
KPOF—Denver, Colo. (KFKA) 500
KFKA—Greeley, Colo. (KPOF) ....1 Kw., 500
CJCB—Sydney, N. S. 50
CHCS—Hamilton, Ontario 10
CHML—Hamilton, Ontario 50
CKOC—Hamilton, Ontario 50
CHRC—Quebec, Quebec 25
CKCI—Quebec, Quebec 22
CKCV, CNRQ—Quebec, Quebec 50

*890 KILOCYCLES, 336.9 METERS

WJAR—Providence, R. I. 400, 250
WKAQ—San Juan, P. R. 500
WMMN—Fairmont, W. Va. 500, 250
WMAZ—Macon, Ga. (WGST) 500, 250
WGST—Atlanta, Ga. (WMAZ) 500, 250
KGJF—Little Rock, Ark. 250
WILL—Urbana, Ill. (KUSD, KFNF) 500, 250
KUSD—Vermillion, S. D. (WILL, KFNF) 750, 500
KFNF—Shenandoah, Iowa (WILL, KUSD)
1 Kw., 500
CFBO—St. John. New Brunswick 50

900 KILOCYCLES, 333.2 METERS

WMAK—Buffalo, N. Y. (WFBL) 750
T—Martinsville, N. Y.
WRDA—Buffalo, N. Y. ....1 Kw.
T—Orchard Park, N. Y. (C. P. only)
WKY—Oklahoma City, Okla. ....1 Kw.
WJAX—Jacksonville, Fla. ....1 Kw.
WLBL—Stevens Point, Wis. ....2 Kw.
KHJ—Los Angeles, Calif. ....1 Kw.
KSEI—Pocatello, Idaho 250
KGBU—Ketchikan, Alaska 500

**910 KILOCYCLES, 329.5 METERS

CJGC—London, Ontario 500
CNRL—London, Ontario 500
CFQC—Saskatoon, Saskatchewan 500
CJHS—Saskatoon, Saskatchewan 250
CNRS—Saskatoon, Saskatchewan 500

920 KILOCYCLES, 325.9 METERS

WAAF—Chicago, Ill........500
WBSO—Wellesley Hills, Mass........500, 250
WWJ—Detroit, Mich. ....1 Kw.
KPRC—Houston, Texas ....2½ Kw., 1 Kw.
T—Sugarland, Texas
WAAF—Chicago, Ill. 500
KOMO—Seattle, Wash. ....1 Kw.
KFEL—Denver, Colo. (KFXF)........500
KFXF—Denver, Colo. (KFEL) 500

*930 KILOYCLES, 322.4 METERS

WJBG—Elkins Park, Pa. 50
WDBJ—Roanoke, Va. 500, 250
WBRC—Birmingham, Ala. ....1 Kw., 500
KGBZ—York, Nebr. (KMA)........1 Kw., 500
KMA—Shenandoah, Ia. (KGBZ) ....1 Kw., 500
KFWI—San Francisco, Cal. (KFWM)........500
KROW—Oakland, Cal. ....500, 1 Kw.
T—Richmond, Cal.
CHNS—Halifax, Nova Scotia 500
CKIC—Wolfville, Nova Scotia 50
CFRC—Kingston, Ont. 500
CKPC—Preston, Ont. 50

940 KILOCYCLES, 319.0 METERS

WAAT—Jersey City, N. J. 300
WCSH—Portland, Maine........1 Kw.
WFIW—Hopkinsville, Ky. ....1 Kw.
WHA—Madison, Wis. 750
WDAY—W. Fargo, N. D. ....1 Kw.
KOIN—Portland, Ore. ....1 Kw.
T—Sylvan, Ore.
KGU—Honolulu, T. H.;........1 Kw.

950 KILOCYCLES, 315.6 METERS

WRC—Washington, D. C. 500
KMBC—Kansas City, Mo. ....1 Kw.
T. Independence, Mo.
KFWB—Hollywood, Calif. ....1 Kw.
KGHL—Billings, Mont 500

**960 KILOCYCLES, 312.3 METERS

CJBC—Toronto, Ontario.
CFRB—Toronto, Ontario 4000

CFCY—Charlottetown, Prince Edward Island...250
CHCK—Charlottetown, Prince Edward Island ...30
CHWC—Pilot Butte, Saskatchewan 500
CJBR—Regina, Saskatchewan 500
CHCK—Regina, Saskatchewan 500
CNRR—Regina, Saskatchewan 500

970 KILOCYCLES, 309.1 METERS

WCFL—Chicago, Ill. ....1½ Kw.
KJR—Seattle, Wash. ....5 Kw.

980 KILOCYCLES, 303.9 METERS

KDKA—Pittsburgh, Pa. ....50 Kw.
T—Wilkins Twp., Pa.
C. P. issued to move near Saxonburg, Pa.

990 KILOCYCLES, 302.8 METERS

WBZ—Springfield, Mass (WBZA) ....15 Kw.
T—E. Springfield, Mass.
WBEN—Buffalo, N. Y. (Formerly WMAK).1 Kw.
WBZA—Boston, Mass. (WBZ) 500

1000 KILOCYCLES, 299.8 METERS

WHO—Des Moines, Ia. (WOC)...............5 Kw.
WOC—Davenport, Ia. (WHO) ....5 Kw.
KFVD—Culver City, Calif. 250

*1010 KILOCYCLES, 296.9 METERS

WQAO, WPAP—New York, N. Y. (WHN, WRNY) 250
T—Cliffside, N. J.
WHN—New York, N. Y. (WQAO, WPAP, WRNY) 250
WIS—Columbia, S. C...............................500
WRNY—New York, N. Y. (WQAO, WPAP, WHN) 250
T—Coytesville, N. J.
KGGF—Picher, Okla. (WNAD) 500
WNAD—Norman, Okla. (KGGF) 500
WIS—Columbia, S. C. ....1 Kw., 500
(C. P. only)
CKCR—Waterloo, Ont. 50
CFLC—Prescott, Ont. 50
CKSH—St. Hyacinthe, Que. 50
KQW—San Jose, Calif. 500

***1020 KILOCYCLES, 293.9 METERS

WRAX—Philadelphia, Pa. 250
KYW, KFKX—Chicago, Ill. ....10 Kw.
T—Bloomingdale, Ill.

**1030 KILOCYCLES, 291.1 METERS

CJOR—Sea Island, B. C. 50
CNRV—Vancouver, B. C. 500
CFCF—Montreal, Que 1650

***1040 KILOCYCLES, 288.3 METERS

WMAK—Buffalo, N. Y.........................1 Kw.
T—Grand Island, N. Y.
WKAR—East Lansing, Mich. ....1 Kw.
KTHS—Hot Springs National Park, Ark. (KRLD) ....10 Kw.
KRLD—Dallas, Tex. (KTHS) ....10 Kw.

1050 KILOCYCLES, 285.5 METERS

KFKB—Milford, Kansas ....5 Kw.
KNX—Hollywood, Calif. ....50 Kw., 5 Kw.
T—Los Angeles, Calif.

1060 KILOCYCLES, 282.8 METERS

WBAL—Baltimore, Md. (WTIC) ....10 Kw.
T—Glen Morris, Md.
WTIC—Hartford, Conn. (WBAL) ....50 Kw.
T—Avon, Conn.
WJAG—Norfolk, Neb. ....1 Kw.
KWJJ—Portland, Ore. 500

***1070 KILOCYCLES, 280.2 METERS

WAAT—Jersey City, N. J. 300
(Day until 6 PM. but not after sunset at Cleveland, O.)
WTAM—Cleveland, Ohio ....50 Kw.
T—Brocksville Village, O.
WCAZ—Carthage, Ill. 50
WDZ—Tuscola, Ill. 100
KJBS—San Francisco, Calif 100

***1080 KILOCYCLES, 277.6 METERS

WBT—Charlotte, N. C. ....5 Kw.
WCBD—Zion, Ill. (WMBI) ....5 Kw.
WMBI—Chicago, Ill. (WCBD) ....5 Kw.
T—Addison, Ill.

***1090 KILOCYCLES, 275.1 METERS

KMOX, KFQA—St. Louis, Mo. .....50 Kw., 5 Kw.
T—Kirkwood, Mo.

1100 KILOCYCLES, 272.6 METERS

WPG—Atlantic City, N. J. (WLWL) ....5 Kw.
WLWL—New York City (WPG) ....5 Kw.
T—Kearny, N. J.
(6 P.M. to 8 P.M.)
KGDM—Stockton, Calif. 250, 50
(C. P. to incr. pwr. to 250 W—D)

***1110 KILOCYCLES, 270.1 METERS

WRVA—Richmond, Va. ....5 Kw.
T—Mechanicsville, Va.
KSOO—Sioux Falls, S. D. ....2 Kw.

*1120 KILOCYCLES, 267.7 METERS

WDEL—Wilmington, Del.........................350, 250
(C. P. to increase pwr. to 500 w.
WDBO—Orlando, Fla. 500
WTAW—College Station, Tex. (KTRH) 500
KTRH (formerly KUT)—Austin, Texas.. (WTAW) (C. P. only)...................500
WISN—Milwaukee, Wis. (WHAD) 250
WHAD—Milwaukee, Wis. (WISN) 250
KFSG—Los Angeles, Calif. (KMIC).............500
KRSC—Seattle, Wash. 50
KFID—Spokane, Wash. 100
KMIC—Inglewood, Calif. (KFSG) 500
CHGS—Sunnyside, Prince Edward Island.......25
CJOC—Lethbridge, Alberta 50
CJRX—Middlechurch, Manitoba.................2000
CFJC—Kamloops, British Columbia..............15

***1130 KILOCYCLES, 265.3 MTEERS

WOV—New York City ....1 Kw.
T—Secaucus, N. J.
Daytime to 6 P.M.
WJJD—Mooseheart, Ill. ....20 Kw.
KSL—Salt Lake City, Utah ....5 Kw.

***1140 KILOCYCLES, 263.0 METERS

WAPI—Birmingham, Ala. (KVOO) ....5 Kw.
KVOO—Tulsa, Okla. (WAPI) ....5 Kw.

***1150 KILOCYCLES, 260.7 METERS

WHAM—Rochester, N. Y. ....5 Kw.
T—Victor Township

***1160 KILOCYCLES, 258.5 METERS

WWVA—Wheeling, W. Va. (WOWO)........5Kw.
WOWO—Ft. Wayne, Ind. (WWVA)........10 Kw.

***1170 KILOCYCLES, 256.3 METERS

WCAU—Philadelphia, Pa. ....10 Kw.
T—Byberry, Pa.

KTNT—Muscatine, Iowa ....5 Kw.

***1180 KILOCYCLES, 254.1 METERS

WDGY—Minneapolis, Minn. (WHDI).........1 Kw.
WHDI—Minneapolis, Minn. (WDGY)..........500
KEX—Portland, Ore. (KOB) ....5 Kw.
KOB—State College, N. M. (KEX) ....20 Kw.

1190 KILOCYCLES, 252.0 METERS

WICC—Bridgeport, Conn. 500
T—Easton, Conn.
WOAI—San Antonio, Tex. ....5 Kw.
C. P. issued to increase power to 50 Kw.

*1200 KILOCYCLES, 249.9 METERS

WABI—Bangor, Maine 100
WNBX—Springfield, Vt. (WCAX) 10
WCAX—Burlington, Vt. (WNBX) 100
WORC—Worcester, Mass. 100
T—Auburn, Mass.
WIBX—Utica, N. Y. 300, 100
WFBE—Cincinnati, Ohio 100
WFBE—Cancinnati, Ohio..................250, 100
WHBC—Canton, Ohio (WNBO) 10
(Sundays)
WLAP—Louisville, Ky. 30
WLBG—Petersburg, Va. 250, 100
T—Ettrick, Va.
WNBO—Silver Haven, Pa. 100
Sundays only.
WEHC—Emory, Va. 100
WEHC—Emory, Va.............................250,100
WCOD—Harrisburg, Pa. (WKJC) 100
WKJC—Lancaster, Pa. (WCOD) 100
WNBW—Carbondale, Pa. 10
KMLB—Monroe, La. Cp. only...................50
WABZ—New Orleans, La. (WJBW)...........100
WJBW—New Orleans, La. (WABZ) 30
WBBZ—Ponca City, Okla. 100
WFBC—Knoxville, Tenn. 50
WRBL—Columbus, Ga. 50
(C. P. only)
KBTM—Paragould, Ark. 100
KGHI—Little Rock, Ark..........................100
WJBC—LaSalle, Ill. (WJBL) 100
WJBL—Decatur, Ill. (WJBC) 100
WWAE—Hammond, Ind. (WRAF) 100
WRAF—Laporte, Ind. (WWAE) 100
KFJB—Marshalltown, Ia. 250, 100
KGCU—Mandan, N. D. 100
WCAT—Rapid City, S. D. 100
KGDY—Oldham, S. D. 15
KFWF—St. Louis, Mo. (WMAY, WIL)........100
KGDE—Fergus Falls, Minn.......................100
KCDE—Fergus Falls, Minn................250, 100
KGFK—Hallock, Minn. 50
WCLO—Kenosha, Wis. 100
WHBY—Green Bay, Wis. 100
T—West De Pere, Wis.
WIL—St. Louis, Mo. (KFWF, WMAY)....250, 100
WMAY—St. Louis, Mo. (KFWF, WIL)...250, 100
KGFJ—Los Angeles, Calif. 100
KXO—El Centro, Calif. 100
KSMR—Santa Maria, Calif. 100
KWG—Stockton, Calif. 100
KGEK—Yuma, Colo. (KGEW) 50
KGEW—Ft. Morgan, Colo. (KGEK) 100
KFHA—Gunnison, Colo. 50
KVOS—Bellingham, Wash. 100
KGHI—Little Rock, Ark. 100
KGY—Lacey, Wash. 50, 10

*1210 KILOCYCLES, 247.8 METERS

WJBI—Redbank, N. J. (WCOH, WGBB)....100
WGBB—Freeport, N. Y. (WCOH, WJBI)......100
WCOH—Yonkers, N. Y. (WJBI, WGBB)......100
T—Greenville, N. Y.
WOCL—Jamestown, N. Y. 25
WLCI—Ithaca, N. Y. 50
WPAW—Pawtucket, R. I. (WDWF, WLSI)....100
WDWF, WLSI—Providence, R. I. (WPAW).100
T—Cranston, R. I.
WMRJ—Jamaica, N. Y...............................10
WMAN—Columbus, Ohio 50
WJW—Mansfield, Ohio 100
WALR—Cambridge, Ohio 100
WALR—Zanesville, Ohio..........................100
WBAX—Wilkes-Barre, Pa. (WJBU)...........100
T—Plains Twp., Pa.
WJBU—Lewisburg, Pa. (WBAX) 100
WMBG—Richmond, Va. 100
WRBL—Richmond, Va. (WMBG) 100
WSIX—Springfield, Tenn. 100
WRBU—Gastonia, N. C. 100
WJBY—Gadsden, Ala. 50
(C. P. only)
KGMP—Elk City, Okla. 100
WRBQ—Greenville, Miss. 250, 100
WQDX—Thomasville, Ga............................50
WGCM—Gulfport, Miss. 100
T—Mississippi City, Miss.
Now Licensed.
KWEA—Shreveport, La. 100
KDLR—Devils Lake, N. D. 100
KGCR—Watertown, S. D. 100
KFOR—Lincoln, Nebr. 250, 100
WHBU—Anderson, Ind. 100
KFVS—Cape Girardeau, Mo. (WEBQ) 100
WEBQ—Harrisburg, Ill. (KFVS)................100
WSBC—Chicago, Ill. (WEDC, WCRW).........100
WCRW—Chicago, Ill. (WEDC, WSBC).........100
KGNO—Dodge City, Kansas 100
WEDC—Chicago, Ill. (WSBC, WCRW).........100
WCBS—Springfield, Ill. (WTAX) 100
WTAX—Streator, Ill. (WCBS) 50
WHBF—Rock Island, Ill. 100
WIBA—Madison, Wis. 100
WOMT—Manitowoc, Wis. 100
KMJ—Fresno, Calif. 100
KFXM—San Bernardino, Calif. (KPPC)........100
KDFN—Casper, Wyo. 100
KPPC—Pasadena, Calif. (KFXM) 50
CHWK—Challiwick, British Columbia 5
CFNB—Frederickton, New Brunswick 50
CFCO—Chatham, Ontario 50
CKMC—Cobalt, Ontario 15
CKPC—Preston, Ontario 50

1220 KILOCYCLES, 245.8 METERS

WCAD—Canton, N. Y. 500
WDAE—Tampa, Fla. ....1 Kw.
WCAE—Pittsburgh, Pa. ....1 Kw.
WREN—Lawrence, Kans. (KFKU) ....1 Kw.
KFKU—Lawrence, Kans. (WREN)..........1 Kw.
KWSC—Pullman, Wash. ....2 Kw., 500

1230 KILOCYCLES, 243.8 METERS

WNAC, WBIS—Boston, Mass. (T. Quincy, Mass.) ....1 Kw.
WPSC—State College, Pa. 500
WSBT—South Bend, Ind. (WFBM) 500
WFBM—Indianapolis, Ind. (WSBT) ....1 Kw.
KGGM—Albuquerque, N. M. 500, 250
KYA—San Francisco, Calif. ....1 Kw.
KFQD—Anchorage, Alaska 100

1240 KILOCYCLES, 241.8 METERS

KTAT—Fort Worth, Texas (WACO)........1 Kw.
T—Birdsville, Texas
WXYZ—Detroit, Mich..........................1 Kw.
WACO—Waco, Texas (KSAT) ....1 Kw.

1250 KILOCYCLES, 239.9 METERS

WGCP—Newark, N. J. (WODA, WAAM) 250
KFMX—Northfield, Minn. ....1 Kw.
WODA—Paterson, N. J. (WGCP, WAAM) 1 Kw.
WAAM—Newark, N. J. (WODA, WGCP) 1 Kw., 2 Kw.
WDSU—New Orleans, La. ....1Kw.
WLB, WGMS—Minneapolis, Minn. (WRHM, KFMX, WCAL).........................1 Kw.
(C. P. to move locally and increase power to 1 Kw.
WRHM—Minneapolis, Minn. (WLB, KFMX, WCAL) ....1 Kw.
T—Fridly, Minn.
KFMX—Northfield, Minn. (WLB, WRHM, WCAL) ....1 Kw.
WCAL—Northfield, Minn. (WLB, WRHM, KFMX) ....1 Kw.
KFOX—Long Beach, Calif. ....1 Kw.
KIDO—Boise, Idaho ....1 Kw.

1260 KILOCYCLES, 238.0 METERS

WLBW—Oil City, Pa. ....1 Kw., 500
KWWG—Brownsville, Texas (KRGV).......500
WTOC—Savannah, Ga. 500
KRGV—Harlingen, Texas (KWWG)............500
KOIL—Council Bluffs, Ia. ....1 Kw.
KVOA—Tucson, Arizona 500

1270 KILOCYCLES, 236.1 METERS

WEAI—Ithaca, N. Y. 500
WFBR—Baltimore, Md. 250
WASH—Grand Rapids, Mich. (WOOD)........500
WOOD—Grand Rapids, Mich. (WASH) 500
T—Furnwood.
WJDX—Jackson, Miss. ....1 Kw., 500
KWLC—Decorah, Iowa (KGCA)...............100
KGCA—Decorah, Iowa (KWLC)..................50
KTW—Seattle, Wash. (KOL) ....1 Kw.
KOL—Seattle, Wash. (KTW) ....1 Kw.
KFUM—Colorado Springs, Colo.. ....1 Kw.

1280 KILOCYCLES, 234.2 METERS

WCAM—Camden, N. J. (WOAX, WCAP).....500
WCAP—Asbury Park, N. J. (WCAM, WOAX) 500
WOAX—Trenton, N. J. (WCAM, WCAP)......500
WDOD—Chattanooga, Tenn. ....2½ Kw., 1 Kw.
WRR—Dallas, Tex. 500
KFBB—Great Falls, Montana (KGIR).......1 Kw.
WRR—Dallas, Tex. 500

1290 KILOCYCLES, 232.4 METERS

WNBZ—Saranac Lake, N. Y.......................50
WJAS—Pittsburgh, Pa. ....1 Kw.
T—North Fayette Twp., Pa.
KTSA—San Antonio, Texas (KFUL) 2 Kw., 1 Kw.
KFUL—Galveston, Texas (KTSA) 500
KLCN—Blytheville, Ark. 50
WEBC—Superior, Wis. ....2½ Kw., 1 Kw.
(C. P. to incr. pr. to 2½ Kw., L. S.)
KDYL—Salt Lake City, Utah ....1 Kw.

1300 KILOCYCLES, 230.6 METERS

WBBR—Rossville, N. Y. (WHAP, WEVD, WHAZ) ....1 Kw.
T—Staten Island.
WHAP—New York, N. Y. (WBBR, WEVD, WHAZ) ....1 Kw.
T—Carlstadt, N. J.
WEVD—New York, N. Y. (WBBR, WHAP, WHAZ) 500
T—Forest Hills, N. Y.
WHAZ—Troy, N. Y. (WBBR, WHAP, WEVD) 500
WIOD, WMBF—Miami Beach, Fla.........1 Kw.
KFH—Wichita, Kansas (WOQ) ....1 Kw.
WOQ—Kansas City, Mo. (KFH) ....1 Kw.
KGEF—Los Angeles, Calif. (KTBI) ....1 Kw.
KTBI—Los Angeles, Calif. (KGEF)........... 750
KTBI—Los Angeles, Cal.........................1 Kw.
KFJR—Portland, Oregon (KTBR) 500
KTBR—Portland, Oregon (KFJR) 500

1310 KILOCYCLES, 288.9 METERS

WBOW—Terre Haute, Ind.........................100
WKAV—Laconia, N. H. 100
WEBR—Buffalo, N. Y. 200, 100
WMBO—Auburn, N. Y. 100
WNBH—New Bedford, Mass. 100
WOL—Washington, D. C. 100
WGH—Newport News, Va. 100
WRK—Hamilton, Ohio 100
WAGM—Royal Oak, Mich. 50
WFDF—Flint, Michigan 100
WHAT—Phiadelphia, Pa. (WFKD)...............100
WFKD—Philadelphia, Pa. (WHAT)...............50
WJAC—Johnstown, Pa. (WFBG) 100
WFBG—Altoona, Pa. (WJAC) 100
WRAW—Reading, Pa. (WCAL) 100
WGAL—Lancaster, Pa. (WRAW) 100, 15
WSAJ—Grove City, Pa. 100
WBRE—Wilkes-Barre, Pa. 100
WKBC—Birmingham, Ala. 100
WRBI—Tifton, Ga. 20
WOBT—Union City, Tenn. 250, 100
WNBJ—Knoxville, Tenn. 50
KRMD—Shreveport, La. (KTSL) 50
KTSL—Shreveport, La. (KRMD)...............100
T—Cedar Grove, La.
WSJS—Winston-Salem, N. C. 100
(C. P. only)
WCSC—Charleston, S. C. 250, 100
KFPM—Greenville, Texas 15
KTSM—El Paso, Texas (WDAH) 100
WDAH—El Paso, Texas (KTSM) 100
KFPL—Dublin, Texas 100
KFXR—Oklahoma City, Oklahoma 100
WKBS—Galesburg, Ill. 100
WCLS—Joliet, Ill. (WKBB).......................100
WKBB—Joliet, Ill. (WCLS) 100
KWCR—Cedar Rapids, Iowa (KFGQ, KFJY)..100
KFJY—Fort Dodge, Iowa (KFGQ, KWCR)..100
KFGQ—Boone, Iowa (KWCR, KFJY)...........100
KTLC—Houston, Texas............................100

KGFW—Ravenna, Nebr. 100
WBOW—Terre Haute, Ind. 100
WJAK—Marion, Ind. (WLBC) 50
WLBC—Muncie, Ind. (WJAK) 50
KGBX—St. Joseph, Missouri 100
(Does not operate when WOQ operates)
WIBU—Poynette, Wis. 100
KFIU—Juneau, Alaska 10
KFBK—Sacramento. Calif. 100
KGRJ—Jerome, Ariz. 100
(C. P. only)
KGCX—Wolf Point, Mont. 250, 100
KGEZ—Kalispell, Mont. 100
KFUP—Denver, Colo. (KFXJ) 100
KFXJ—Edgewater, Colo. (KFUP) 50
KMED—Medford, Ore. 50
KXRO—Aberdeen, Wash. 75
KIT—Yakima, Wash. 50

1320 KILOCYCLES, 277.1 METERS

WADC—Tallmadge, Ohio ....1 Kw.
WSMB—New Orleans, La. 500
KGIQ—Twin Falls, Idaho (KID) 250
KGHF—Pueblo, Colo. 500, 250
KGMB—Honolulu, Hawaii 500
KID—Idaho Falls, Idaho (KGIQ)......500, 250

1330 KILOCYCLES, 225.4 METERS

WDRC—New Haven, Conn. 500
WSAI—Cincinnati, Ohio 500
T—Mason, Ohio
WTAQ—Eau Claire, Wis. (KSCJ) ....1 Kw.
T—Township of Washington, Wis.
KSCJ—Sioux City, Iowa (WTAQ) ..2½ Kw., 1 Kw.
KGB—San Diego, Calif. 250

1340 KILOCYCLES, 223.7 METERS

WSPD—Toledo, Ohio ....1 Kw., 500
KFPY—Spokane, Wash. ....1 Kw., 500
KFPW—Fort Smith. Arkansas..........................50

1350 KILOCYCLES, 222.1 METERS

WBNY—New York, N. Y. (WMSG,
WCDA, WKBQ) 250
WMSG—New York, N. Y. (WBNY,
WCDA, WKBQ) 250
WCDA—New York City (WBNY,
WMSG, WKBQ) 250
T—Cliffside Park. N. J.
WKBQ—New York City (WBNY,
WMSG, WCDA) 250
KWK—St. Louis. Mo. ....1 Kw.

1360 KILOCYCLES, 220.4 METERS

WFBL—Syracuse, N. Y. ....1 Kw.
WQBC—Vicksburg, Miss..........................300
WJKS—Gary, Ind. (WGES)..............500, 1250
WGES—Chicago, Ill. (WJKS).........500, 1 Kw.
KGIR—Butte, Mont. (KFBB)..........................500
KGER—Long Beach, Calif. (KPSN)........1 Kw.
KPSN—Pasadena, Calif. (KGER)............1 Kw.

1370 KILOCYCLES, 218.8 METERS

WRDO—Augusta, Maine, CP. only............100
WQDM—St. Albans, Vermont (C.P. only)........5
WSVS—Buffalo, N. Y. 50
WPOE—Patchogue, N. Y..........................100
WCBM—Baltimore, Md. 250, 100
WHBD—Mt. Orab, Ohio..........................100
WHDF—Calumet, Mich..................250, 100
(C. P. to increase power to 250)
WBCM—Baltimore, Md..........................1370
(Case pending in court)
WBGF—Glens Falls, N. Y. CP. only............50
WLEY—Lexington, Mass. 100
WJBK—Ypsilanti, Mich. (WIBM)..............50
WIBM—Jackson, Mich. (WJBK)..............100
WRAK—Williamsport, Pa. 50
WELK—Philadelphia, Pa. 250, 100
WFDV—Rome, Ga. 100
WRBJ—Hattiesburg, Miss. 10
WHBQ—Memphis, Tenn. 100
WRBT—Wilmington, N. C..........................100
KGFG—Oklahoma City, Okla. (KCRC).........100
KFJZ—Fort Worth, Texas..........................100
KCRC—Enid, Oklahoma (KGFG)........250, 100
WMBR—Tampa, Florida..........................100
KGCI—San Antonio, Texas (KONO)............100
KONO—San Antonio, Texas (KGCI)............100
KGKL—San Angelo, Texas..........................100
KFLX—Galveston, Texas..........................100
WGL—Ft. Wayne, Indiana 100
WBTM—Danville, Virginia (WLVA)............100
(C. P. only)
WLVA—Lynchburg, Virginia (WBTM)........100
(C. P. only)
KGDA—Dell Rapids, S. D..........................50
C. P. to move to Mitchell, S. D.
KFJM—Grand Forks, N. D..........................100
KWKC—Kansas City, Missouri..........................100
WRJN—Racine, Wisconsin 100
KGAR—Tucson, Arizona....................250, 100
(C. P. to incr. pr. to 250)
KOH—Reno, Nevada 100
KRE—Berkeley, California 100
KZM—Hayward, Calif. 100
KLO—Ogden, Utah 200, 100
KOOS—Marshfield, Ore..........................100

KFBL—Everett, Wash. (KVL)..........................50
KVL—Seattle, Wash. (KFBL)..........................100
KFJI—Astoria, Ore. 100
KGFL—Raton, N. M..........................50

1380 KILOCYCLES, 217.3 METERS

WSMK—Dayton, Ohio. (KQV)..........................200
KQV—Pittsburgh, Pa. (WSMK)..........................500
KSO—Clarinda, Ia. (WKBH) 500
WKBH—LaCrosse, Wis. (KSO) ....1 Kw.

1390 KILOCYCLES, 215.7 METERS

WHK—Cleveland, Ohio. T—Village of Seven
Hills ....1 Kw.
KLRA—Little Rock, Ark. (KUOA)..........1 Kw.
KUOA—Fayetteville, Ark. (KLRA) ....1 Kw.
KOY—Phoenix, Ariz. 500

1400 KILOCYCLES, 214.2 METERS

WCGU—Brooklyn, N. Y. (WSGH-WSDA,
WLTH, WBBC) 500
WSGH-WSDA—Brooklyn, N. Y. (WCGU,
WLTH, WBBC) 500
WLTH—Brooklyn, N. Y. (WCGU, WSGH,
WSDA, WBBC) 500
WCMA—Culver, Ind..........................50
WBBC—Brooklyn, N. Y. (WCGU, WSGH-
WSDA, WLTH) 500
KOCW—Chickaska, Okla. 250, 500
WCMA—Culver, Ind. (WBAA, WKBF) 500
WKBF—Indianapolis, Ind. (WBAA, WCMA)..500
WBAA—W. Lafayette, Ind. (WCMA, WKBF) 500

1410 KILOCYCLES, 212.6 METERS

WBCM—Bay City, Mich. Hampton Twp.,
Mich. 500
WLEX—Lexington, Mass. 100
KGRS—Amarillo, Texas (WDAG)............1 Kw.
WMAF—South Dartmouth, Mass. (WELX,
WSSH) 500
WODX—Mobile, Ala. (WSFA)..........................500
T—Springhill, Ala.
WSFA—Montgomery, Ala. (WODX)...........500
(C. P. only)
WRBX—Roanoke, Va. 250
WSSH—Boston, Mass. (WLEX, WMAF)......500
WDAG—Amarillo, Texas (KGRS) 250
KFLV—Rockford, Ill. (WHBL) ....500, 1 Kw.
WHBL—Sheboygan, Wis. (KFLV)............500

1420 KILOCYCLES, 211.1 METERS

WELL—Battle Creek, Mich. 50
WHDL—Tupper Lake, N. Y..........................10
WTBO—Cumberland, Md..........................100
WILM—Wilmington, Del. 100
WEDH—Erie, Pa. 30
WMBC—Detroit, Mich. 250, 100
WKBP—Battle Creek, Mich. 50
WHIS—Bluefield, W. Va. 100
WIBR—Steubenville, Ohio 50
WFDW—Talladega, Ala. 100
(C. P. only)
WJBO—New Orleans, La. 100
KTAP—San Antonio, Tex. 100
KTUE—Houston, Texas 100
KFYO—Abilene, Texas 250, 100
WSPA—Spartansburg, N. C. 250, 100
(C. P. only)
KICK—Red Oak, Iowa..........................100
WIAS—Ottumwa, Iowa 100
WLBF—Kansas City, Kans. 100
WMBH—Joplin, Mo. 250, 100
KLPM—Minot, N. D. 100
WEHS—Evanston, Ill. (WKBI, WHFC)........100
WHFC—Cicero, Ill. (WKBI, WEHS)............100
WKBI—Chicago, Ill. (WHFC, WEHS)..........50
KFIZ—Fon du Lac, Wis. 100
KFXY—Flagstaff, Ariz. 100
KGIX—Las Vegas. Nev. 100
(C. P. only)
KFQU—Holy City, Calif. (KGGC)..............100
KFXD—Jerome, Idaho 50
KGFF—Alva, Okla. 100
KGIW—Trinidad, Colo. 100
KGKX—Sandpoint, Idaho 100
KGGC—San Francisco, Calif. (KFQU)..........50
KBPS—Portland, Ore. 100
KXL—Portland, Oregon (KFIF)..........................100
KFIF—Portland, Oregon (KXL) 100
KORE—Eugene, Ore. 100
KFQW—Seattle, Wash. 100

1430 KILOCYCLES, 209.7 METERS

WHP—Harrisburg, Pa. (WBAK, WCAH)......500
T—Lemoyne, Pa.
WBAK—Harrisburg, Pa. (WHP,
WCAH) ....1 Kw., 500
WCAH—Columbus, Ohio (WHP, WBAK).....500
C. P. to incr. pr. to 1 Kw.
WGBC—Memphis, Tenn. (WNBR) 500

KGNF—North Platte, Nebraska 500
(C. P. only)
WNBR—Memphis, Tenn. (WGBC)..............500
KECA—Los Angeles, Calif. ....1 Kw.
WOKO—Poughkeepsie, N. Y. (WHEC-WABO).500

1440 KILOCYCLES, 208.2 METERS

T—Mt. Beacon, N. Y.
WCBA—Allentown, Pa. (WSAN)..............250
WSAN—Allentown, Pa. (WCBA) 250
WNRC—Greensboro, N. C. 500
WTAD—Quincy, Ill. (WMBD) 500
WMBD—Peoria Hgts., Ill. (WTAD)....1 Kw., 500
KLS—Oakland, Calif. 250

1450 KILOCYCLES, 206.8 METERS

WBMS—Hackensack, N. J. (See Note)..........250
WHOM—Jersey City, N. J. (WBMS, WNJ,
WKBO) 250
WNJ—Newark, N. J..........................250
WKBO—Jersey City, N. J..........................250
WSAR—Fall River, Mass. 250
(Note: WBMS, WNJ, WIBS and WKBO
divide time with each other)
WCSO—Springfield, Ohio (WFJC) 500
WFJC—Akron, Ohio (WCSO) 500
WTFI—Toccoa, Ga. 500
KTBS—Shreveport, La. ....1 Kw.

1460 KILOCYCLES, 205.4 METERS

WJSV—Mt. Vernon Hills, Va. ....10 Kw.
KSTP—St. Paul, Minn. ....10 Kw.

1470 KILOCYCLES, 204.0 METERS

WTNT—Nashville, Tenn (WLAC)............5 Kw.
WLAC—Nashville Tenn. ....5 Kw.
KGA—Spokane, Wash. ....5 Kw.

1480 KILOCYCLES, 202.6 METERS

WKBW—Buffalo, N. Y......................5 Kw.
T—Amherst, N. Y.
KFJF—Oklahoma City, Okla. ....5 Kw.

1490 KILOCYCLES, 201.2 METERS

WFBL—Syracuse, N. Y......................1 Kw.
(Also operates ½ time with 750 w. on 900 kc.)
WCHI—
T—Deerfield, Ill. ....5 Kw.
WCKY—Covington, Ky. ....5 Kw.
WTNT—Nashville, Tenn. (WLAC)..........5 Kw.
T—Crescent Springs, Ky.
WLAC—Nashville, Tenn. (WTNT)...........5 Kw.
WORD—Chicago, Ill (WJAZ, WCHI,
WCKY) ....5 Kw.
KPWF—Westminster, Calif. ....5 to 10 Kw.
(C. P. only)
WJAC—Mt. Prospect, Ill. (WORD, WCKY,
WCHI) ....5 Kw.

1500 KILOCYCLES, 199.9 METERS

WMBA—Newport, R. I..........................100
WLOE—Boston, Mass (WMES)..........250, 100
T—Chelsea, Mass.
WMES—Boston, Mass. (WLOE) 50
WBBS—Boston, Mass. 50
WNBF—Binghamton, N. Y. 100, 50
(C. P. to incr. pr. to 100 w.)
WMBQ—Brooklyn, N. Y. (WLBX, WCLB,
WWRL) 100
WCLB—Long Beach, N. Y. (WLBX, WMBQ,
WWRL) 100
WLBX—Long Island City, N. Y. (WMBQ)
WCLB, WWRL) 100
WWRL—Woodside, N. Y. (WMBQ, WLBX,
WCLB) 100
WKBZ—Ludington, Mich. 50
WMPC—Lapeer, Mich. 100
WPEN—Philadelphia, Pa. 250, 100
WMBJ—Penntownship, Pa. 100
WODY—Tupelo, Miss. CP. only..............100
WOPI—Bristol, Tenn. 100
WRDY—Augusta, Ga. CP. only..............100
KGKY—Scottsbluff, Nebr. 100
(C. P. only)
KGFI—Corpus Christi, Tex. 100
KUT—Austin, Texas 100
KGKB—Brownwood, Texas 100
KTLC—Houston, Texas 100
WKBV—Connersville, Ind. 150, 100
KPJM—Prescott. Ariz. 100
KVEP—Portland, Ore. 1
KDB—Santa Barbara, Calif. 100
KREG—Santa Ana, Calif. 100
KUJ—Long View, Wash. 100
(½ time)
KGMD—Roswell, N. M..........................100
KGFK—Moorhead, Minn..........................50
(C. P. only)
KGIZ—Grant City, Mo. 50
KPG—Wenatchee, Wash..........................100
KPG—Wenatchee, Wash. 50

List of Impending Changes, Not Yet in Effect

[Stations marked (***) on list by Frequencies are under consideration for change in frequencies as follows:]

1500 KILOCYCLES

Ozark Radio Co.—Carterville, Mo..............100
WQDV—Tupelo, Miss. 100
E. Dwight Craig—Indianapolis, Ind..............50
(Requests change from 970 k.c.)
John R. Sylvester—Derry, Pa................100
(Requests transfer from 1420 kc.)

1370 KILOCYCLES

Clifford C. Sawyer, Elkhart. Kans...........20

1220 KILOCYCLES

George F. Bissell, Lake Placid, N. Y......500

950 KILOCYCLES

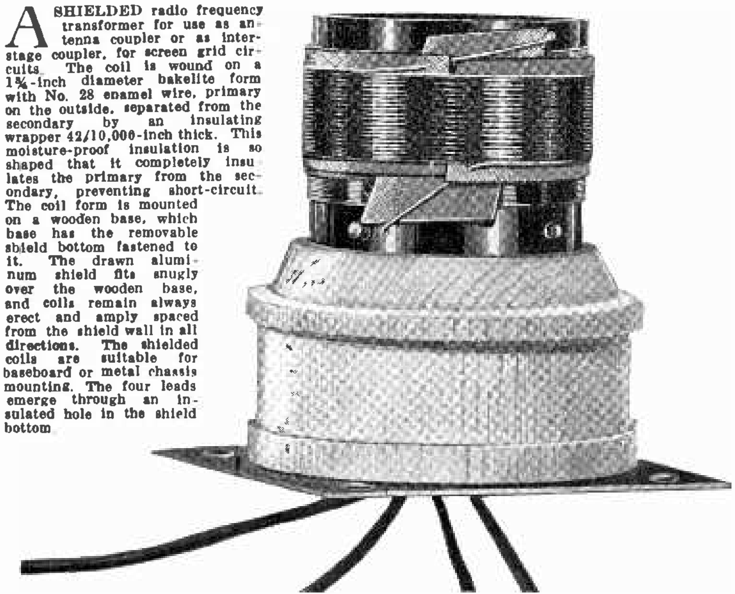
Martin C. Newman—Sturgis, Mich............100
(Requests transfer from 1310 kc.)

630 KILOCYCLES

D. H. Castille—New Iberia, La 500

High-Gain Shielded Coils

A SHIELDED radio frequency transformer for use as antenna coupler or as interstage coupler, for screen grid circuits. The coil is wound on a 1¾-inch diameter bakelite form with No. 28 enamel wire, primary on the outside, separated from the secondary by an insulating wrapper 42/10,000-inch thick. This moisture-proof insulation is so shaped that it completely insulates the primary from the secondary, preventing short-circuit. The coil form is mounted on a wooden base, which base has the removable shield bottom fastened to it. The drawn aluminum shield fits snugly over the wooden base, and coils remain always erect and amply spaced from the shield wall in all directions. The shielded coils are suitable for baseboard or metal chassis mounting. The four leads emerge through an insulated hole in the shield bottom.

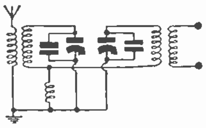


The coil comes already mounted on a shellacked wooden base, which is fastened at the factory to the shield bottom. Series A coil is illustrated.

The external appearance of the shield, with four 6/32 machine screws and nuts, which are supplied with each coil assembly.

Precisely Matched for Gang Tuning

ONE primary lead-out wire from the coil, for antenna or plate connection, has a braided tinned alloy covering over the insulation. This alloy braid shields the lead against stray pick-up when the braid alone is soldered to a ground connection. The outleads are 6 inches long and are color identified. The wire terminals of the windings themselves, and the outleads, are soldered to copper rivets. Each coil comes completely assembled inside the shield, which is 2¾ inches square at bottom (size of shield bottom) and 3¾ inches high. High impedance primaries of 40 turns are used. Secondaries have 80 turns for .00035 mfd. and 70 turns for .0005 mfd.



BP-6 is the coil at bottom.

EXTREME accuracy in winding and spacing is essential for coils used in gang tuning. These coils are specially suited for gang condensers, because the inductances of all are identical for the stated size condenser. The coils are matched by a radio frequency oscillator. The color scheme is as follows: shielded wire outlead is for antenna or plate; red is for ground or B plus. (These options are due to use of the same coil for antenna coupling or interstage coupling.) Blue is for grid and yellow is for grid return. For .00035 mfd. the Cat. No. is A-40-80-S. For .0005 mfd. the Cat. No. is A-40-70-S.

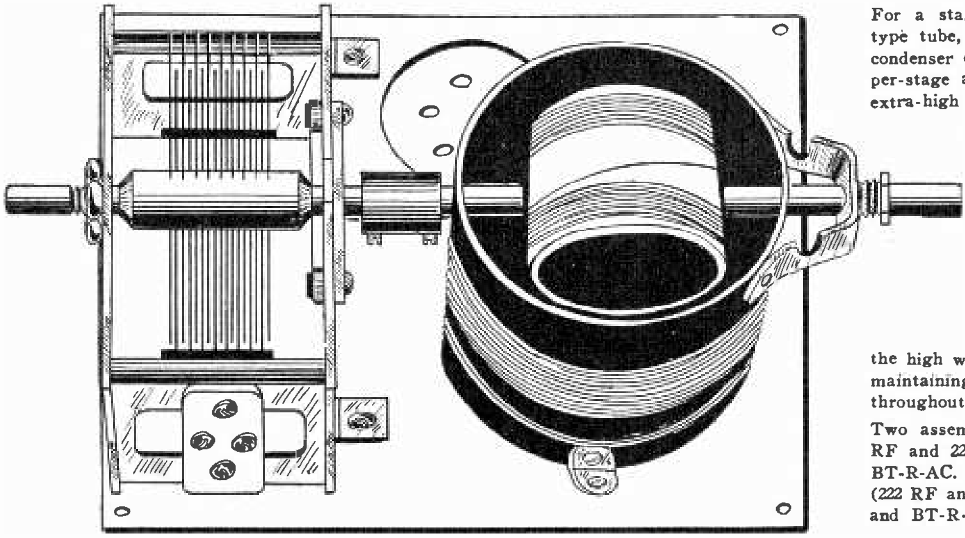
Where a band pass filter circuit is used the small coupling coil to unite circuits is Cat. BP-6. The connection is illustrated herewith.

Junior Model Inductances

The Series B coils have the same inductance and the same shields as the series A coils, but the primary, instead of being wound over the secondary, with special insulation between, is wound adjoining the secondary, on the form, with ¼-inch separation, resulting in looser coupling. No wooden base is provided, as the bakelite coil form is longer, and is fastened to the shield bottom piece by means of two brackets. No outleads. Wire terminals are not soldered. Order Cat. B-SH-3 for .00035 mfd. and Cat. B-SH-5 for .0005 mfd.

Coils for Six-Circuit Tuner

Series C coils for use with six tuned circuits, as in Herman Bernard's six-circuit tuner, are wound the same as type A shielded coils, but the shields are a little larger (3 1/16-inch diameter, 3¾ inches high), and there are no shield bottoms, as a metal chassis must be used with such highly sensitive cricuits. Fasten the brackets to the shield and then, from underneath the chassis, fasten the other arm of the two brackets to the chassis. Order Cat. C-6-CT-5 for .0005 mfd. and Cat. C-6-CT-5 for .00035 mfd. Five needed for Bernard's circuit. If band pass filter coupling coil is desired order Cat. BP-6 extra.



For a stage of screen grid RF, either for battery type tube, 222, or AC, 224, followed by a grid-leak-condenser detector, no shielding is needed, and higher per-stage amplification is attainable and useful. This extra-high per-stage gain, not practical where more than one RF stage is used, is easily obtained by using dynamic tuners. Two assemblies are needed. These are furnished with condensers erected on a socketed aluminum base. Each coil has its tuned winding divided into a fixed and a moving segment. The moving coil, actuated by the condenser shaft itself, acts as a variometer, which bucks the fixed winding at the low wavelengths and aids it at the high wavelengths, thus being self-neutralizing and maintaining an even degree of extra-high amplification throughout the broadcast scale.

Two assemblies are needed. For AC operation (224 RF and 224 or 227 detector), use Cat. BT-L-AC and BT-R-AC. For battery or A eliminator operation (222 RF and any tube as detector), use Cat. BT-L-DC and BT-R-DC.

BT-L for the antenna stage and BT-R for the detector input. BT-L consists of a small primary, with suitable secondary for the .00035 mfd. condenser supplied. BT-R has two effective coils: the tuned combination winding in the RF plate circuit, the inside fixed winding in the detector grid circuit.

The moving coils must be "matched." This is done as follows: Turn the condensers until plates are fully enmeshed, and have the moving coils parallel with the fixed winding. Tune in the highest wavelength station receivable—above 450 meters surely. Now turn the moving coils half way round and retune to bring in the station. The setting that represents the use of lesser capacity of the condenser to bring in that station is the correct one. If gang tuning is used, put a 20-100 mmfd. equalizing condenser across the secondary in the antenna circuit and adjust the equalizer for a low wavelength (300 meters or less).

Screen Grid Coil Co., 143 West 45th Street, New York (Just East of Broadway):

Enclosed please find $............ (Canadian must be express or P. O. Money Order), for which send me prepaid the following:

☐ A-40-80-S, each $2.25
☐ Matched set, 4 A-40-80-S, $1 matching 10.00
☐ A-40-70-S, each 2.25
☐ Matched set of four A-40-70-S........ 10.00
☐ B-SH-3, each $1.00
☐ Matched set of four B-SH-3........... 4.00
☐ B-SH-5, each 1.00
☐ Matched set of four B-SH-5........... 4.00
☐ BT-L-AC and BT-R-AC, assembled, with condenser, link, socket and base, per pair....... 6.00
☐ BT-L-DC and BT-R-DC, assembled, with condenser, link, socket, base, per pair......... 6.00
☐ C-6-CT-5, .0005 mfd. shielded coil for six-circuit tuner.............each $2.25
☐ C-6-CT-3, .00035 mfd. shielded coil for six-circuit tuner............each $2.25
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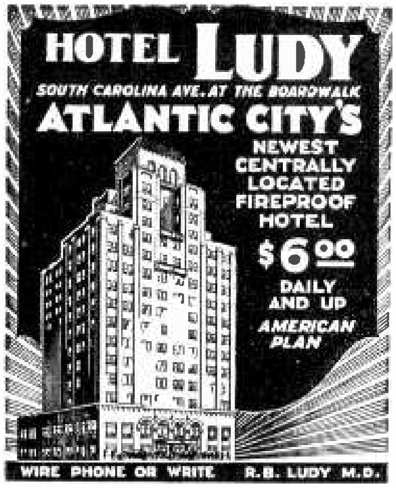

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FOR turning nuts down or up there is nothing as efficient and handy as a socket wrench. Here is a set of three wrenches for hexagonal nuts, enabling use with 5/32, 6/32, 8/32 and 10/32 nuts. Fit the nut into the proper socket and turn down or up. The three different size sockets, one size on each wrench, enables use of three different outside diameters of nuts, but at least ten different sizes of threads. Send 50 cents for four weeks subscription for RADIO WORLD and get this set of three wrenches FREE!

RADIO WORLD, 145 W. 45th St., New York, N.Y.
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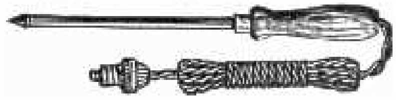

Works on 110-120 volts, AC or DC; power, 50 watts. A serviceable iron, with copper tip, 5 ft. cable and male plug. Send $1.50 for 13 weeks' subscription for Radio World and get these free! Please state if you are renewing existing subscription.

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The following constitute the thirteen most popular tubes used in radio today. Despite the severely low prices the Key tubes are firsts of the very first quality. The tubes are manufactured under licenses granted by the RCA and its affiliated companies.

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Enclosed please find $.............. for which ship at once tubes marked below:

☐ 224 AC screen grid $1.43
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☐ 171A power tube .... .78
☐ 201A battery tube .... .53
☐ 240 hi mu tube $1.60
☐ 250 power tube $4.95
☐ 210 power tube $3.25
☐ 280 AC rectifier $1.60
☐ 281 AC rectifier $2.95

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DOUBLE RANGE POTENTIOMETER; made by Centralab, designed for volume control. In dust-proof bakelite case. Price, $1.05. Guaranty Radio Goods Co., 143 W. 45th St., New York.

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TUBES that fall a trifle below the most exacting laboratory specifications may be obtained at prices that seem incredible. They are called "seconds" and they are "seconds," but they are not "thirds." Note the prices. Remit with order.

201A	50c	224	70c
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TESTED TUBES—201A, .43; 226, 227, 171A, 224, 245, 280, .48. Unshielded 85 milliampere filter chokes, .49. Waterman Radio, 2140 Kirby West, Detroit, Mich.

COLOSSAL BARGAIN—A 4-tube AC 105-120 Volt, 50-60 cycle, custom made receiver, in table model cabinet, with Mayolian B eliminator, A battery, Westinghouse trickle charger, C bias batteries, Relay switch, 5 tubes (includes Raytheon rectifier). One dial finger tuning, 171 output. Operates dynamic. Humless, sturdy performer. Can be heard by appointment. Will install free in residence if in or around New York City. A. Bashein, 1116-56 Street, Brooklyn, N. Y.

ELECTRAD LOFTIN-WHITE DIRECT-COUPLED AMPLIFIER NEVER USED $17.50. USED FRESHMAN PORTABLE 210 POWER AMPLIFIER $10.00, WITH TUBES $13.75. REAL BARGAINS. H. DE LANEY, 35 REMY AVE., MANSFIELD, OHIO.

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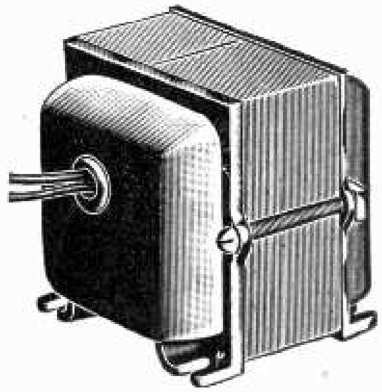
"CITY OF CHICAGO" WORLD'S DURATION PLANE—30″ Plan 10c. Model Aviator, Dept. RW, 605 Washington, Chicago.

BARGAINS in first-class, highest grade merchandise. B-B-L phonograph pick-up, theatre type, suitable for home, with vol. control, $6.57; phono-link pick-up with vol. control and adapter, $3.50; steel cabinet for HB Compact, $3.00; four-gang .00035 mfd. with trimmers built in, $1.95; .00025 mfd. Dubilier grid condenser with clips, 18c. P. Cohen, Room 1214, at 143 West 45th Street, N. Y. City

New Polo Power Transformers and Chokes

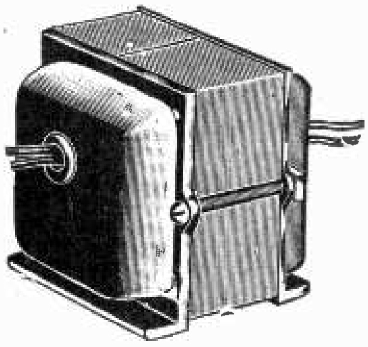


Shielded single choke, 200 ohms D.C. resistance, nonsaturable at 100 milliamperes, with two black outleads, each 6 inches long. For filtration of B supplies. Inductance, 30 henrys.
Cat. SH-S-CH, price $5.00

The shielded single choke will pass 100 ma. One will suffice if the current is 100 ma. or less, for filtration of B supplies, provided the capacity at the filter output is 8 mfd. or more. Use two such shielded chokes if less than 8 mfd. is used at the filter output. Also, the shielded single choke may be used as in the power tube circuit for an output filter. In this connection use at least 2 mfd. for the capacity section of the filtered speaker output. Order Cat. SH-S-CH @ $5.00

The shielded double choke may be used for filtration where the B current is 60 ma. or less, with relatively small filter capacities, no less than 4 mfd at the output, however. This choke consists of one winding, center-tapped. Its use is especially recommended for 171, 171A, 245 or 210 push-pull output. Connect the black leads (extremes of windings) to plates of the push-pull tubes, red center tap to B plus, and the speaker may be connected directly to plates without any direct current, but only signal current, flowing through the speaker. This system is applicable only to push-pull. Order Cat. SH-D-CH @ $6.00

In the same type of case a 20-volt secondary filament transformer, for 110 volts, 50-133 cycle, may be obtained for use in conjunction with dry rectifiers, such as Kuprox, Westinghouse, Benwood-Linze and Elkon, in dynamic speakers or A battery eliminators. Not made for 25 or 40 cycles. Order Cat. SH-F-20 @....................$2.50



Twenty-volt filament transformer, 110 v. 50-133 cycle input, for use in conjunction with dry rectifiers. It will pass 2.25 amperes.

In a different type case, square, of cadmium plated steel with four mounting screws built in, size 4½ inches wide by 5⅝ inches high by 4 inches front to back, a 50-60 cycle filament transformer is obtainable with the same windings as the 245 power transformer, except that the high voltage secondary is omitted. Order Cat. 245-FIL, @ $4.50
For 40 cycles order Cat. 245-FIL-40 @.......... 7.00
For 25 cycles order Cat 245-FIL-25 @............8.50

[Any of the above three in the same case as the 245 power transformer, @ $1.00 extra. Add PTC after the Cat. number.]

A single choke, unshielded, 65 ma rating, 30 henrys inductance, for B filtration or single output filter of speaker, is our Cat. US-S-CH @.................$1.25

Polo Engineering Laboratories, 143 West 45th St., New York, N. Y.

Enclosed please find $———— for which ship at once:

☐ Cat. 245-PT @...$8.50
☐ Cat. 245-PT-40 @ 9.50
☐ Cat. 245-PT-25 @ 12.00
☐ Cat. SH-S-CH @ 5.00
☐ Cat. SH-D-CH- @ 6.00
☐ Cat. 245-FIL @..$4.50
☐ Cat. 245-FIL-40 @ 7.00
☐ Cat. 245-FIL-25 @ 8.50
☐ Cat. SH-F-20 @. 2.50
☐ Cat. UN-S-CH @. 1.25
☐ F-2.5-D @ 3.75

Note: Canadian remittance must be by post office or express money order.

☐ If C.O.D. shipment is desired, put cross here. No C.O.D. on 25 and 40 cycle apparatus. For these full remittance must accompany order. The 25 and 40 cycle apparatus bears the 50-60-cycle label, but you will get actually what you order.

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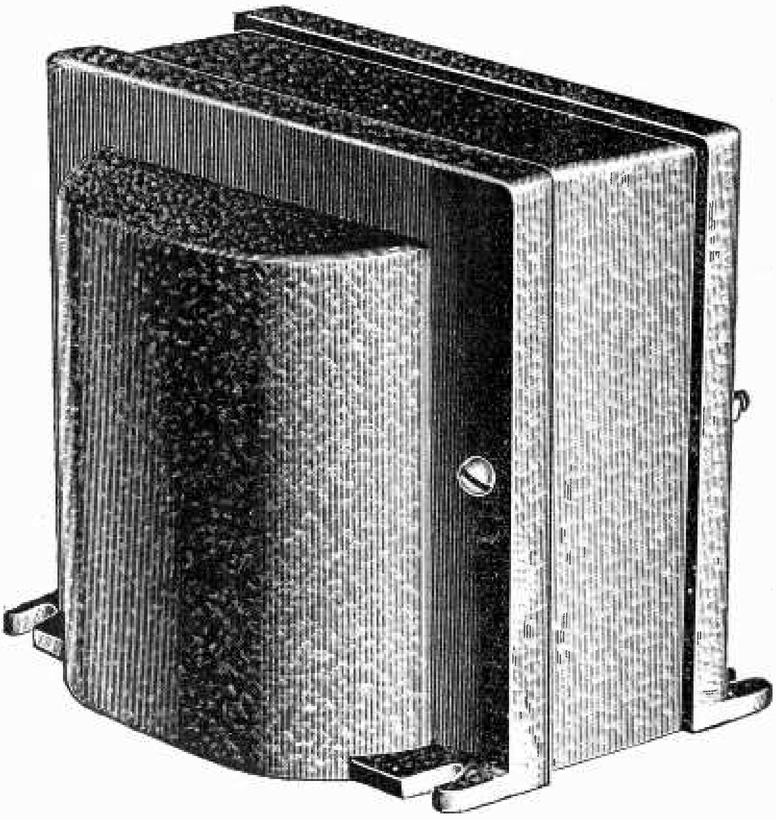
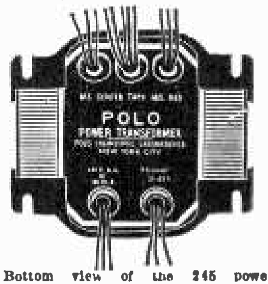


245 Power Transformer for use with 280 rectifier, to deliver 300 volts D.C. at 100 milliamperes, slightly higher voltage at lower drain, and supply filament voltages.
Cat. 245-PT price $8.50

The Polo 245 power transformer is expertly designed and constructed, wire, silicon grade A steel core and air gap large enough to stand the full rated load. The primary is for 110v A.C., 50-60 cycles tapped for 82.5 volts in case a voltage regulator, such as a Clarostat or Amperite, is used. The black primary lead is common. If no voltage regulator is used, connect black lead to one side of the A C line, green lead to the other side of the line, and ignore red lead, except to tape the end. For use with a voltage regulator (82.5-volt primary) use red lead and ignore the green except to tape the end. The secondaries are: high voltage for 280 plates, with red center tap to ground; 2.5 volts, 3 amperes, red center tap to C plus, for 245 output, single or pushpull; 5 volts, 2 amperes, red center tap, as positive B lead, for filament of 280 tube; 2.5 volts, 16 amperes, red center tap to ground, for 224, 227 and pentode tubes, up to nine heater type tubes. Hence there are five windings.



Bottom view of the 245 power transformer. All leads are plainly marked on the nameplate, including the top row.

A special filament transformer, 110 v., 50-60 cycles, with two secondaries, one of 2.5 v. 3 amp. for 245s, single or push-pull, other 2.5 v. 12 amperes for 224, 227, etc., both secondaries center-tapped. Shielded case. 6 ft. AC cable, with plug. Order Cat F-2.5-D @.......$3.75

The conservative rating of the Polo 245 power transformer insures superb results even at maximum rated draw, working up to twelve tubes, including rectifier, without saturation, or overheating due to any other cause. This ability to stand the gaff requires adequate size wire, core and air gap, all of which are carefully provided. At less than maximum draw the voltages will be slightly greater, including the filament voltages, hence the 16 ampere winding will give 2.25 volts at maximum draw, which is an entirely satisfactory operating voltage, increasing to 2.5 volts maximum as fewer than a total of nine RF, detector and preliminary audio tubes are used.

The avoidance of excessive heat aids in the efficient operation of the transformer and in the maintenance of good regulation, for excessive heat increases the resistance of the windings.

The transformer is equipped with four slotted mounting feet and a nameplate with all leads identified. It is one of the very finest instruments on the radio market.

Highest Capacity of Filament Secondary

SPECIAL pains were taken in the design and manufacture of the Polo 245 power transformer to meet the needs of experimenters. For instance, excellent regulation was provided, to effect minimum change of voltage with given change in current used. Also, the 2.5 volt winding for RF, detector and preliminary audio tubes, was specially designed for high current, to stand 16 amperes, the highest capacity of any 245 power transformer on the market. Hence you have the option of using nine heater type tubes. The shielded case is crinkle brown finished steel, and the assembly is perfectly tight, preventing mechanical vibration.

The power transformer weighs 11½ lbs., is 7 inches high, 4⅞ inches wide, and 4¼" front to back, overall.

Elevating washers may be used at the mounting feet to clear the outleads, or holes may be drilled in a chassis to pass these leads, and the transformer mounted flush.

Advice in Use of Chokes and Condensers in Filter

With the 245 power transformer either one or two single chokes should be used, or a shielded double choke, depending on the current drain and the capacity of filter condenser used. Where the capacity at the output is 8 mfd. or more for a drain of 65 to 100 ma., a single choke will suffice (Cat. SH-S-CH), but where smaller output capacity than 8 mfd is used on such drain, two such chokes should be used in series. Next to the rectifier, in either instance, use a 1 or 2 mfd., 550 A.C. working voltage rating condenser (D.C. rating, 1,000 volts). You may use your choice of capacity at the midsection.

If the drain is to be 65 milliamperes or less, the double choke, Cat. SH-D-CH, may be used for filtration, instead of two single shielded chokes.

The Polo 245 power transformer may be obtained for 25 cycles or 40 cycles on special order, as these are not stocked regularly, and remittance must accompany order. The same guaranty attaches to them as to all other Polo apparatus—money back if not satisfied after trial of five days. In these the primary and secondary voltages and taps are the same, only the case is deeper (front to back) because of larger core and wire for lower frequency.
For 40 cycles order Cat. 245-PT-40..@ $9.50
For 25 cycles order Cat. 245-PT-25..@ $12.50

[Note: The filter for 40 cycles should consist of two shielded single chokes, Cat. SH-S-CH, with 2 mfd. next to the rectifier and 4 mfd. minimum at the joint of the two chokes and at the end of the filter. For 25 cycles the same holds true, except that the output capacity at end of chokes should be 8 mfd. minimum.]

We Make Special Transformers to Order