REQUIREMENTS FOR HIGH FIDELITY

RADIO WORLD

The First National Radio Weekly

666th Consecutive Issue—Thirteenth Year

Extending the Use of a Current Meter

First Principles of Light for Photo-Electric Cell Use

A Simple Three-Tube Universal S-W Converter

8-TUBE T-R-F SET USING 6.3 VOLT SERIES

DEC. 29 1934

15¢ PER COPY
New Signal Generator Free with $6 (One Year) Subscription

NOW for the first time you can get a wired and tested Signal Generator free with a $6 subscription for Radio World (52 issues, one year). Imagine getting Radio World for a year, and also a splendid Signal Generator! Never before have we made so generous an offer as this. Moreover, the offer is revocable without notice. So you'd better act now.

The Signal Generator, PRE-6, has practically straight-frequency line tuning. It works on 90-125 volts, a.c. or d.c., and is modulated on a.c.

The Signal Generator offered as a premium with a one-year subscription is a serviceable instrument, of durable and accurate construction, and enables the peaking of intermediate frequencies, as well as broadcast frequencies. Moreover, short-wave frequencies can be determined. Determinations in frequencies in kilocycles and wavelengths in meters are made by use of this splendid instrument.

SCALE READS DIRECTLY IN FREQUENCIES AND WAVELENGTHS

Many experimenters and service men want a really good Signal Generator that serves their purposes abundantly and that costs little. Here it is. Model PRE-6 Signal Generator is given free with a one-year subscription for Radio World, a most amazing offer, nothing of the sort.

The scale reads directly in frequencies of the fundamental (100 to 200 kc., with bars 1 kc. apart), and wavelengths of the fundamental (2,700 to 1,500 meters, with bars 10 meters apart). Besides the intermediate frequencies, the wires on the fundamental scale, others are on the scale on the next tier from top, including the following imprinted twice: 400, 410, 465 and 480 kc.

The reason for these imprints appearing twice is that an automatic check-up on whether the channel measured is tuned exactly to the right i.f. is obtained, when using harmonics for there is a response in the receiver placed when the generator is turned on and then another of these two points. Hence no harmonic confusion is possible. Also, 210 and 240 kc are imprinted once on the second tier, for no confusion can result, as second harmonics are used.

GUARANTEED ACCURACY IS 1% TO THE upper tier, at the edge, is 109-200 kc, the lower corresponding tier at the edge is for wavelengths. One inside tier has the registrations for the popular intermediate frequencies not on the fundamental. The other inside scale ranges 0-180, so that any odd frequency one is interested in may be recorded elsewhere in respect to a calibration in degrees of a semi-circle.

The 331 dial scale is used. The guaranteed accuracy is 1 per cent. This is checked twice in a precision laboratory. The accuracy is not changed when a tube is inserted. The wired, calibrated, tested Signal Generator is supplied less tube. All you have to do is to insert a 30 tube and start making precision measurements.

Send $6.00 for one-year subscription, and ask for PRE-6. Present subscribers may renew on this basis. Shipping weight, 3 lbs. Envelope postage if prepaid shipment is desired. It's cheaper.

BAND SPREAD RECEIVER AND PACK

A large number of short-wave enthusiasts like the separate tuner and power pack. This method we have developed with bandspread tuning. The five-tube outfit covers 15 to 200 meters and provides most excellent results.

The wired chassis, with front panel, with coils, Power pack, wired, less the five tubes. 4.98

Five tubes and speaker set

Complete kit, with tubes, speaker set, diagram

DIRECT RADIO COMPANY

145 West 45th Street
New York, N. Y.

EFFICIENT BOOSTER

The performance of any short-wave receiver may be improved by the Supertone Booster. No wiring changes required in this set. The booster has a sensitivity range of 50-1.500 r.p.m. a.c. or d.c. operation. Reduces interstage interference to a minimum.

Wired Booster, with plug-in coils for 12-200 meters, hinged-top cabinet (less tubes)

Booster kit, complete, less tubes
P. A.

PRINCIPLES OF PUBLIC ADDRESS SYSTEMS

- A practical handbook, full of useful information, fully illustrated, written by M. N. Beitz, an engineer and noted authority on amplifiers.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.

P. A.

PRINCIPLES OF PUBLIC ADDRESS SYSTEMS

- A practical handbook, full of useful information, fully illustrated, written by M. N. Beitz, an engineer and noted authority on amplifiers.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.

P. A.

PRINCIPLES OF PUBLIC ADDRESS SYSTEMS

- A practical handbook, full of useful information, fully illustrated, written by M. N. Beitz, an engineer and noted authority on amplifiers.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.

P. A.

PRINCIPLES OF PUBLIC ADDRESS SYSTEMS

- A practical handbook, full of useful information, fully illustrated, written by M. N. Beitz, an engineer and noted authority on amplifiers.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.

P. A.

PRINCIPLES OF PUBLIC ADDRESS SYSTEMS

- A practical handbook, full of useful information, fully illustrated, written by M. N. Beitz, an engineer and noted authority on amplifiers.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.

P. A.

PRINCIPLES OF PUBLIC ADDRESS SYSTEMS

- A practical handbook, full of useful information, fully illustrated, written by M. N. Beitz, an engineer and noted authority on amplifiers.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.

P. A.

PRINCIPLES OF PUBLIC ADDRESS SYSTEMS

- A practical handbook, full of useful information, fully illustrated, written by M. N. Beitz, an engineer and noted authority on amplifiers.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.

P. A.

PRINCIPLES OF PUBLIC ADDRESS SYSTEMS

- A practical handbook, full of useful information, fully illustrated, written by M. N. Beitz, an engineer and noted authority on amplifiers.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.
- Contains complete details of the use of a small loudspeaker system, and sound engineering principles.

GUARANTY RADIO GOODS CO.
145 West 45th Street, New York, N. Y.
A T-R-F Set with 6.3-v. Tubes
Four-Gang Condenser Found Necessary,
Also Plate Bend Rectification

By Herman Bernard

An 8-tube tuned-radio-frequency circuit, using 42 tubes in push-pull pentode Class AB, an unusual method. If the B voltage is high enough, 350 volts between cathode and B plus, the 720-ohm biasing resistor may be retained, 10 watts output. For 250 volts plate supply use 410 ohms, 6 watts output. If Class AB triode use is desired tie screen to plate of each and use 730 ohms, with 350 volts. R is a resistor of 10-watt rating, to reduce B feed if 3,500 ohms in series establishes more than 250 volts.

Using eight tubes you can get more out of a superheterodyne than out of a tuned-radio-frequency set, but the t-r-f circuit is easier to build and adjust and besides more simply lends itself to quality reproduction. Whatever the reasons, there is quite a percentage of radioists that prefers the t-r-f variety. Selectivity will be less, of course, than in the example of the superheterodyne. There is no such thing as a really selective, stabilized t-r-f set. However, excess of selectivity, as is often present in a superhodnye, is one of the marring factors in considering quality reproduction.

Plate-Bend Detection
To attain sufficient selectivity in a t-r-f set it is necessary to use four tuned circuits. It is scarcely practical to use five because of tracking problems. It is preferable to use the tuned circuits between tubes. Thus there are three stages of t.r.f. and a tuned input to the detector.

In line with supporting selectivity to the utmost—and it will never be excessive—the detector should be of the plate bend type, as distinguished from grid-leak-condenser or diode type. The plate-bend variety, as in the diagram, does not depend on grid current. Whenever grid or diode current is drawn it is equivalent to a resistance load across the tuning line, hence is at the expense of selectivity. Quite a voltage may be developed at the detector input, therefore the detector has to be biased more negatively than the r-f tube ahead of it. Also for reasons of dynamic operation on a satisfactory part of the tube characteristic the negative bias must be more negative. So the bias as obtained from the drop in the cathode resistor common to the detector and third r-f tubes is augmented by the bias derived from the drop in the 2,000-ohm resistor in the 6C6 cathode circuit.

Thus the bias is much more negative than the usual recommendation for the 6C6. The reason is that the standard recommendations presuppose a small input to the detector, whereas here we may have a large one, as quite an amplifier precedes the detector, and what is desired is not utmost sensitivity but rather capability of standing a substantial voltage input and operation at a fairly sensitive point. This point was best established by using a lower value plate load resistor than usually recommended. The total voltage drop is divided unequally among the plate load, the tube and the bias on the detector, which is acceptable with plate circuit detection. Thus the operation sufficiently removed from grid current conditions.

Precautions Against Oscillation
Naturally with three r-f stages there must be precautions against oscillation. Choke-coil-condenser filters were tried in the plate circuit but did little good unless other remedies were introduced, and when these other remedies were applied the filters became unnecessary.
The coils were constructed so that the coupling between primary and secondary was almost critical, and thus with fewer turns than usual a high primary impedance was established. The turns were adjusted until the squels were absent under normal terminal voltages, 250 volts for the r-f plates, 100 volts for the screens. The voltage ratio is rather critical. Not so of the plate voltage. On the output tubes the plate voltage is high, 350 volts. Some tubes must be drooped, and a resistor of 3,500 to 4,000 ohms will accomplish this, approximately.

The indicated voltage values need to be precisely duplicated. In fact, the voltages change a little, due to the volume control. Current through limiting resistors is greater or lesser, depending on whether the volume control setting causes lower or higher negative bias, the screen voltage change being about 12 volts. This produces some effect in the first stage, but the fact that input in cut down at the same time that bias is heightened results in a loss of such frequency change. Of course the remaining circuits are affected a little, too, but not much differently than they would be due to bias change caused by impedances of carriers.

Why No. A. V. C.

It is not practical to introduce automatic volume control in a r-f receiver for this reason, since the biasing would be greatly different, and there would be serious distortion and calibration for audio frequencies, particularly for frequencies between 1,000 and 1,000 kc.

The detector is a 2A5 driver stage, which in turn works into the push-pull output. The bias on the output tubes should be close to 38 volts, if 350 volt a-pa is used on plate and grid. Therefore the total voltage for B and C supply is 388 volts, after the filter. Electrolytic filter condensers will stand high bias, as are necessary. Good ones, rated at 390 volts, stand up at 600 volts.

The tubes used are all of the 6.3-volt series, and all have heaters, excepting the rectifier, which is a 5-volt filament type tube. The plate-to-plate load for the output tubes is 384 ohms. This reduces the impedance of the primary of the output transformer.

The biasing resistor did not require a condenser across it, as there was no appreciable difference in the output, when a 60-cycle note was used as the input. No possible input is possible in, or out.

The condenser would be needed, high as practical, say, 30 mfd., 50 volts rating, if there were degenerative effects, but the test disclosed absence of these.

Also there was some audio feedback through the B-B supply and other impedance common to the audio system, of which the detector must be considered a part because it handles audio frequencies.

This circumstance is not considered of course in mere tabulations of tube characteristics.

Pentode Output

The output tubes are pentodes used as pentodes, so that one has performance, Class AB. Theoretically the output circuit is capable of 15 watts, but that would require a driver of more powerful performance than the 76, for instance, another 4A5 as triode. The case is the same as for 2A5's as Class AB, and a 2A5 triode driver, for the 42 and the 2A5 are the same, except for the difference in high voltages. Therefore it is quite practical also to use 78, 37, 56 and 2A5 tubes with 2.5 transformer winding, with or without making any changes in the circuit itself.

It is conceivable that during certain load passages, in the positive peaks of the cycle, grid current will flow in the 42 circuit, and the driver should contribute some power for this purpose, thus reducing the actual grid current, that is, within the parallel grid. The output rating may be taken as 0.4 watt for the 76 or 56. So it can be seen that the driver is there mostly for the voltage effect, though it will give the output tubes some lift when the positive cycles of strong audio exist. For this reason, therefore, the power output rating is not 15 watts but 7.5 watts. Most persons run their sets at home at about 1 watt output. Higher values are within the capabilities of the receivers, and come in handy during those surge demands on the output, for instance when the steady 1-watt condition of operation becomes momentarily a 2- or 3-watt condition, due to the modulation. Rating of 5 watts is ample, 7.5 watts abundant.

Why Push-Pull is Used

The reason for using push-pull at all is to increase the power output and improve the quality by another means, the elimination of the even-order harmonics. The Class AB use reduces the nuisance of strong odd-order harmonics, particularly the third harmonic as found in pentode output tubes. It is generally stated that the odd-order harmonics can be eliminated without eliminating the fundamental, for the fundamental is an odd-order harmonic, the first. This is true. However, in signal generator experiments at radio frequencies it was found that when there was a high resistance in the plate circuit, bypassed by an appropriate condenser, while the fundamental of course was reduced in amplitude, the odd-order harmonics were reduced in greater proportion. This is a hint to power-tube practitioners who might want to try relative reduction of third harmonics.

There are two pilot lamps shown. This is because some airplane dials have two pilot lamp capacitors in the lamps may be connected in parallel and to the 6.3-volt winding, for 6-volt pilot lamps; or in series, with free terminals of lamps across the 6 volts, for 3.5-volt lamps.

Hum Eliminated

For the use of an airplane dial the tuning condenser mounting spades are to be fitted with washers ½ inch high, threaded so that they engage the spades, which have 6/32 threads. Then from underneath the chassis the 6/32 screws are inserted into the bushings and tightened.

The audio transformer is put on the induct-ohm side wall of chassis, near the radio-frequency section, to be as far as practical from the power transformer. In that way hum is kept very low. With the audio transformer attached to the center of the chassis on the under side it was impractical to eliminate the hum even when "angling" attempts were made. Hum kept out by proper audio transformer placement also eliminates the necessity for hum filter networks of the resistor-capacitance type strung throughout the detector and audio channel.

There is considerable flexibility as to the power transformer and speaker field. As stated, 2.5-volt tubes may be used. In either instance, 2.5 or 6.3 volts, the high-voltage winding may not afford the correct voltage, possibly too high a value. This may be corrected by leaving the voltage as found, so long as it is within the break-down voltage limit of the electronics, increasing the power tube biasing resistor so that not more than a total of 60 milliamperes flows through the resistor at no signal input, and increasing the limiting resistor, marked 3,000 ohms in the diagram, to whatever value is necessary to cut down the supply to the prior plates to 250 volts.

Speaker Field 2,500 Ohms

A test the speakers of various d-c field resistances may be used, the difference between 2,500 ohms being taken up by a 50-watt resistor. So if the field has 1,800 ohms, the extra resistor would be 700 ohms, 50 watts. Fields close to 2,500 ohms may be used as found, and the compensation introduced by heightened negative bias on the power tubes and r-f B voltage reduction as explained.

The output transformers on dynamic speakers differ of course as to impedances on the primary side. For any push-pull circuit, compared to single-sided hookup, the plate load would be doubled. This a 2A5 pentode takes a 7,000-ohm load, but in push-pull, plate to plate, the value is 14,000 ohms. Here we have a requirement of 16,000 ohms for the class AB tubes.

(Continued on next page)
The tuned-radio-frequency receiver adapted to "universal" use, 90-125 volts a.c. or d.c. The total voltage is dropped in the series of heaters and pilot lamps.

(Continued from preceding page)

plate to plate. An acceptable substitute would be an RMA engineer's pull speaker. That would be nearly right.

For purposes of adjusting the push-pull broadcasting system, the gain transformer, determine from the originally intended use of the speaker what the impedance is like to be, see whether that is higher or lower than the transformer plate to plate. If the value is lower, decrease the biasing resistor, but no more than to permit 40 ma per tube, or 80 ma total, and if the speaker transformer impedance is higher, increase the biasing resistor. The increase in resistance may be up to 1,000 ohms total resistance, the test being whether low notes come in better. The B voltage delivered to the set then will increase, due to less current dropped in the limiting devices, including speaker field. The limiting fixed resistor in the B feed to r-f detector and first audio tubes would be increased so that 250 volts would prevail, approximately.

Removing Squeals

The main trouble has to do with radio-frequency oscillation. Coils have been prepared that will eliminate this trouble fundamentally, if the rest of the circuit is followed closely. These coils consisted of 127 turns of No. 32 enamel wire on 1-inch diameter tubing. A layer of insulating fabric is put over the center of the winding, and then a 12-turn primary put on. All four coils are alike. If there is squealing trouble, with voltages correct, reverse the connections to the antenna winding, as transient pickup may be causing plate-circuit energy of the first tube to be fed to the primary. Then if the phase is adding there will be regeneration, as the primary becomes a tank. Reversing the connections, so ground goes to "Ant." terminal of the coil, and antenna to the "Gnd." terminal of the coil, will cure the trouble if arising from this cause.

Check the screen voltage, as that is a determining factor. The plate voltage is as important on the r-f and detector tubes.

The screen voltage must not exceed 100 volts. It is permissible to increase the screen resistor from the prescribed 25,000 ohms to 45,000 ohms, if needed to eliminate squealing.

Higher Bias

The circuit will tend to oscillate rather at the lower frequencies than at the higher ones. Severe oscillation trouble would be evidenced by squealing all over the dial. The remedy is being applied in the right direction when the high-frequency squealing disappears but the low-frequency squealing continues. Correct the persistence by increasing the limiting resistor in the circuit of the oscillating tube, usually the first tube. This resistor then might be 400 or 600 ohms, if need be.

Do not overlay the application of any of these squeal-correcting remedies, as when one over-seeps the mark one does so too pronouncedly and there is a decided loss of sensitivity.

Removing turns from primary in the plate circuit of the first r-f tube is another remedy. Three to five turns off should be enough, otherwise do not remove more than five turns, and use the other methods outlined, leaving the primary as reduced.

Correction of Distortion

Bad distortion may be experienced. This should not be attributed at once to the power stage, mismatched impedances, etc., but rather to the detector bias. Increase this bias experimentally, by using a much higher extra resistance than the 2,000 ohms shown in the detector's augmentative biasing circuit. If r-f and detector plate voltages are too high and can not be readily corrected, that is, even doubling the limiting resistor does not reduce the voltage enough, connect a 10-watt resistor of a few thousand ohms from screen to ground.

**

More data on the a-c operated receiver will be printed next week, issue of January 5th. Precision frequency measurements will be detailed in that issue, also.

---

Fascimile Standards and Terms Studied

Fascimile experiments have reached the point where organized development is being undertaken by the RMA manufacturers Association Engineering Division.

A special committee on facsimile, headed by W. W. Enstrom of Camden, N. J., as chairman, has been organized by Dr. W. R. G. Baker, chairman of the Engineering Division, and Virgil M. Graham of the Committee. This New Facsimile Committee has begun to function, starting work on nomenclature and standards. Four facsimile circuits, between New York and San Francisco, London, Berlin and Buenos Aires, are now in operation by RCA Communications Inc.

The romantic appeal as well as the service aspects of facsimile are both being considered by the RMA engineers in directing scientific progress toward eventual development of a practicable facsimile broadcasting system. The drum type of facsimile apparatus is now in use but eventual development of a continuous type of recorder, taking its paper from a feed roll, instead of the ultimate practical solution for broadcast facsimile recording. Higher speed also is an engineering goal.

It Sticks

Simple, perhaps, but nevertheless not to be depreciated, is the method used by Bertram Reinitz, of 18 East Twenty-first Street, Brooklyn, N. Y. When he has to pick up nuts and carry them over to tight places, whereby the socket wrench must be used, with opening downward, he fills the wrench hole with soldering paste, puts the nut into the wrench, and the nut never falls out.

Canada Proposes Station in Windsor on 530 kc

Ottawa

The Canadian Broadcasting Commission is about to establish a broadcast station in Windsor, Ontario, on a wavelength of 530 kilocycles. As the United States is committed to a policy of prohibiting broadcasting below 540 kilocycles, another controversy with the Canadian Government may result. The United States, Navy and other federal services now are allocated below 540 kilocycles and have strenuous objections to any extension of the broadcast band below 540 kilocycles.

Canadian radio manufacturing interests also are reported opposing the establishment of the proposed Windsor station on 530 kilocycles.

Hearings on Communication

The Federal Communications Commission's Telegraph division held hearings in the matter of recommending laws to Congress that would authorize the consolidation of communication companies.

The following interests attended:

Postal Telegraph-Cable Company
Western Union Telegraph Company
Continental Telegraph Company
American Telephone and Telegraph System
American Radio News Corporations
Radio Corporation of America
Leon Cammen
Association of Western Union Employees
Commercial Telegrapher's Union
United Telegraphers of America
New Hampshire state government
Navy Department
War Department

RADIO WORLD

December 29, 1934
Current Meter Use Extended Voltages and Resistances Determined in Switch Instrument

By L. C. Forster

The diagram shows a circuit for switch operation of a volt-ohm-milliammeter.

The Accuracy Rating

Incidentally, this condition applies only to full-scale deflection, and for any readings less than full scale the actual ohms per volt will be less and the accuracy in use may be less. Therefore meter accuracy is based on one setting only, full-scale deflection, and all meter ratings should be considered accordingly. The accuracy of some other types of instruments, such as signal generators, applies to any setting. This difference must be carefully noted.

Now, if we have a meter that requires 1,000 ohms per volt at maximum deflection when used as a voltmeter for 10 volts, we would need 10,000 ohms for 100 volts, 100,000, for 1,000 volts, 1,000,000 ohms.

Since the scale reads 0-1, we may use the decimal factor conveniently, and then will not have to do any longhand figuring to determine a measured voltage. Thus, for the 10-volt scale, any reading within range, multiply the milliamperes calibration by 10 to obtain the decimal system.

For 1 volt, the resistance is 1/0.0001, from the formula R = E/I, where R is the resistance in ohms, E is the voltage in volts and I is the current in amperes. For a 0-1 milliammeter therefore the ohms-per-volt rating is 1,000.

How to Determine Shunts

At this point it becomes necessary to determine what the value of the shunts should be for establishment of practical ranges we have in mind. Let us say that (Continued on next page)
From this curve, it is possible to obtain the value of an unknown series resistance directly from the reading of the 0-1 milliampere meter used in this test. Example: meter reads 5. Look up the left-hand column where a meter reading of 5 will be found. Follow this line horizontally until it strikes the curved line, then note which vertical line intersects. Following this vertical line back on the scale, we read 15. This is 1500 ohms, the zeros having been left out on part of the curve sheet because of the cramped space. In like fashion, the 2 represents 2000, the 25 represents 2500, etc. If the battery voltage and series-limiting resistor are increased divide the new battery voltage by 1.5 and multiply the read resistance by the factor.

(Continued from preceding page)

The extension is to include 0-10, 0-100 and 0-1000 milliamperes. We must know what is the resistance of the meter itself. This in general is the resistance of the magnet coil winding. The manufacturer will supply the information. In two popular type meters, made by one manufacturer, the 0-1 milliampere resistance is 30 ohms, while another manufacturer's meter is 32 ohms.

The formula for determining the shunt is:

\[ R_s = \frac{R_m R_f}{R_m - R_f} \]

where \( R_s \) is the unknown shunt resistance, \( R_m \) is the meter resistance and \( R_f \) is the effective resistance resulting from \( R_m \) in parallel with \( R_s \). If the meter resistance \( R_m \) is divided by the extension factor, \( R_f \) is obtained. Thus for a 30-ohm instrument, 1 ma. to extend the range to 10 ma. the factor is 10, and \( R_f \) is 30/10 or 3. So applying the formula for 10 milliamperes we have

\[ R_s = \frac{30 \times 3}{30 - 3} = 3.33 \text{ ohms} \]

Simpler for Bigger Ranges

The greater extension factors the meter resistance may be divided by the factor, as the error is less than 2 per cent, the accuracy of the meter, so

\[ R_s = \frac{R_m}{K} \]

where \( R_s \) is the unknown shunt resistance, \( R_m \) is the meter resistance and \( K \) is the extension factor.

If we are to limit ourselves to a commercially obtainable two-deck, nine-position switch (double-pole, nine-throw type) we could bring out the meter terminals themselves for 0-1 milliampere, especially as we shall have another use for them, and could devote the nine positions to four voltages (1, 10, 100, 1000 volts); three currents (10, 100, 1000 milliamperes), and two resistance ranges, medium and high. The medium range could be afforded by a 1.5-volt cell and 1,500 ohms in series. As we have 1,000 ohms from the 1-volt scale we could use a carbon or metalized resistor of 400 ohms or so and a 400-ohm rheostat, and thus have a zero adjuster. And for the high-resistance range we could use a 10,000-ohm inexpensive limiting resistor and a 5,000-ohm rheostat, picking up the 10,000-ohm voltmeter series resistor, as we would use a 22.5-volt battery, requiring 22,500 ohms.

The Zero Adjusters

The reason for the adjusters is that the battery resistance changes with age and use and must be compensated for, so the zero adjustment is made each time resistance is to be read. Because of the zero adjustment the inexpensive resistors become practical in the ohmmeter circuit only. All other resistors should be wire-wound, for constancy.

The range resistors so far discussed may be considered as 100 to 5,000 ohms and 1,000 to 2,000,000 ohms. What the range limits are depend to some extent on what you consider fairly legible conditions. The difference between unknowns of 1,000,000 and 2,000,000 ohms is small, between 2,000,000 and 3,000,000 ohms so small that it is not well to assert that 3,000,000 ohms can be defined, except as greater than 2,000,000.

Now there often arise occasions when low resistance shunt must be determined. This is ordinarily done with a high-current circuit. However, we have no such circuit in our ohmmeter inclusion, nor any batteries or cell that will stand high current. But we do have a meter that, when closed as an ohmmeter for either of the two ranges discussed, can be shunted. Since the meter resistance is low, and known to be 30 ohms, we can determine what currents will flow when unknown small resistors are shunted across the meter alone, with other ohmmeter circuit closed. The medium-resistance circuit is selected for closing (by switch setting to position R1), and the two terminals of the meter, brought out for 0-1 milliampere reading purposes originally, will be used for connection of the small unknowns.

Calibration for Ohmmeter

Let us take the simplest example. If the meter resistance is 30 ohms, and a circuit is set up to cause full-scale deflection, suppose a small unknown is shunted across the meter, and causes the meter reading to be 0.5 milliampere. What is the resistance of the unknown? It is obvious that the same 1 milliampere total is flowing with, but only half of the current is flowing through the meter, the half through the shunt. What resistance shunt will detour exactly as much current through itself as it permits through the meter? A resistance equal to the meter resistance. Therefore the unknown is 30 ohms. Thus one may tell quickly whether a resistor is equal to, more than or less than 30 ohms. Of course one would desire integral values.

The ohmmeter service in general is not a part of the calibration because the meter scale is linear for current (hence for voltage readings), but is far from linear for any resistance measurement. Hence the original meter calibration can not be interpreted. Instead, either a special scale must be used, or one may refer to charts. The chart for 0-1 milliampere, 1.5-volt dry cell, and 1,500 ohms limiting resistor, is shown. The high-resistance scale is applicable to this curve as explained in the caption above. The low-resistance example is shown on a separate curve sheet.

The switch stops are given position numbers, 1 to 9 inclusive. E9 reads the highest voltage, 1,000; E8, E7, E6 the succeeding lower voltages. So the highest current, 1 ampere, is read at the 15 posi-
Shunt Meter to Measure Small Resistance

When the meter is shunted by the unknown resistance, quite low values of resistance may be measured by reference to the curve shown. The procedure here is similar to that employed with the other curve and accordingly need not be repeated here. Any condition causing full-scale deflection makes this curve apply to the 0-1 milliammeter.
How to Determine Unknown Shunt Resistances

Improved Standards for Sets and Tubes

Nomencature of radio receiving sets and also of tube numbering standards have been perfected by the General Standards Committee, of Radio Manufacturers Association, Virgil M. Graham, of Rochester, New York, chairman. In considering the industry definitions of receiving sets, the committee revised two standards as follows:

A Standard Broadcast Receiver is one which will respond to the entire broadcast frequency range of 540 kilocycles (552 meters) to 1600 kilocycles (187 meters)."

An All-Wave Receiver is one whose tuning ranges will respond to all frequencies between 540 kilocycles (552 meters) and 18,000 kilocycles (16.6 meters)."

Definition of the "Standard and All-Wave Broadcast Receiver" is having further study by RMA committees with a view to a better definition.

The General Standards Committee has also adopted as RMA standards the "Requirements on Power Operated Receiving Appliances" of the Underwriters' Laboratories. This action is to effect adoption of these standards by the American Standards Association for establishment in pending ordinances of New York City and other municipalities in local regulation.

The new tube standards adopted by the General Standards Committee provide for designation of types of receiving tube bases by a system of three digits, the first being a letter indicating the size and type of base shells; the second digit being a figure, indicating the number of pins; and the third digit a letter, indicating the pin arrangements.

Average Hourly Wages - 53.3 Cents in September

Radio excise tax collections during October, 1934, were $280,699.11. This compares with excess taxes of $305,291.75 during the previous month and with $292,332.20 in October, 1933.

The September, 1934, report on radio factory employment of the U. S. Department of Labor, Bureau of Labor Statistics, indicates slight changes in employment conditions from those of last August. During September, 1934, fifty-eight radio and phonograph establishments reported employment of 39,999 employees as compared with 39,063 employees reported in sixty radio establishments during the previous month. No wage changes during September were reported.

During September, 1934, per capita weekly earnings of the reporting companies were $18.36, an increase of 2.1 per cent over August, 1934, and 8.7 per cent over September, 1933.

Average hourly earnings of radio employees during September, 1934, were 53.3 cents as compared with 53.9 cents during August, 1934, but 12.4 per cent larger than average hourly earnings during September, 1933.

Radio employment indices during September, 1934, compared with the three-year average of 1931-32, were 219.9 per cent, an increase of 12.3 per cent over September 1933. Payroll indices during September 1934 as compared with the three-year average were 17 per cent, an increase of 22 per cent over September 1933.

(Continued from page 8)
Improvised Kite Aids Ham

Carl L. Gartner, of 200 East Sixteenth Street, New York City, had hardships in putting up a short-wave antenna, because he lives in a twenty-story apartment house. However, he solved the problem he tells us as follows:

The house antenna system is far from efficient for short waves. Having a short-wave set I was desirous of installing an antenna of my own, but the landing on my floor was so small that this could not be done. I finally decided on running wires along the window ledge of the apartment, but the difficulty was that there was a corner apartment and I would not have sufficient length of wire on any one side.

To run around the corner to the next window seemed almost impossible, as I am on the eleventh floor and I didn’t have enough wire to drop two lines to the street, and that would be too apparent to the doorman or visible to some other tenant as the line passed his windows. Each of the windows I had to work from was some ten to fifteen feet from the corner and there was no way to pass around.

I made a miniature kite out of a tiny piece of paper and attached it to a thimble of sufficient strength. Fortunately the wind was from West to East that day, the direction the wire first had to take, and my kite carried out past the end of the building. Now, as you may have often observed, when a breeze passes a building of this nature, there is bound to be a back eddy at the end of the building. Thus my kite quite promptly shot around the corner and then it was only a matter of waiting a few moments for the string to pass my hand at the second window, draw it in, attach my wire back at the first window and then draw it carefully around the corner. I assure you that the results obtained with this new aerial quite repaid the effort expended and I proceeded to get a valuable treasure of DX on the 49-meter band, a range that I had previously skipped on the old antenna.

B Eliminator Trouble

I HAVE a three-tube ham short-wave receiver which works fine on batteries. However, I recently bought an eliminator for this set and cannot stop a loud low-frequency oscillation from creeping in. Is it possible to get rid of this disturbing noise?—M. L. K.

You are probably experiencing the phenomenon known as B eliminators. This is caused by the fact that the various stages of your receiver are intercoupled through the eliminator which causes these low frequency audio oscillations to be generated. You may attempt to minimize this reaction by placing an audio choke coil in the direct plate supply line of sufficient size to prevent this action. Another scheme utilizes a resistor of about 10,000 ohms in series with the high voltage plate supply line across the high-voltage line on both sides of this resistor should be placed a 2 mfd. condenser for bypass purposes. This action, of course, would not be necessary if the original B voltage be slightly raised to compensate for the drop in the series resistance.

Television Amateur Work

WHICH AMATEUR band is mostly used for television purposes? To construct an amateur short-wave radiophone, can a custom-built short-wave receiver be used as the receiving end? Which amateur-frequency is unlimited in its use for radiophone?—W. C. G.

The majority of amateurs who have engaged in television transmission have used the band 1715 to 2000 kilocycles. However, now that the ultra short waves are being more exploited, it would not be surprising to see this endeavor soon utilize the other band available for amateur television work—56,000 to 60,000 kc.

The manufactured receiver that you mention in your letter may be used for the reception of amateur short-wave messages. However, it is apropos to mention that ordinary all-wave receivers put out by broadcast receiver concerns are not as suitable since they do not possess the necessary selectivity for the crowded signals of the amateur bands. The government has set aside the series resistor for radiophone communication that can be used by beginners not licensed with Class A licenses: 1800 to 2000 kc., 28,500 kc., 60,000 to 60,000 kc., and 400,000 to 401,000 kc. Of course, it is understood that the operator must either have a Class B or C operator’s license.

Quiet Hours

WHAT ARE the quiet hours that the Government may impose upon amateur radio operators?—H. G. N.

In the event that the operation of an amateur radio station causes general interference to the reception of broadcast programs with receivers of modern design, that amateur station shall not operate between the hours of 8 p.m. to 10:30 p.m., local time, and on Sunday from 10:30 a.m. to 1 p.m., local time, upon such frequencies or frequencies as cause such interference.

Condenser Voltage Test

HOW MAY a condenser’s voltage rating be most effectively tested?—O. M. B.

Solid disc condensers, as used in fixed condensers, will break down at different voltages dependent upon the temperature, the length of time they are subjected to the voltage, and sometimes the humidity. Therefore, Radio Manufacturers Association, Inc., has established that the voltage test for fixed condensers should be: Connect the condenser to a source of direct voltage that is twice the rated working voltage. This connection should be maintained for fifteen seconds and must not break down under these conditions. The condenser should then be immediately discharged through a suitable resistance that will limit the discharge current to not more than one ampere. The working voltage is usually marked on the case of the condenser and should be known since it is this value that it is desired to verify.

Wavelength Formula

WHAT IS the formula that is used in the calculation of frequency from wave-lengths?—L. M.

This relation is: 

\[ \lambda = \frac{c}{v} \]

where \( \lambda \) is the wave-length in feet, \( c \) is the velocity of radio wave in 10,000 miles per second, and \( v \) is the frequency in cycles per second.

It will be seen that to convert frequency and wave length, it is necessary to know the velocity of the radio wave. Until a few years ago, this figure was accepted as 300,000,000 meters per second. However, subsequent measurements of greater accuracy have evolved this figure as 299,820,000 meters per second. Incidentally, it should be appreciated that this velocity will vary slightly in accordance with the temperature of the terrain over which the wave passes, so that the computations should in reality utilize a wave velocity that is variable. But, for the present, the present state of the art does not provide us with these exact measurements and also since their effect upon the final result is trivial, this factor need not concern us too much.

Rochester Convention Feb. 9

The ham gang at Rochester, N. Y., intend to have its annual convention in that city on Saturday, February 9, according to Johnny Long, chief engineer of WAM. Several manufacturers, including Clark Rohman of the A. R. R. L. and Dr. B. T. Simpson, W8CIC, will be heard.

THE "CAP" OF A TUBE

The metal projector at top of screen grid tubes is often called a cap, but the clip or cup put on it comes nearer to being a cap.

Improvised Kite Aids Ham

Carl L. Gartner, of 200 East Sixteenth Street, New York City, had hardships in putting up a short-wave antenna, because he lives in a twenty-story apartment house. However, he solved the problem he tells us as follows:

The house antenna system is far from efficient for short waves. Having a short-wave set I was desirous of installing an antenna of my own, but the landing on my floor was so small that this could not be done. I finally decided on running wires along the window ledge of the apartment, but the difficulty was that mine is a corner apartment and I would not have sufficient length of wire on any one side.

To run around the corner to the next window seemed almost impossible, as I am on the eleventh floor and I didn’t have enough wire to drop two lines to the street, and that would be too apparent to the doorman or visible to some other tenant as the line passed his window. Each of the windows I had to work from was some ten to fifteen feet from the corner and there was no way to pass around.

I made a miniature kite out of a tiny piece of paper and attached it to a thimble of sufficient strength. Fortunately the wind was from West to East that day, the direction the wire first had to take, and my kite carried out past the end of the building. Now, as you may have often observed, when a breeze passes a building of this nature, there is bound to be a back eddy at the end of the building. Thus my kite quite promptly shot around the corner and then it was only a matter of waiting a few moments for the string to pass my hand at the second window, draw it in, attach my wire back at the first window and then draw it carefully around the corner. I assure you that the results obtained with this new aerial quite repaid the effort expended and I proceeded to get a valuable treasure of DX on the 49-meter band, a range that I had previously skipped on the old antenna.

G. C. Willecke, Box 24, Unity, Wisconsin.
Frederick Panozzo, 1026 Chatham Park, Peoria, Ill.
Charles Mentrel, P. O. Canada.
Eugene Popik, 1316 Duss Avenue, Ambridge, Pennsylvania.
George J. Heldman, 2836 Southport Ave., Chicago.
Jack Downies, 22-23 110th Street, Corona, N. Y.
Fred Moon, Box 234, Lewistown, Pa.
John W. Nectett, P. O. Box 29, Chico, Illinois.
M. A. Jones, 110th St., Los Angeles, Calif.
Andrew Adams, Second Casual Co., Fort Slocum, N. Y.
Herbert Reck, 536 So. W. A St., Richmond, Indiana.
A. E. Bryant, 411 Warren Ave., Lynneburg, Va.
Chester Reeve, Radio Service, P. O. Box 6, Beaumont, Tex.
Jack Cannonett, Jr., c/o R.K.O. Prospect Theatre, 327-39th St., N.W., N. Y.
James Quint, Route 1, Box 67, Terraceville, S. C.
Chilton James, Bryce Avenue, Pa.
E. W. Johnson, 38 Olea St., Hingham, N. Y.
Joseph Nicolici, R.F.1, 2 Box 6, Altona, Pa.
John A. Ostrum, 145 Main St. East, North Bay, Ont., Can.
C. H. Primus, 611 E. 21st St., Los Angeles, Calif.
Leopold Blauth, Aviencia, Bolivia, No. 22, Santa Domingo, Dominican Republic.
FACTORS THAT DETERMINE THE FAITHFULNESS OF THE BROADCAST RECEPTION

SEVERAL years ago the ordinary broadcast receiver in a console was quite the rage. Time however soon rendered this type of installation secondary and the midget and pygmy receivers were introduced to stem the tide of a waning market. These gadgets proved to be the answer to the public’s prayer since they were purchased by many because of the low cost. The depression caused the public to lay more stress upon the monetary side of their purchases so that the poor quality rendered by these small receivers was forgiven. However, the more universal did these receivers become, the more apparent was the blatant cacophony, so that a waning interest again became general.

Effect of Channel Width

Though the operation of these high fidelity sets is limited by the fact that broadcast stations are allocated every ten kilocycles which allows a maximum audio channel 3 kilocycles in width, it is hoped that eventually this limitation will be obviated by a change in the allocation scheme, or perhaps through the general use of transmitters with single side bands. Until that takes place, it is necessary to equip these high fidelity sets with a variable control of the audio band width according to whether or not a station in an adjacent channel is powerful enough to mar results above 3000 cycles.

It should be generally conceivable that the adoption of high fidelity characteristics for broadcast receivers is a real substantial benefit to the enjoyment of broadcast programs. But what is high fidelity and what determines its limitations? To understand that, it is necessary to allude to the diagram showing the ranges of various musical instruments, etc., in connection with an appreciation of the characteristics of the human ear.

Broadcast programs comprise audible modulations of a radio wave which when received and suitably rectified by a receiver will be made to affect the human ear. In this process, the broadcast transmitting apparatus, the receiving apparatus and the ear will determine what the results will sound like. Of course, the person at the receiver can not control the operations of the transmitter and so a consideration of this phase can be neglected here.

Many Stations Do Well

This does not necessarily indicate that broadcast transmitters are in need of consideration in this respect since many of them have been refined to the point where they may be classed as high fidelity instruments. Accordingly, the output of a great many of the transmitting plants of the broadcast stations around the country may be considered to be of good quality.

The fidelity with which a sound is reproduced by a radio receiver after the manner upon the faithfulness with which the studio walls, the transmitter, the sound’s electrical counterpart. These sketches indicate, in the lower part, indicates the pitches that emanate from various musical instruments and pitch ranges of the various instruments represent the limits.
wave has traveled over the vast spaces of its ethereal journey depends primarily on the receiver and even the listener's ear will affect or be affected by the original sound. A normal ear will react to various sounds. The upper part of the sketch shows three human voices. The numbers appearing after some of the lines indicate the ranges of the individual instruments extend.

Attributes of Sound

This is not a phenomenon attributable to deafness, since the hearing at the lower frequencies may be perfectly normal. It will be understood that sounds possess three attributes: Pitch (synonymous with frequency of vibrations and tone), Volume (synonymous with air pressure in dynes per square centimeter), and Timbre (synonymous with overtones and harmonics). It will be noted in the sketch that the overtones of various instruments are indicated as numbers at the end of the lines showing pitch range. The curves that have been referred to above indicate the potentialities of the average human ear with respect to various volumes of different pure sounds at one pitch. It will be seen from it that the ear will respond to all sounds within the area of the closed loop of the curve that have the volumes indicated. When the volume of the sound is such that it is below the lower curve of the loop, it will not be audible to the ear.

In this connection, it is interesting to see that the notes corresponding to the octave on the piano between the vibrations of 1024 and 2048 will affect the ear most easily. That is to say, these notes require the least energy to make themselves audible to the average human ear.

Effect on Ear

On the other hand, when the volume of the sound is such that it occurs above the upper curve of the loop, it will affect the ear with a sense of feeling rather than with hearing. To put it another way, the amplifier will feel his head vibrating when these high intensities are inflicted upon him. This is, of course, not a desirable state of affairs and should be avoided, for continued subjection to such intensities would be disastrous psychologically. Further deductions may be drawn from these curves. It will be seen that the lowest frequency to which the ear is sensitive is in the vicinity of about 20 cycles, and that the upper limit is at about 20,000 cycles. Thus, we needn't concern ourselves with frequencies below or above this range since the ear will not hear them.

From the upper portion of the diagram will be seen the tonal ranges of various common sounds that are heard in broadcast programs. It will be noted that these ranges are given as the pure tones (Continued on next page)
(Continued on next page)
dered by these instruments in other words, it concerns only the fundamental frequencies involved. A most important factor of musical instruments is that the tones derivable from them contain a great number of overtones or harmonic frequencies which comprise the instrument’s timbre.

Recognition Made Possible

It is these overtones that permit the auditor to recognize one instrument from another. Should these overtones not be heard, the identity of the instrument would be lost and the efforts at high fidelity would be defeated. It is accordingly pertinent to mention that the ranges of the instruments shown should in reality be continued further so as to include the overtones.

If the frequencies were done, it would be found that the overtones of the piano occur up to 5500 cycles, the piccolo to 9,000 cycles, the bassoon to 14,000 cycles, the violin to 14,000 cycles, the cello to 8500 cycles, etc.

Interesting additional sounds are those due to handclapping which require a frequency range of 350 to 16,000 cycles; jingling keys, a range of 1,000 to 16,000 cycles; foot steps, a range of 100 to 15,000 cycles and the snare drum, a range of 90 to 14,000 cycles. Thus, it can be seen that for absolute high fidelity reproduction of sound, it is necessary that the equipment be capable of transmitting frequencies between about 20 cycles to about 16,000 cycles.

Frequency Range

Well, the ear will do that or it will be restricted in this ability by various human frailties; but this is our starting point. We might consider this ideal case of a condition that isn’t as comprehensive in scope may still be satisfactory for the average person.

This frequency range would thus require that the radio frequency carrier of a transceiver be capable of modulation up to 16,000 cycles. This would necessitate that broadcast stations be allocated into channels that are further apart than 10 kc, but, since such a condition does not exist at present, present day high fidelity set manufacturers have decided that the upper limit can be 75 cycles without a serious effect upon the fidelity. This may be accepted since most of the sound energy exists in this region and those harmonics which come outside this range are quite weak and not readily missed by the average ear.

Now to understand the limitations imposed by the human ear, we should realize that the receiver is the next consideration which will affect the sound to be reproduced.

Quite a Problem

It is quite a manifold problem to design receiving equipment that will render a frequency range of 2500 cycles to 7500 cycles with equal effectiveness since this ability is affected by all the gadgets in the equipment. These gadgets may be categorized into the r-f stages, the oscillator stage, the stages, the detector stage, the a-i stage, the loudspeaker, and any other special devices. In all stages except the audio tuning instruments are provided. Because no variations are thus permissible in the audio stages, the selectivity and fidelity of this part of the circuit will be fixed under ordinary circumstances. Since no variation can be obtained, as ordinary sets go, it is desirable that the audio stages be designed especially for fidelity purposes. We shall accordingly consider the various types of audio frequency amplifiers available.

Audio frequency amplifiers are classed into three groups generally and may be one of the following types: (a) resistance-coupled; (b) transformer-coupled. (See first three diagrams on this page.)

Although the resistance-coupled audio amplifier is the simplest type of audio amplifier from an elementary point of view its design and construction present considerable practical difficulties. To obtain an amplification per stage approaching the amplification factor of the tubes used it is necessary to use an inserted plate resistance considerably larger than the internal resistance of the tube and so that the plate voltage supply must be quite large so as to enable the tube to operate at the desirable portion of the characteristic.

The use of tubes with low amplification factors taking plate currents of a few milliamperes is limited in resistance amplifiers. This limitation is removed by the use of tubes with high amplification factors and high resistances in which the plate current is only on the order of 100 microamperes. This current of course does not cause an excessively low effective plate voltage despite a high load resistance and so the difficulty mentioned is minimized. By this means, a plate voltage supply in the order of 180 volts is quite satisfactory.

Problem of Resistor

Serious progress in the design of resistance-coupled amplifiers started when the large resistances used in audio amplifiers were used in conjunction with tubes having voltage amplification factors as high as 10,000. Since then, progress in this field has been rapid. The high amplification obtainable from resistance-coupled amplifiers using these tubes has rivaled the results obtained by the transformer method.

A resistance-coupled amplifier is preferable to that of the impedance or transformer methods due to a better frequency characteristics, assuming that the capacity shunting effect of the succeeding stages is negligible. Owing to the lack of a step-up action, however, an amplification factor of the tube must be high if the overall amplification of the stage is to compete with the transformer coupling. Since this high amplification factor as yet can only be obtained by a tube with a high internal resistance, the plate resistor inserted into the output circuit must be large and the plate current necessarily becomes small. The design of this plate resistor has proceeded originally in itself, since the old compound and carbon types have small power dissipation, and create microphonic difficulties. Wire wound resistors, on the other hand, were found preferable but the self-capacity was large and the dimensions such that component was bulky. The vacuum type of resistor using a metalized filament has to a some extent replaced previous forms of audio resistor because of small self-capacity and bulk.

The Capacity Effect

A high amplification factor tube with a large plate resistance gives great input impedance, and the shunting effect of the complete stage is serious, thereby reducing the effective plate impedance of the preceding stage at high frequencies. This effect plays a very important part in the operation of the amplifier and somewhat offsets from high frequency limitations of the tube with the high amplification factor. The coupling condenser between stages must be large if the latter stage is to pass and this condenser must have a very high insulation resistance, since it is connected directly between the plate of one stage and the grid of the next. If this condenser is too large, the time constant of the condenser and grid leak may be so large as to prevent the system from suffering from temporary paralysis of action due to grid condenser charges resulting from occasional abnormal large signals.

These defects have led some to use more stages of tubes with high amplification factors and small coupling resistors, the lower plate resistors serving to prevent serious frequency dependence and the smaller grid resistor serving to maintain bias stability, due to low resistance confronting any possible grid current.

We can generalize the theory. It might be stated that (1), the use of tubes with high amplification factors causes a small plate current to flow, and (2) that the resistance if the plate potential supply is kept within reasonable limits. This means that the input impedance of the system will be low due to a large stage factor, with consequent reduction in the amplification at high audio frequencies which will result in frequency distortion (2).
The use of tubes with low amplification factors permits an improvement in the frequency characteristic of the transformer, but a larger coupling condenser becomes necessary to maintain the low frequencies. The difficulty here lies in the fact that a transformer temporarily paralyzing the normal action of the tube and the requirement of the use of a greater number of stages.

**Combined Method**

Notwithstanding the difficulties outlined above, the resistance-coupled amplifier can be improved and the amplification frequency characteristic of the transformer type of amplifier, though usually at the sacrifice of uniform amplification at all frequencies. By such an arrangement high and low audio frequencies can be equally transmitted through the system.

In concluding these statements on resistance coupling, it might be well to indicate that when a coupling condenser of 0.006 mfd. is used, the range of frequencies extended to as low as 30 cycles. This good response on the low frequencies, however, increases the possibility of trouble from a coupling condenser since by-pass condensers ordinarily used are not very effective at very low audio frequencies and therefore a by-pass condenser plate supply must be considered as a coupling between stages. This coupling gives rise to oscillations in the amplifier called "motor boiling," which actuates the plate supply by using a low resistance grid leak across the input circuit of each stage or by using a smaller coupling condenser.

**Impedance-coupled Amplifier**

The impedance method of coupling consists, usually, of the same circuit as the resistance-coupled system except that the plate resistor is replaced by an audio choke coil. The action of such a circuit is similar to the coupled transformer. With the choke coil in the output plate circuit, however, it is possible to obtain an arrangement whereby a high impedance is presented to audio frequencies at the same time that a low resistance is presented to the current flow. Thus the plate supply's potential need not be as great as in the case of the pure resistance coupled system and the tube, the plate impedance. Of course, this is obviously an advantage. However, this advantage is somewhat nullified by the poorer frequency characteristic of the circuit and also perhaps by the inductance which has a definite frequency discrimination towards the higher audio frequencies. It is evident that the impedance method of coupling has been practically discarded.

**Transformer-coupled Amplifier**

The transformer-coupled amplifier has been more generally used because of the greater amplification available through the use of a transformer. Its use has been prevented, however, by the fact that its frequency characteristic is not as good as that of the resistance-coupled method. Accordingly, to put it differently, it can be said that the advantage of step-up effect obtainable by the use of transformer coupling so that the amplification factor of the stage is greater than the voltage amplification factor of the tube alone is the cause of certain disadvantages. The frequency response of the early type of transformer was so poor that it has been vastly superior. But, due to the development of transformers with large primary inductance and low second-order self-capacitance, the transformer of audio can now give a characteristic in some ways preferable to the resistance coupled type. Hence the transformer-coupled stage is found to possess a frequency response characteristic that has two peaks corresponding to the first and the second resonant frequency of the transformer. The sharpness of these peaks and the frequency at which they occur are largely dependent on the ratio of plate resistance and input resistance of the tube. By suitably arranging the tube constants, it is possible to damp out almost completely the first resonance point and maintain the second one at a frequency in the neighborhood of 4,000 cycles or over. The characteristic is therefore that of two frequencies where the resistance coupled stage tends to fall off.

**Voltage Amplification**

Although a well-designed resistance-coupled system has a frequency factor, low internal resistance tubes give a better frequency response than the transformer type, a well designed transformer stage usually has a better response characteristic than can be obtained with a resistance stage using high mu tubes, owing to the higher resistance and interelectrode capacities. The combination of the resistance and transformer types of amplifiers gives the best arrangement for an amplifier tube 100 times the input voltages.

The purpose of the amplifiers mentioned above has been to increase the base voltages so that the output voltage is greatly increased as compared with the voltage fed to the input of the amplifier. Effectively to work modern dynamic speakers it is necessary that large power rather than high voltage be introduced into the voice coil of the speaker. Therefore, the need exists for an amplifier that amplifies power rather than voltage, and, in this connection, the reader is referred to the next two sketches in the diagram, where the push-pull and Class B arrangements are shown. The Class B amplifier is a special case of the push-pull arrangement. An explanation of these two circuits follows.

**Case of Class B**

It has been intimated that the power stage is a converting mechanism whereby high voltage changes are transformed into high power changes. Since the output of the output transformer is demand that is large, tubes of high mutual conductance and with a long straight characteristic are needed. The most effective of these need a push-pull or a push-pull circuit, and it is capable and appear in either one of two types: the form known as a "push-pull" and the form known as Class B. The push-pull arrangement involves two tubes operating back to back on the straight portion of the tube's characteristic. The Class B arrangement operates on the portion of the characteristic ordinarily occupied by detectors and lower bend. In this circuit it is not essential that the tubes be perfectly matched although it is preferable for best operation. In the case of Class B amplification, it is imperative that these two tubes be perfectly matched. It is for this reason that the amplification of the output tube has been made in one envelope, like the 53 and 29 type tubes. Thus, automatically, two matched tubes are obtained. Push-pull amplification offers four major advantages over ordinary amplification.

1. It more than doubles the limit of voltage output because the output is the sum of the output wattage of both tubes, plus the extra volume limit obtained by the push-pull working for a part of its characteristic. The amplification of a single tube is limited to the straight part of its characteristic; therefore the output is limited to a characteristic to bend causes distortion. Push-pull amplification practically removes this limitation.

2. Distortion, due to tube overload when operating at the upper volume limit, is reduced. Voltages in push-pull are canceled out and do not appear in output — permitting greatly increased power output. These grid voltages are due to the amplification of the output stage and give a curved part of its characteristic — introducing harmonics of the original frequency. Due to the relation these cancel out and no distortion is introduced in the output. The working range in a push-pull amplifier is not limited to the straight part of the tube curve.

3. A. C. hum in the speaker is practically eliminated by using A. C. on the filament of the power tube. The hum is on the grids of the two tubes cancel out in the output.

4. Saturation of the core by the constant component of plate current from the output transformer, is eliminated, together with the tendency to cause wave distortion at the low frequencies.

**Power Tubes**

The importance of a power tube (two, in push-pull) in the last stage of a receiving set cannot be overstated. The liquid sound demands a large output of power expressed in watts. This power can only be furnished by a power tube capable of delivering sufficient wattage.

**Direct Coupling**

It will be noted from the diagram that the direct coupling method of audio-frequency amplification takes a step in the direction of Class B by connecting the plate of the first stage directly to the grid of the second stage. At first glance this would seem to indicate that the grid of the second stage be at the same high positive potential that the plate of the first tube is. If this is so, how do these operate? It will be noted that the theory of this concept that grids should never go positive in order to avoid distortive influences, which is true for the push-pull type.

All this is true, but we have not studied the circuit sufficiently. It is to be understood, first, before reversing the diagram, that the potential of the grid of a vacuum tube is not what the potential of a battery connected to it is, but rather it is the potential that exists between the grid and cathode within the tube itself. Thus, if 100 volts positive are impressed upon the grid the potential across the grid and cathode of the tube will be the algebraic sum of these two potentials, and not the 100 volts positive of the original potential. This is the situation in the push-pull coupled amplifier. In the push-pull circuit, the push-pull arrangement due to the diagram, it will be seen that the cathode of the second tube is at a higher potential. The second tube is receiving a seemingly high potential on the second tube's grid is in reality a negative bias on the grid as it should be.

The advantage of using this system is, in practice, low weight, low bulk, high gain and the fact that any frequency can be handled with practically no frequency discrimination or wave-form distortion. The amplifying possibilities are limited only by the power handling capacity of the tube, and accordingly, it is advantageous to utilize a screen grid tube in the first stage because of its high amplification factor.

(Continued on page 21)
An Understanding of Light
As Groundwork for Photo-Electric Cell Use

By Samuel Wein

The light from a 50 candlepower lamp varies inversely as the square of the distance between the source and a surface. Various light units are handy in the description of light conditions on a surface as shown in the sketch.

The last five years the photo electric cell has received more combined attention of engineers and students than has its first cousin, the multi-element vacuum tube. I don't want to be misunderstood in my comments that the vacuum tube has made no progress; on the contrary, it has. But the progress made in photoelectric cell techniques in the last five years surely exceeds that of the vacuum, including adaptations, though the "cell" is so closely knit with the multi-element vacuum tube.

If I were to be asked to co-ordinate all of the uses to which cells are put in technical as well as commercial uses, it would fill one issue of Radio News. Take any one to cover; to cover. The number and types of light-sensitive cells in common use are becoming great in number. Each of these cells has its particular physical characteristics. It is well that we first have a review of the electrical characteristics of light, for association of these characteristics of the cells.

Ratings Considered

When we purchase electrical devices as, for instance, a motor, to serve a particular purpose, it is necessary that we know the requirements of the motor, so that we can intelligently adapt it for the use to which it is to be put. In other words, the motor is rated in horsepower (HP), volts (EMF), current in amperes (I), watts (W), kilowatts (KW), etc., in terms of generally accepted electrical units used. In radio-electric art, it is equally essential that the conditions to be encountered for a particular installation be understood, and that some standard terminology be adapted which may be readily interpreted by another who is familiar with this work.

The following definitions of light units are given, together with practical information as to the actual values of such units in tangible form.

Before we discuss these light terms we show the various forms or means for creating light in the following series, which have been used from time to time.

The definitions given here have been taken from the report of the Standards Committee of the Illuminating Engineering Society, and in some instances amplified.

Unequal Eye Sensitivity

For the purposes of studying the effect of electrical effects of light, light is radiant energy evaluated in proportion to the luminous sensation produced by it.

Visible radiation or luminous flux lies roughly between the wavelengths of 400 and 700 microns, which is less than one octave of the electromagnetic spectrum. Radiation in wavelengths immediately below the violet end of the visible spectrum (400 millimicrons) is called ultra-violet rays, which are invisible. Radiation immediately beyond the red end of the visible spectrum (700 millimicrons) is called infra-red rays, which are also invisible.

The eye is not equally sensitive to all colors in the visible spectrum for the same intensity of radiant flux. For example, if a yellow light, a blue light and a red light have the same intensity of radiant flux,

that is, if they radiate to a surface the same amount of energy per unit area, per unit time, the yellow light produces much more illumination or luminous flux than the blue or red.

Radiant Flux

This is the time rate of flow of radiant energy. It is expressed preferably in ergs per second or in watts.

Luminous Flux

Luminous flux is the time rate of flow of light.

Lumen

This is the unit of luminous flux. It is equal to the flux in a unit solid angle (steradian) from a uniform point source of one lumen, or to the flux on a unit surface all points of which are at unit distance from a uniform point source of one lumen.

If a 21-candlepower lamp had its filament placed at the center of a sphere of one foot radius, it would deliver 21 lumens to each square foot of the sphere's surface.

Luminous Intensity

Luminous intensity, in a given direction, is a solid angular flux density in the direction in question. Hence, it is the luminous flux on a small surface normal to the direction divided by the solid angle (in steradians) which the surface subtends at the source of light.

Mathematically a solid angle must have a point at its apex; the definition of luminous intensity therefore applies strictly only to a point source. In practice, however, a light emanating from a source whose dimensions are negligible in comparison with the distance from which it is observed may be considered as coming from a point.

Candlepower

This is luminous intensity expressed in candles. An international candle is one candlepower, two international candles constitute a two candlepower light source, etc. The candlepower was uniformly used extensively in rating incandescent lamps. Many such lamps are now rated in wattage consumption. However, automobile lamps which are commonly used as light sources for photo-electric applications are rated in candlepower. The candlepower is generally given for a specified direction from the lamp, since obviously the light flux emitted in the direction of the base is not the same as that from other parts of the bulb. If a lamp is rated at 21 horizontal candle power, the information is intended to mean that in a horizontal plane the lamp produces the effect of 21 international candles theoretically placed at the position of the filament.

Illumination

The density of the luminous flux on a surface, or the quotient of the flux by the area of the surface when the latter is uniformly illuminated.

Foot Candle

This is the unit of illumination when the foot is taken as the unit of length. It is the illumination on a surface one square foot in area on which there is a uniformly distributed flux of one lumen, or the illumination produced at a surface all points of which are at a distance of one foot.
from a uniform point source of one candle.

The Lux

This is the practical unit of illumination in the metric system, equivalent to the "meter-candle." It is the illumination on a surface one square meter in area on which there is a uniformly distributed flux of one lumen; or the illumination produced at a surface all points of which are at a distance of one meter from a uniform point source of one candle.

Brightness

This is the quotient of the luminous intensity of a surface measured in a given direction by the area of this surface projected on a plane perpendicular to the direction considered. In practice, no surface obeys exactly the cosine law of emission or reflection; hence, the brightness of a surface generally is not uniform, but varies with the angle at which it is viewed.

The Lambert

The unit of brightness is equal to the average brightness of any surface emitting or reflecting light at the rate of one lumen per square centimeter, or the uniform brightness of a perfectly diffusing surface emitting or reflecting light at that rate. For most purposes, the millilambert, 0.001 lumen, is the preferable practical unit.

Brightness expressed in candles per square centimeter may be reduced to lamberts by multiplying by \( \pi \).

Brightness expressed in candles per square inch may be reduced to lamberts by multiplying by \( \pi /6.45 = 0.487 \).

The "flux on white" used by some Europeans is the same kind as the lambert, and is equal to 0.1 millilambert.

Cosine Law

The illumination upon a surface which is inclined to the direction of the light rays is less than it would be if it were perpendicular to it, and is equal to the illumination perpendicular to the direction of the light multiplied by the cosine of the angle of incidence. Combining the inverse square and cosine laws we get

\[
\text{Illumination} = \frac{C_p}{D^2} \cos \theta
\]

where \( C_p \) is candlepower of the source, \( D \) the distance between the source and the surface, and \( \theta \) is the angle of incidence.

Radiation

Radiation is the transmission of energy through space by electromagnetic waves. Radiant energy may emanate from a body by reason of its temperature, as for example from a heated filament of an incandescent lamp, or as a result of electrical or other excitation, as for example in the arc or spark of a neon lamp.

All of the known forms of radiant energy, such as cosmic rays, gamma rays, X-rays, ultra-violet rays, visible light, infra-red rays, Hertzian waves and radio waves, are electromagnetic waves, the only difference between them being in the frequency and wavelength. The length of the electromagnetic spectrum extends from a wavelength less than 0.00005 mill-microns in the cosmic-ray region to more than 20,000 meters, which is a long radio wave.

Inverse Square Law

The intensity of illumination produced by a point source varies inversely as the square of the distance from the source. For example, the illumination on a surface placed at a distance of two feet from a luminescent source of one candle is one-quarter (1/4) of a foot-candle.

To carry the example of the 21 candle-power lamp further, we may say that the illumination of one foot from the filament is 21 foot candles, because 21 lumens of light flux are intercepted by an area of one square foot at this distance. In other words, to say that a surface has an illumination of 21 foot candles is equivalent to saying that it received 21 lumens per square foot.

As a practical example of the size of a foot candle, it is to be noted that the illumination in a home is usually somewhere between 2 and 5 foot candles, while the illumination in an office ordinarily varies between 3 and 10 foot candles. An illumination of 15 foot candles is good lighting for either an office or a home. The illumination in direct sunlight may run as high as 10,000 foot candles.

Light is a form or radiant energy and emanates from its source in straight divergent lines. As a result the illumination falls off according to the inverse square law of radiant energy as you recede from the light source. This law states that the illumination (foot candles) is inversely proportional to the square of the distance from the light source.

To review the above definitions we shall take another example:

Given: A 50 c.p. lamp; also a screen No. 1 having an area of two square feet placed ten feet from the lamp filament, also a screen No. 2 having an area of eight square feet at 20 feet from the filament.

Questions:

1. What is the illumination in foot candles on screen No. 1?
2. What is the amount of light flux in lumens falling on screen No. 1?
Thus the answer to question No. 2 is:

\[ 2 \times 3 = 1 \text{ lumen} \]

**Question No. 3.** The illumination on screen No. 2 is

\[ \frac{50 \times 8}{400} = 1.25 \text{ foot candles} \]

since the illumination on a surface does not depend on the area of the surface. However, with one square foot screen at 20 feet, the lumens of light flux intercepted would be:

\[ \frac{50 \times 1}{400} = 0.125 \text{ lumens} \]

as much.

As before, the light flux could be calculated from the known number of foot candles and the area. Thus, the light flux on screen No. 2 equals \( 8 \times 125 = 1 \text{ lumen} \).

**Question No. 5.** If the screen No. 2 were reduced in size to one square foot, the illumination would still be the same on this screen: namely

\[ \frac{50 \times 1}{400} = 0.125 \text{ foot candles} \]

since the illumination on a surface does not depend on the area of the surface.

**Experiment Suggested**

In order that you may obtain a definite conception of the approximate illumination represented by a given number of foot candles, the following experiment is suggested. A new 60-watt, 115-volt incandescent Mazda lamp operated on a 115-volt line (a.c. or d.c.) will give approximately 35 foot candles illumination at one foot from the center of the lamp. At 5 feet the illumination is approximately 2 foot candles. The curve shown herewith in Fig. 2 is for such a lamp from which the distances can be read at which various illumination values may be obtained.

**Color Temperature**

The color temperature of a source of radiant energy is the temperature at which a complete radiator (black-body radiator) must be operated to give a color matching that of the source in question.

Color temperatures are usually assignable only for sources which give a spectral distribution of energy not greatly different from that of a black-body radiator.

A complete (black-body) radiator is one which absorbs all radiant energy falling upon it, and which at any temperature radiates the maximum possible amount of energy in all parts of the spectrum.

Color temperature is measured from the absolute zero in degrees of the centigrade (C) scale, and to distinguish the absolute scale from the usual centigrade scale, it is designated as degrees Kelvin, as for example, 3,000° K.

**FIG. 3**

Although the sun is the primary source of light, man has availed himself of the sun's energy that has been stored in other materials so that he can generate light by other means indicated above.

**Code for Special Group**

**JUST IN TIME!**

**AND WHY NOT A MERRY CHRISTMAS!** The world has, we admit, changed much during the passing of the centuries, but the cycles are not so different today from what they were in the days before electric lights, railroad trains, airplanes, radio and Einstein came along to add interest, luxury and almost uncanny knowledge to the curriculum of everyday existence. Human nature is still the greatest problem, the greatest asset and the greatest wonder there is, and that is why we do not hesitate, even in the face of odd events and terrible happenings, to broadcast the most beautiful message of the ages: Merry Christmas to everybody, everywhere, now and always.

**Washington**

Until the pending Radio Manufacturers Association application for an independent code for the entire radio industry is settled, no action will be taken by the National Recovery Administration on proposed supplemental codes for separate groups of radio manufacturers. Such directions were given by NRA legal counsel at a hearing on the supplemental code, proposed by National Electric Manufacturers Association, for the so-called "radio transmitting and public address apparatus and commercial radio receiver industry." The directions of NRA counsel sustained a protest made to NRA by William Sparke and the RMA Code Committee. The NRA ruling is expected to hasten final action.
THE design of a short-wave converter shown here is widely used and is similar to the converter shown in the December 6C6 is voltage the same as that in the circuit worked by the 4-1 V is the halfwave rectifier of the 6.3 volt, 0.3-mphere series of tubes. The limiting resistor to reduce the line voltage to the 19 volts total drop across heaters may be built into the line cord.

Capacity Coupling

The modulator is coupled to the oscillator by means of a small capacity, 0.6 mmfd., from grid to grid. This is a commercial product, but about the same capacity can be produced by using two pieces of flexible insulated wire about 2 inches long, twisting them together, and connecting one pair of ends to the respective grids and leaving the other ends free. In this way the capacity between the twisted wires is used.

Output is taken through a broadcast transformer "used backwards," so to speak. The primary is the large winding and the selectivity of the capacity of the condenser across this determines the most effective frequency of transfer and this of course would be the intermediate frequency. Selection of that frequency in the receiver will provide the clue. In general, the lower end of the dial is to be used, speaking of frequencies as then the operation is quieter, and also the selectivity is much better.

The selectivity meant is derived from the receiver more substantially at that end than at the other, but the selectivity against interfering stations and images at the short-wave level is lessened by the lower ratio of oscillator and modulator frequencies. This ratio is constantly changing, but is directly related to the intermediate frequency. Generally speaking, using 545 kc as intermediate frequency, a 1,500 kc, you would have to square the number of tuned circuits in the receiver to get as much selectivity compared to use of 545 kc.

The Ratios of Tuning

Having decided on an intermediate frequency, it is necessary to prepare the coils accordingly. That is, the oscillator frequencies are determined considerably by the intermediate frequency. So if we desire to start tuning at 1600 kc with an intermediate frequency of 545 kc, using a higher oscillator than modulator frequency, we would require striking 2145 kc at the low end. Using a condenser that has a 4-to-1 capacity ratio, we would wind up at 4290 kc for the first band, since the frequency ratio is the square root of the capacity ratio. The modulator would have to tune from 1,600 to 3,745 kc, a ratio of 2.31, obtainable from a condenser with a capacity ratio of 5.33.

It can be seen that the capacities will be different and that no attempt is made to use a two-gang condenser, for then a separate variable would have to be put across the modulator section to the same effect.

The condensers required for the purpose have a capacity of 90 mmfd. for the oscillator and 124.5 mmfd. for the modulator and are commercially obtainable as midget midline capacities. Separate diodes are used, a small vernier affair for the oscillator, a larger and closer vernier for the modulator.

Frequency Ranges

By using the condensers this way there is no need to resort to the difficulty of padding.

The required tuning ranges are therefore as follows:

<table>
<thead>
<tr>
<th>Modulator</th>
<th>Oscillator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band 1: 1600-3745</td>
<td>2145-4290</td>
</tr>
<tr>
<td>Band 2: 3700-8045</td>
<td>4245-8590</td>
</tr>
<tr>
<td>Band 3: 7500-15550</td>
<td>8649-16100</td>
</tr>
<tr>
<td>Band 4: 15600-30550</td>
<td>18545-31100</td>
</tr>
</tbody>
</table>

It can be seen that the usual four bands for short-wave special devices is retained. Allowing for the usual circuit conditions, the inductances required would be as follows, turns on 1/8 inch diameter.

<table>
<thead>
<tr>
<th>Modulator</th>
<th>Oscillator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band 1: 80 microhenries</td>
<td>44 t.</td>
</tr>
<tr>
<td>Band 2: 80 microhenries</td>
<td>38t.</td>
</tr>
</tbody>
</table>

The Ratios of Tuning

Diagram of a simple converter, using a smaller capacity in the oscillator than in the modulator. The condenser marked 0.5 mmfd. should be 0.6 mmfd.
Radio University

ANSWERS to Questions of General Interest to Readers. Only Selected Questions Are Answered and Only by Publication in These Columns.

Resistor-Capacity Filters

YOU HAVE mentioned that resistor-capacity filters serve a good purpose that is, reduce hum well, if the current is very low. I assume that a two-tube short-wave set is coming under this classification. Therefore please show a diagram of such a set, with a small resistor for L. E. H.

In the diagram of a universal short-wave two-tube earphone receiver the conditions are such that the current will be small enough to meet the purpose prescribed. The resistor R7 is 25,000 ohms. C4 and C8 being the 8 mfd. filter condensers, which may have 175-volt ceramic C1 is 50 mmfd., C2, 0.0001 mfd., C3, C4, C5, C6 and C7 are 0.05 mfd.; C10 (lower left) is 0.05 mfd. and C11 is 0.0014 mfd. R1, 2 meg.; R2, 0.02 mfd.; R4, 0.05 mfd.; R5, 0.025 mfd.; R6, 0.02 mfd. The tubes used are the 6F7 and 37, the latter the rectifier. The earphones are put between the binding post of plate of the pentode, to the point on the B plus line directly below.

Still, the Condensers Do Go

IN THE SEPTEMBER issue of Radio World, there appeared the statement that irreremedial damage could be done to electrolytic condensers in a-c/d-c sets when the sets are connected to the a-c line in the wrong polarity. That rectifier tube will not pass current of the wrong polarity, I fail to see how this damage can accrue. Current will not reach the condensers, being stopped by the rectifier. Please explain this paradox, set A.

It should be realized that when a voltage is supplied to a circuit, regardless of whether it is a-c, or d-c in its steady state, a transient voltage will be induced that may result in damage to them. Of course, high-grade condensers that are capable of withstanding higher voltages will not be as likely to this destructive influence as a poorer grade. It should be appreciated that whenever any sort of voltage is applied to a circuit, even though a negligibly small amount of current flows, transients of the order of thousands of volts may sometimes be induced that can be damming. Since transients are of instantaneous nature and occur only for an infinitesimal fraction of a second usually, such results do not happen where, though this is no reason for carelessness. As to the rectifier tube preventing current flow, when the tube will not rectify due to wrong polarity, its effect in the circuit is that of a resistance, and leakage current will flow.

When Radiation Is or Isn’t WHEN THE STATEMENT is made that a vacuum tube is to be reduced from a state of generation or oscillation to one of regeneration, does that refer to a difference that is sharp and distinctive, or gradual? Is there no radiation under a condition of regeneration, that is, operation just below the point of oscillation, which I understand is the most sensitive point? L. O.

There is some radiation when tubes in a radio-frequency circuit are operated at or near their maximum sensitivity point, especially at high frequencies. The condition referred to as generation or radiation is one in which there is a pronounced effect. For instance, if there is radiation it is possible to pick it up on another receiver, in the same room, in the same neighborhood or perhaps even a distance of miles. Where the propagation is so meager that it is practically impossible to pick it up more than a few inches from the set, it is not classified technically as radiation at all. If you will bring your hand within a few inches of a tube working at a highly sensitive point at radio frequencies, the exciting effect due to body capacity will be noticed. The coupling between hand and circuit is due to the radio field, which may be electromagnetic or even electrostatic, or may be a combination of both components. The change in tube operation from spillover to non-spillover is abrupt, which makes tuning a regenerative receiver a critical process, but even below spillover there can be a highly localized field, though it is too weak to be considered technically as a form of radiation.

Audio Regeneration

TO IMPROVE the low-note response in a receiver I have been having difficulties about using audio regeneration. Can you state a simple method of accomplishing this? Can one readily determine the constants?—R. W. C.

Audio regeneration may be introduced by uniting cathode current of two audio tubes in a common circuit. To make regeneration to be present the phases must be the same, or nearly so, but not opposing, for then there would be negative feedback, or degeneration. A method of assistance is to connect a resistor from the cathode of one tube to the cathode of another, each tube leaving its own input circuit. When bypass condensers may be omitted, as regeneration will have the cancellation effect on negative currents. It is difficult to suggest any formula that would be practical, because the impedance of the supply and other factors are unknown quantities, and the solution on a theoretical basis would be speculative. Better use the cut-and-dry method, especially as only the value of a single resistor is at stake. In general, the circuits united would have to be alternate, hence detector and output tubes would be concerned, wherein there is a direct path between. These two successive tubes are to be used in a parallel condition of secondary or primary, in the event that no feedback is encountered. This may be identified readily because of lower sensitivity and second harmonic portion of the low notes. When regeneration is introduced it may be raised to just below that point where audio output begins to be obvious, usually called "motorboating." This may be of any frequency, from a few cycles. The introduction of a cycle of 60 cycles, or 10 ke or so. If the note is near the higher limits specified, the circuits may be continued to be regenerated in this way, and a condenser put across the audio line of capacity just large enough to remove the note. Around 0.00005 mfd to 0.0005 mfd. might be sufficient.

Soldering Iron Too Hot

MY SOLDERING iron gets too hot. I have been told that a small resistor may be used to remedy this. The trouble is that the tip gets carbonized too quickly, and a new tip is pitted the first night I use it.—L. O.

A series resistor may be used, but it would have to be of large wattage, and might prove troublesome to the point of failure. A small resistor may be applied in parallel with the iron, and the wattage cut down. The temperature under these conditions is still considerably higher than that under normal operating conditions. It is therefore suggested that you use a long tip. This is standard. If instead of a 2-inch or 3-inch tip you are using a 6-inch tip you will find that the overheating of the tip will stop.

Pilot Lamp Shunts

IN USING PILOT LAMPS in series with heater tubes of the automotive variety, it is not necessary to shunt the pilots with resistors, and if not, why are shunts shown so often?—L. K.

Where the resistance of the pilot lamp would be a sizable factor in the reduction of the voltage drop across the heaters it is advisable to shunt the pilots, because of the non-removable non-varying resistance of pilot lamps inherently, and also the fact that the resistance of the lamp will change considerably with use. Shunting the lamp with a resistor of about half the lamp resistance makes the voltage drop across the parallel circuit more nearly constant and reduces the lamp current. However, if the lamp resistance is negligible compared to the sum of the heater resistances, the shunt is unnecessary.
IC6 in a Converter

WILL YOU KINDLY explain the use of the IC6 in a short-wave converter, with output transformer to feed the set, in the circuit layout, as you requested? — R. B. S.

The IC6 is a pentagrid converter tube with twice the conductance of the 1A6 and is therefore more suitable for shortwave use, because it will oscillate at higher frequencies. The signal-carrier frequency is introduced into the control grid of the first stage, which is represented by the metal lead on the tube. A simple method for use in battery sets, to attain modulation, is to use in and condenser. Give modulator is a pentode tube, hence there are plate and screen. The screen consists of two joined elements, and numerically is Grids Nos. 3 and 5, shown as suggestively of this condition in the diagram, with single socket connection. That is, there is only one base terminal for these two grids, Grid No. 1, for the oscillator control, and Grid No. 2 for the positive grid, or you may say, plate, of the oscillator, although the elements is not structurally a plate but a rod. Now the two frequencies are introduced, the signal-carrier wave, and the wave generated by the local oscillator. There is an electron coupling in the tube, meaning that the emission current paths of the two distinctive tubes, hence frequencies, in the one envelope are united. 1LZ, L3L4, L3L5, L3L6. The grid No. 2 will be plug-in coils C2 and C4 separate 0.00014 mfd. condensers, R1 2 meg., C3, 0.0001 mfd.; C5, 50 mmd.; C6 0.0001 mfd.; R2 0.05 meg. to 0.1 meg.; Rk a rheostat for which 3-volt supply may be 10 ohms and adjusted until the filament voltage is 2 volts. C5, a 0.0005 mfd. condenser set once across the larger winding of a broadcast coil, of which the right-hand winding is the primary.

(Continued from page 15)

The desire to obtain linear frequency amplification characteristics from all types of audio amplifiers is due to a lack of exact knowledge regarding the response characteristic of the loudspeaker and the assumption that the audio service is perfect if the linear relationship holds. Since the amplifier is a link in the transfer characteristics of the system, it is required that its characteristics be as flat as possible as it is operated by the apparatus preceding it and the loudspeaker after it.

A good deal is known about the apparatus that precedes the amplifier but little is known concerning the loudspeaker performance, and until exact information is obtained, the performance of amplifiers will continue to rest upon the assumption that uniform amplification at all audio frequencies means that the result is perfect.

The ultimate quality from a loudspeaker depends upon:

(a) The response characteristic in connection with the original acoustic energy to the microphone with the modulated energy in the transmitting antenna.

(b) The frequency-amplification characteristic of the receiver.

(c) The energy-frequency characteristic of the loudspeaker in free space, which includes the listener's aural mechanism.

(d) The acoustic qualities of the room in which the speaker is operated.

From a consideration of items (a) and (c) it does not follow that the overall characteristic of a receiver is better achieved by a system of high fidelity at all audio frequencies. Certain types of loudspeakers require an amplifier characteristic that dips in the middle audio region to give due prominence to the low and high audio frequencies, the amount of such dip depending upon the loudness level. For other types, the amplifier should give a prominent low audio frequency resonance to compensate for the insensitivity of the speaker at these frequencies.

Having obtained the most satisfactory characteristic at a given loudness level, there are still two salient defects:

(a) The absence of stereophonic effect or auditory perspective or the sense of directivity or location.

(b) Resonances introduced at various parts of the system, such as around the speaker.

Blurring Explained

A variable overall characteristic can be obtained by various artifacts inserted in the tube coupling units, such devices taking the form of filter circuits. So far as low-tuned instruments are concerned, a good fundamental is required for realism; they should not be "sensed" by their overtones. Conversely, incoherent spurious harmonics often become prominent with increasing intensity. The time required for the resonant component to decay to inaudibility increases with the intensity, and with the diaphragm type of speaker the lower the frequency of the resonant note, the more sustained is its effect, because the damping is usually less for the low than for the high tones. Hence, at high intensities, the time taken for the natural vibration to die away to inaudibility is usually appreciable and causes an unpleasant blurring distortion of the output.

Four resonances are not particularly objectionable for the weaker sounds, but with loud sounds the low tones are usually badly defined. Owing to the lack of exact information on these important points, there is a need for research on the acoustic aspect of this subject with a view to defining the required characteristics of the amplifier.

It should be pointed out, however, that this is only an expedient to correct the faults of the loudspeaker by a suitable amplification-frequency characteristic from the amplifier. The correct procedure would be to develop a loudspeaker with the required characteristics but since this is more difficult, such amplification modification is justifiable at present. Of course, a decided disadvantage of this sort of treatment is that a particular amplifier would need to be designed for every different loudspeaker.
TO YOU AND ALL!

HERE'S a Happy New Year to all my friends. The outlook seems to be much better this year, both in radio and general business, and it's all the more reason for celebration in the air which bids fair to make the coming season a memorable one. ... Only a few times ago, on NBC's airwaves, is the tone of the announcer who put thumbs down on women announcers. They even raised disapproving eyebrows at women who essayed to announce in the same manner as members—but they definitely ordered change. And here is Elsie Janis joining the NBC staff as the first woman announcer. Well Elsie has had experience enough as an entertainer and producer to at least know enough to inject personality into written lines. Here's wishing her jolly good luck with her new assignment. ... Wondered what had become of Doc Rockwell, that rollicking co-star of the screen, silent and sound. Have just discovered that he is writing and producing a new radio series called "Doughnuts and Coffee." He is trying to solve the age-old question of what husbands and wives discuss between arising and going to bed. Two characters, Joe and Stella, will place an NBC microphone on their breakfast table every Sunday, except 4:30 a.m. EST. If you'd like a jolly good laugh about a serial dramatical to WJZ and network at that time. The Road to Romance has returned to NBC, under the direction of Alexander Kirillof. Celia Brauz, distinguished concert contralto, is the soloist. Each Sunday night at 2:00 p.m. EST, WEAf and network.

LAWRENCE TIBBETT ON DECK

Lawrence Tibbett's Tuesday night broadcasts will continue to be heard through the winter over an NBC-WJZ network at 8:30 p.m. EST., according to a renewal of contract which became effective Christmas Day, December 29, 1934. The NBC-WJZ network has made its first appearances on this program at 8:30 p.m. EST. on January 7th. The following Monday and Tuesday was made by the NBC Microphone Orchestra under the direction of Nathaniel Shilkret and members of the NBC Hollywood studios. The NBC-WJZ network which became effective Christmas Day, December 29, 1934 and which becomes a part of the NBC staff on January 4th, for her first extended radio engagement. She has signed a contract to start Sunday, January 5th, the NBC's "Penthouse Party," sponsored by Enos Mark Hellinger, Broadway columnist, and his wife, Gladys Baker, and with Follies beauty, will be featured. Mark will write the stories himself. Each Wednesday, NBC's new program at 8:30 p.m. EST. "The Carefree Caravan," has won a sponsor for the new year. This program has been on the air since June, 1933, originating from New York's Crazy Cigarette Water Crystals have taken it for the better-or at least for a time: it will be heard, this week, one half-hour, at 8:30 p.m. on the Coast-to-Coast NBC-WJZ network. There will be an extended NBC series of programs broadcast on NBC for New Year's Eve from 10:30 p.m. to 1:30 a.m. The National Biscuit Company has made its program available on both NBC-WJZ and network at that time as a New Year's gesture to their many customers.

WE REFER TO O'FLYNN

The historical novel of an attempt by men allied with William of Orange, ruling England by virtue of the sword, to steal apear necklace from the Queen of the Dutchwomen, that the Venetian, and the English, during the 17th Century warfare, will be depicted during the first broadcast of the colorful, new series of music drama's titled after and based upon the glamorous and adventurous Irish figure, "The O'Flynn." The program will be heard over the WABC-Columbia network from 10:30 to 11:00 p.m. EST. The O'Flynn, in real life Captain Flynn O'Flynn, is a romantic subject of his torical records extant in Ireland, and the music dramas are based upon a modern story of the character, entitled "The O'Flynn." It is the pen of Justin Huntly McCarthy, who wrote the book on which "The Vagabond King" was based.

Viola Philo, well-known soprano, and Milton Watson, baritone, will sing the leading roles in the music drama. The cast of veteran radio actors will be co-featured with them. The dramatists will include a character to play the role of Captain Flynn O'Flynn; Lucille Wall, the role of Lady Benedetta Mount-michael; Jo Anna Poulson, the queen of James II; Leigh Lovell, the role of Roger Hendigg, an ally of William of Orange; Jack Smart, the court jester; James Barrows, servant and constant companion of "The O'Flynn," and John Gregg, the cook. Nathaniel Shilkret and a thirty-piece concert orchestra will provide the music, all of it written especially for the radio series, and David Ross will be the announcer.

A THought for the Week

HERES TO GOOD OLD 1934—mark it down, mark it down! Let's try to re- member, without being at all sentimental or bromidic, that 1935 will probably be just about as good to us as we are to 1935. ... We're going to remark, let's remember the little things to which we might have called attention before, but which it would be well to repeat more than once during the coming year. You can't ever lose the smile on the face of good old "Judge," the humorous paper of 1934, "We'll more than win suc- ceeds—let's keep on repeating for the same sentiment—Mr. Kellogg said that the New York Sun repeats every year the query, "Is there a Santa Claus," and the wonderfully human answer thereto.

Elise Janis Is First

NBC Woman Announcer

Elise Janis is NBC's first woman announcer. The former star of musical review and vaudeville became known to millions who had never heard her voice as she entertained the troops during the World War, she brought her music and songs to the A.E.F. camps in France.

As a regular member of the NBC announcer staff, Miss Janis will guide many network songs from song to song each day. She was invited into the mysteries of the announcer's profession and other studio intricacies.

Miss Janis is not a novice at broadcasting, as she has been heard as guest star in many NBC programs during the past few years.
DUAL-BAND TUNING UNIT

FOR broadcast reception, plus a number to higher than 1,000 kc, thus yielding a total span of 540 to higher than 4,000 kc. We have an exceptionally wide range of oscillators, consisting of three r-f units, one of which is used as antenna coupled, and one oscillator coil, also the necessary condenser (Hermetically sealed adjustable type). The tuning coils for the r-f units have variable spacing between them that the condenser tester may be switched from full inductance to least inductance to pick up the broadcast band where the full inductance sets in. The oscillator coil is approximately tuned, also, for this purpose. A four-pole double throw switch would be needed for each set. Only aluminum alloy, 2.5 inches outside diameter by 2.5 inches inside diameter, is used for the r-f coil, and for the oscillator coil, 2.56 inch outside diameter by 2.56 inch inside diameter. Order PR-BCTP-178.

TUNING UNIT FOR TEST OSCILLATOR

Hence is your very first opportunity to get the parts for constructing a universal, modulated test oscillator to cover fundamentals from 125 to 350 kc, and cover higher intermediate frequencies and the entire broadcast band. The particular oscillator coil is the oscillator will be direct frequency-reading. The parts consist of one metal shielded coil, one metal condenser, 0.004-466 tuning condenser with trimmer built in, one oscillator transformer (transistor inductance correct 4.5 to 1.6 c.f.) and one knob for control. Circuit diagram and full directions for making and using all parts supplied for universal model modulated test oscillator ($0.15). Would you like to examine this equipment and try it out? If you do, please let us know. If you do not, send $1.50 for use and only one finish with adjustment on broadcast band, beating with some stations on 1,200-1,400 kc. Whole deal then will total $1.20. The complete description will be sent free. Order PRE-SPTO and send $1.00 for one-year subscription (11 issues). Next post paid.

VITAL BOOK

The biggest help any one can have in setting up or testing radio frequency circuits for the radio-frequency range from just below the audio range to the highest audio frequencies is to have a book that tells just what to do and how, and gives all the necessary data. That is what this book does. The Induction Authority, by Edward M. Shapiro, gives just that information. The price for it is $3.00, sent free. Send $3.00 for an additional annual subscription (12 issues) and order PRE-LIA sent postpaid.

POWER TRANSFORMER

Primaries-100-1,100 volts. Secondaries 2.5-3.0 volts, 100 m a, 1-110 volts, 100 to 1100 volts, 200 to 2500 volts. Special built for connecting a.-c. test set. Test transformer or any other transformer for not more than three small tubes, and for tuning coils, 400 to 500 volts, no center, 2500 to 3000 volts, no center. Send 40 for an additional annual subscription (12 issues), and order PRE-LIA sent postpaid.

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

SOME EXCELLENT RADIO BOOKS

"This Thing Called Broadcasting" by Alfred N. Goldsmith and Austin C. Lecancher, $3.50
"Audio Power Amplifiers," Anderson, Bernard 1.50
"Frequency Measurements," by E. E. Resler.
"Modulin," $1.25
"Short Waves," by Charles R. Lesch and Robert B. Gable. 2.00
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50
"Perpetual Trouble Shooter's Manual," by Rider. 7.50

Short-Wave Condenser

Three-gang 0.00014 mfd. tuning condenser, with interchangeable trimmer condenser, built in on both sections. Section with trimmer off is to be used for antenna-antenna tuning. As a variable series antenna condenser, 30 mmfd. or somewhat less, is recommended, and changes the tuning of this stage, no fixed trimmer is used. The section here is by any of the best brass plates, such as the most expensive condensers have, and in. A manner that it is easily handled. Shipping will be $3.50 for 26-week subscription for RADIO WORLD (30 issues, one each week), and add for $1.00. We pay transportation on these condensers.

Radio World, 145 W. 45th St., New York, N. Y.

Quick-Action Classified Advertisements

5 cents a word. 50 cents minimum.


INVENTIONS WANTED. Patented or unpatented, any size, any material, for any legitimate purpose. Now is the time to act. Send us your ideas. A square deal assured. Bosley Mfg. Co., 79 High Street, Torrington, Conn.

COMPLETE TRAINING FOR AMATEUR LICENSE, $2.50 weekly. N. Y. Wireless School, 45th St., New York City; phone: C. L. 2-745.

"WILCOX AUTOMATIC ELECTRICIAN'S WIRING MANUAL." Complete wiring diagrams for all cars made in 1928-1930. In stores now. Contains the latest in ignition systems, generators, starting motors, batteries, single and double systems. Full instructions, and a complete wiring diagram for each type. In stores now. Send $2.50 by mail, or call at 4:11 Radio World, 5th Street, New York City.


"RADIO TROUBLE SHOOTING," E. R. Haan. 128 pages. 300 Illustrations. $3. RADIO WORLD, 145 W. 45th St., New York City.
1935 MODEL SIGNAL GENERATORS WITH DIRECT-READING AIRPLANE DIALS

MODEL 339, FUNDAMENTALS 54 kc. to 17,000 kc.

The most up-to-date Signal Generator, just released from the laboratories of Herman Bernard, is Model 339, for all-wave coverage, band-shifts by switching. All frequencies fall on fundamentals: 54 to 170 kc; 170 to 540 kc; 540 to 1,700 kc; 1,700 to 5,400 kc; 5,400 to 17,000 kc.

This is a three-tube device for lining up intermediate, standard broadcast and short-wave frequencies, and for station-finding, where results in frequency and wavelength (both) are read from the dial. Bernard Signal Generators are the only ones that give results in both frequency and wavelength.

Model 339 uses the new Bernard decimal repeating airplane dial, the latest dial invention for maximum legibility on all tuning ranges.

ACCUARTE

Fixed Mica Condensers
Capacities measured on a bridge.

1,000-VOLT RATING

0.002 mfd... 12c; 0.0048 mfd... 1c, 0.0094 mfd... 1c
0.004 mfd... 12c; 0.0096 mfd... 1c, 0.0019 mfd... 1c
0.006 mfd... 1c
Any six of above, 6c; any 12 of above, $1.10.
Any assortment permitted.

ACCURATE

PIGTAIL RESISTORS

1/4-WATT RATING

Bridge Measured

100 ohms... 5c; 1,000 ohms... 10c, 10,000 ohms... 1c
300 ohms... 5c; 10,000 ohms... 1c
400 ohms... 5c; 10,000 ohms... 1c
500 ohms... 5c; 10,000 ohms... 1c
600 ohms... 5c; 10,000 ohms... 1c
700 ohms... 5c; 10,000 ohms... 1c
800 ohms... 5c; 10,000 ohms... 1c
900 ohms... 5c; 10,000 ohms... 1c
1,000 ohms... 1c; 15,000 ohms... 1c, 15,000 ohms... 1c
1,500 ohms... 1c; 19,000 ohms... 1c, 19,000 ohms... 1c
2,000 ohms... 1c; 20,000 ohms... 1c, 20,000 ohms... 1c
2,500 ohms... 1c; 25,000 ohms... 1c, 25,000 ohms... 1c
3,000 ohms... 1c; 30,000 ohms... 1c, 30,000 ohms... 1c
3,500 ohms... 1c; 35,000 ohms... 1c, 35,000 ohms... 1c
4,000 ohms... 1c; 40,000 ohms... 1c, 40,000 ohms... 1c
Any six of above resistors, 5c; any 12 resistors, 9c.

Each condenser and each resistor is specially tested and calibrated, and a personally written notation of the resistance or capacity value is furnished. We pay postage sending out these condensers or resistors if you remit purchase price with order.

DIRECT RADIO CO.
145 W. 45th Street, New York, N. Y.

World-Famous SHORT-WAVE PRODUCTS

“COSMAN TWO” “DUO WONDER”

Battery operated S. W. receiver. Novel rack permits placing of five coils in proper band order—no sorting for coils. Efficient design permits tuning from 15 to 200 meters. The regular broadcast band can be tuned with a broadcast coil (200 to 550 meters) at additional cost of 99c. Uses a 232 and 233 tube.

Kit of parts .................. $5.95
Wired and tested ................ 1.50 extra
Set of RCA licensed tubes ...... 1.40

2-in-1 short wave receiver. Features the new type "19" tube. Supplied with coils to cover the entire wave band. The coils are white-gold plated from 15 to 200 meters. A fifth coil, covering the broadcast band (200-550 meters) supplied for 30c additional.

Kit of parts .................. $4.95
Wired and tested ................ 1.00 extra
RCA licensed "19" tube ....... .80

RELIABLE RADIO CO., 145 W. 45th St., New York