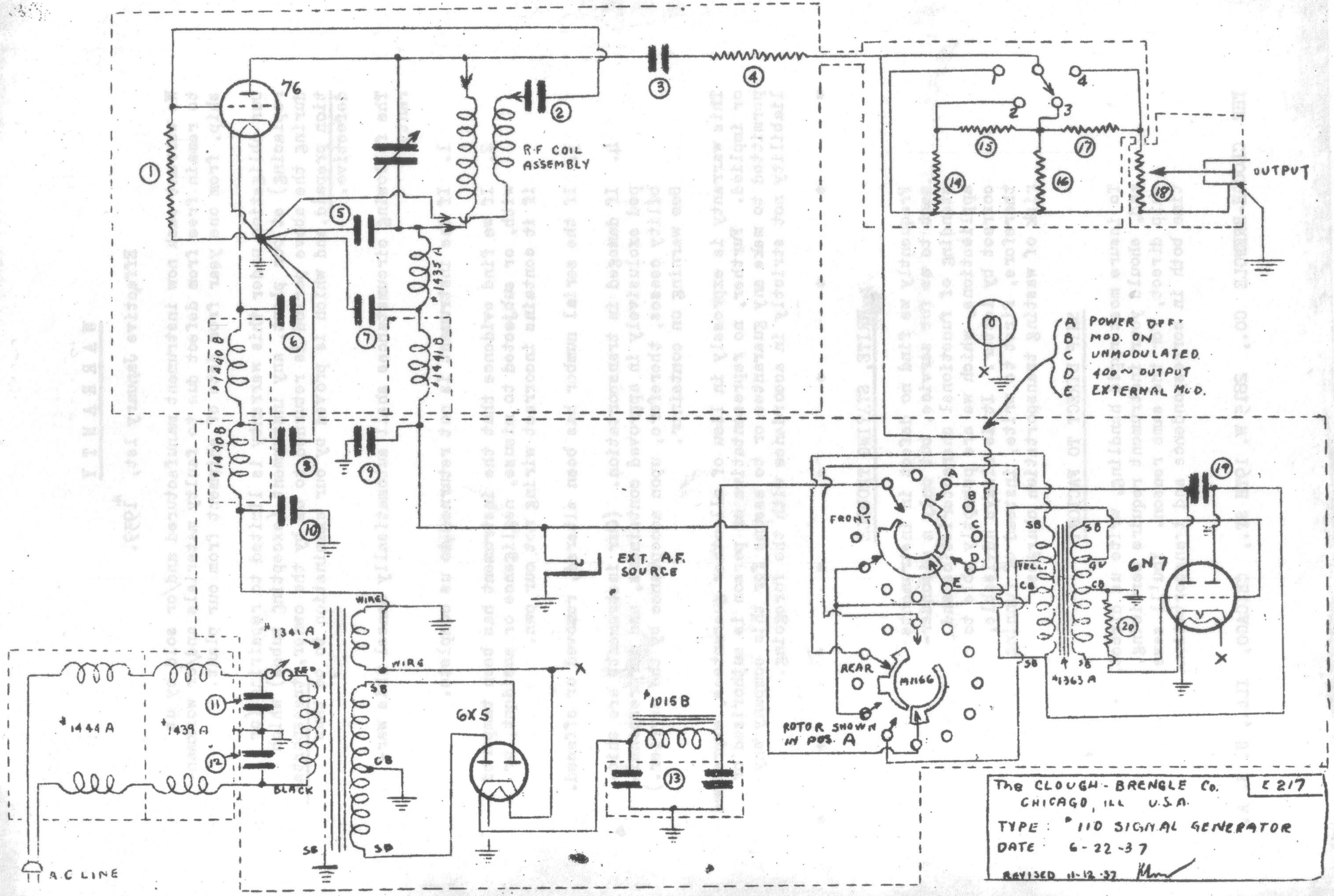

76
R.F COIL ASSEMBLY
#1435 A
#1441 B
#1440 B
#1440 B
OUTPUT
A POWER OFF
B MOD. ON
C UNMODULATED
D 400~ OUTPUT
E EXTERNAL MOD.
EXT. A.F. SOURCE
FRONT
REAR
ROTOR SHOWN IN POS. A
6N7
#1363 A
#1341 A
WIRE
RED
BLACK
6X5
#1015 B
#1444 A
#1439 A
A.C LINE
The CLOUGH-BRENGLE Co.
CHICAGO, ILL U.S.A.
E 217
TYPE: #110 SIGNAL GENERATOR
DATE 6-22-37
REVISED 11-12-37

WARRANTY

Effective January 1st, 1939.

We warrant each new instrument manufactured and/or sold by us to remain free from defect due to faulty materials and/or workmanship, from one year from date of shipment from our plant.

Our obligation under this warranty is limited to repairing (or replacing) at our plant, any instrument (excepting tubes) which during the above period is returned to us by the owner, transportation prepaid, and which is proved by our examination to be thus defective.

The following circumstances shall automatically cancel this warranty:

1. If the instrument is not returned to us complete.
2. If we find evidence that the instrument has been tampered with, or subjected to misuse, negligence or accident, or if it contains incorrect wiring not our own.
3. If the serial number has been altered, removed or effaced.
4. If damaged in transportation. (Our instruments are shipped exclusively in approved containers, and our responsibility ceases, therefore, upon acceptance by the carrier.) See warning on container.

This warranty is expressly in lieu of all other guarantees, expressed or implied. Further, no representative or person is authorized or permitted to make any guarantee or to assume for this company any liability not strictly in accordance with the foregoing.

* * * * * * * * *

WRITE, STATING TROUBLE

Frequently we find no defect in instruments sent to us for service, but only a misunderstanding of functional characteristics and applications, which we are promptly able to correct by letter. It is always advisable, therefore, first to write, instead of running risk of wasting transportation charges.

SHIP DIRECT TO FACTORY

To insure most rapid handling, write us direct, and, should your instrument require servicing, ship direct, for the same reason. You'll save time both in correspondence and transportation.

THE CLOUGH-BRENGLE CO., 2815 W. 19TH ST., CHICAGO, ILL., U. S. A.

CLOUGH-BRENGLE MODEL 110 SIGNAL GENERATOR

105. When the best possible accuracy is desired, the MODEL 110 should be connected to the line power for twenty minutes before using. This permits the tubes and other parts to come to the same thermal state which obtained during the calibration of the instrument on our primary standard of frequency at the factory.

106. CONNECTING TO THE RECEIVER. A shielded concentric cable is provided for this. One end is provided with a shielded plug for insertion in the output jack at the lower left of the panel.

107. ALIGNMENT PROCEDURE. When such information is available, always follow the recommendations of the receiver manufacturer as closely as possible. In the absence of such information, excellent suggestions will be found in the attached treatise on test oscillator operation.

LICENSE NOTICE. This instrument is licensed under patents of the American Telephone and Telegraph Co., for use in testing radio receivers and parts thereof.

**

THE CLOUGH-BRENGLE CO.,
2815 W., Nineteenth sSt.,
Chicago, Illinois, U.S.A.

3

Form #108.

INSTRUCTIONS

CLOUGH-BRENGLE MODEL 110 SIGNAL GENERATOR

101. SETTING UP. The MODEL 110 is made for operation on alternating current only. The standard is for operation from 115 volt, 50 and 60 cycle lines. Models for other voltages and frequencies are available. Consult the name-plate on the top of the case to be sure that you have the correct model before inserting the line cord in the power socket.

102. THE FREQUENCY DIAL. This dial is somewhat different from those that have appeared on previous designs, and should be studied until its utter simplicity is recognized. It should be read like an ordinary multiple range voltmeter, using the lower scale for coil bands 1, 3, and 5, and the upper scale for coil bands 2 and 4. No charts or corrections of any kind are needed for the most accurate service work. The dial is driven by the knob in the center.

103. SELECTOR KNOB. This knob controls the power supply to the unit as well as the type of modulation used.

(a) 400-MOD. (400 cycle Modulation). In this position of the SELECTOR knob, the line power is turned on, and the output signal is modulated to a depth of 30% at a frequency of 400 cycles.

(b) UNMODULATED. With this position of the SELECTOR switch the output of the MODEL 110 is pure radio frequency with no modulation of any kind.

(c) 400-OUTPUT. This position of the SELECTOR SWITCH connects the 400 cycle internal audio oscillator to the output jack through the attenuator. In this connection, an undistorted audio note is available through the output jack, which is controllable from 0 to 1.2 volts. The wave form is excellent, which permits the checking of audio amplifiers for distortion with the cathode-ray oscillograph.

(d) EXTERNAL MOD. (External Modulation). In this position the output signal may be modulated by any desired source, through the jack marked AUDIO FREQUENCY SOURCE. Connection should be made through a standard phone plug with a blocking condenser of about 1 MFD connected in the high or top side. For 60% modulation, it is necessary for the source to supply 120 milliwatts at 5,000 ohms impedance. This power is supplied properly by the CLOUGH-BRENGLE Type 79 Beat Frequency Oscillator, where a source of continously variable modulation is required. With such a comb ination, the frequency characteristic or fidelity of the entire receiver may be examined. This fidelity characteristic will include the effects of side band cutting in the selective circuits of the receiver.

104. ATTENUATOR CONTROLS. These are at the left of the dial, and include a four-stop ladder attenuator (1-2-3-4) and a continously variable vernier (0-10). A step will be noted between each of the main steps on the 1-4 dial. These are grounding steps for shielding purposes and should be disregarded.

If the intermediate frequency amplifier operates in conjunction with an automatic volume control circuit, it is extremely important that the output from the radio frequency signal generator be kept as low as will give a satisfactory reading on the output meter. Otherwise, the amplifier will be extremely broad and the receiver will lose a considerable portion of its selectivity. The output of the signal generator should be kept below the operating point of the AVC circuit, and a lower range on the output meter used if necessary.

The response curve of any intermediate frequency amplifier is obtained in the following manner:

Tune the amplifier to resonance with the test oscillator, and adjust the output from the RF oscillator until a suitable reading is obtained on the output meter — say 10 volts. The RF output should then be left constant at this value and the oscillator tuned 2 kc. higher than the receiver dial. The output meter will now read a lower value, for instance 8 volts. Similarly, if the oscillator is turned 2 kc. off resonance in the minus direction, the output meter reading will fall off to 8 volts. Now obtain output meter readings when the test oscillator is set at 4 kc. above resonance and 4 kc. below resonance, and proceed in 2 kc. steps on either side of resonance until you are no longer able to obtain any reading on the output meter. Then plot these readings on a piece of graph paper, as shown in Fig. 3, and connect them by smooth curved lines.

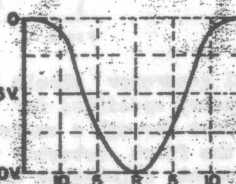


FIG.3

It should be noted at this point that every time a trimmer condenser is adjusted in the intermediate frequency amplifier, the shape of the response curve will be changed accordingly. If the curve reaches practically zero level on the output meter reading before the signal generator is turned 10 kc. off resonance with the receiver, it will be found that the receiver is sufficiently selective to prevent interference from stations operating in adjacent channels. You may now determine the width of the response curve at approximately 75% full output voltage. Assuming that this is 2.2 kc. in width, it indicates that the intermediate frequency amplifier should pass audio frequency signals as high as 2,200 cycles with a reasonable degree of fidelity.

There are numerous design methods employed to broaden the receiver response curve so the receiver will have greater fidelity and still hold the sides of the curve steep enough to prevent a high output signal voltage at 10 kc. off resonance. One of the most common methods of obtaining this type curve, which is known as the flat-top curve, is to overcouple the intermediate frequency transformers. Because there are two peaks to this type of curve and a slight dip at the resonance point, it is virtually impossible to achieve it with an oscillator and output meter, as it will be found that one of the peaks will be brought to a considerable height, while the other one will fall off in such a manner as to give an extremely lopsided curve. Instead, an oscillograph, which simultaneously depicts both peaks for correct adjustment of one against the other, must be used. The correct flat-top curve as obtained with an oscillograph is illustrated in Fig. 4, while the curve obtained when attempting to align with an oscillator and output meter is shown in Fig. 4A.

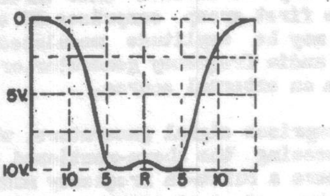


FIG. 4

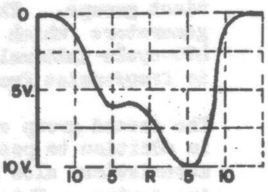


FIG. 4A

To align by cathode-ray oscillograph, it is necessary to use a frequency modulated RF signal, set to the IF frequency of the amplifier and applied to the first detector through a suitable resistor and condenser, as mentioned in the procedure above. The vertical plates of the cathode-ray oscillograph should be connected across the load resistor in the plate circuit of the second detector tube, as illustrated in Fig. 5. With the frequency modulator and the oscillograph in operation, the receiver response curve will appear on the screen of the cathode-ray oscillograph, and as adjustments are made to the trimmer condensers in the intermediate frequency amplifier, it will be found that the height and shape of the curve will change in a corresponding manner. The curve of a normal fidelity amplifier should be adjusted for maximum height, as long as the curve can be kept symmetrical. On high-fidelity receivers with over-coupled intermediate frequency transformers, a flat-top curve should be obtained, such as that illustrated in Fig. 4, through adjustment of the various trimmers until maximum height is obtained while still maintaining the general shape of the flat-top curve.

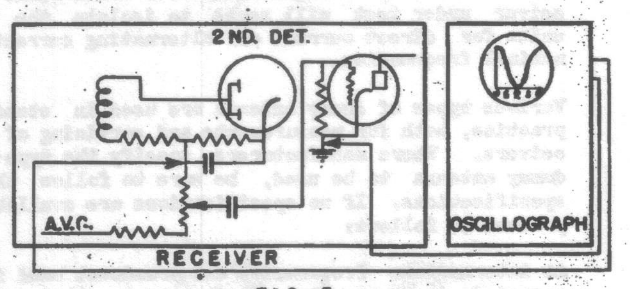


FIG. 5

The output level of the RF signal generator should always be kept below the actuating level of the AVC circuit, or the receiver will tune quite badly after it is aligned. An alternative procedure is to connect a potentiometer across a 22½-volt battery and to insert one side of the potentiometer in the AVC circuit. To accomplish this, the main AVC lead should be broken and the potentiometer so connected that the positive side is towards the grounded side of the AVC circuit and the movable arm is connected to the lead going to the various coils. Negative voltage may now be applied by adjusting the potentiometer until there is no AVC action.

4. AFC ALIGNMENT

The automatic frequency control circuit in modern receivers should be adjusted after the intermediate

RADIO FREQUENCY OSCILLATOR MEASUREMENTS

1. TYPES OF SIGNAL GENERATORS

There are many types of radio frequency signal generators on the market today, however, for the purposes of study these may be divided into three distinct groups. The first group comprises RF signal generators which may be amplitude modulated by a 400-cycle internal audio frequency generator, or audio freqfencies from an external source.

The second group comprises signal generators, which, in addition to possessing the above-mentioned characteristics, also have a built-in frequency modulating device. This type of instrument is primarily designed for use with the cathode-ray oscillograph.

The third class of signal generators include instruments incorporating an attenuator accurately calibrated in microvolts, so that the radio frequency output of the instrument may be set at any desired signal strength. These instruments normally may be either internally or externally amplitude modulated by a suitable source of audio frequencies.

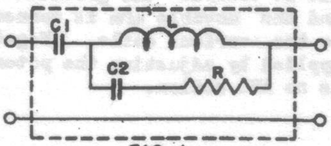
Either the first or last-mentioned types of signal generators may be used with the cathode-ray oscillograph in conjunction with a frequency modulator unit, which is an absolute necessity for making cathode-ray pictures of receiver selectivity.

2. DUMMY ANTENNA

In order to provide proper impedance relationships between any RF signal generator and the receiver under test, it is necessary to use a dummy antenna between the two instruments. This dummy antenna also serves to load the receiver, so that correct pad adjustment of the input circuit will result. Finally, it will be found that the use of the proper dummy antenna between a signal generator and a radio receiver under test will serve to isolate the two units for direct current or alternating current of nominal frequencies.

Various types of dummy antenna are used in standard practice, both for measurements and servicing of receivers. Where manufacturers specify the type of dummy antenna to be used, be sure to follow these specifications. If no specifications are available, proceed as follows:

At intermediate frequencies and broadcast band frequencies, it is usually satisfactory to place a 250-mmf. condenser in series with the high RF output lead of the signal generator at the receiver. At higher frequencies (5 to 50 mc.) it is well to use a 250-mmf. condenser and a 200 to 400-ohm resistor in series as a dummy antenna. The dummy antenna illustrated in Fig. 1 is that suggested in a preliminary report by the Institute of Radio Engineers, and should be used for precise measurements if at all possible.



L = 20 MICROHENRIES
C1 = 200 MICROMICROFARADS
C2 = 400 "
R = 400 OHMS

FIG. 1
I.R.E. STANDARD DUMMY

At extremely high radio frequencies, a good short low impedance ground connection to the signal generator and receiver will be of great advantage. This should be connected to the ground post of the receiver, or at the point where the shield of the concentric output lead connects to the chassis. This is a point which is usually overlooked, and quite frequently causes various attenuation difficulties at the higher frequencies.

3. INTERMEDIATE FREQUENCY ALIGNMENT

Normal fidelity intermediate frequency amplifiers may be aligned with a 400-cycle modulated radio frequency oscillator to supply a constant RF signal voltage, with an output meter connected in the final stages of the receiver to indicate when the resonance point has been reached. It is important, when aligning these types of amplifiers, to know the intermediate frequency at which the amplifier was designed to operate, as without this information it is practically impossible to complete a satisfactory adjustment.

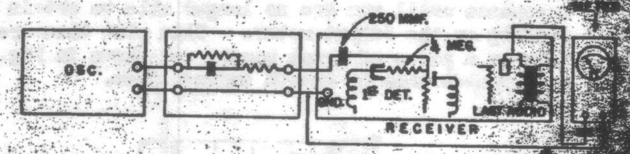


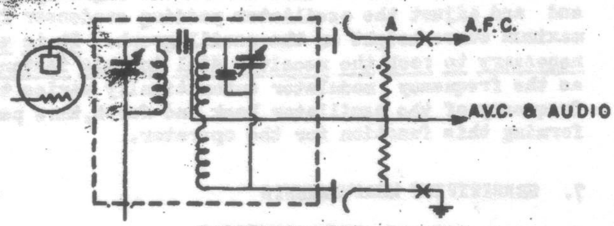
FIG. 2

The RF signal generator should be set to the intermediate frequency specified for the receiver, and the output connected through a condenser and resistor to the grid of the first detector tube. (See Fig. 2). This arrangement eliminates the RF tuner from the alignment, but picks up the correct bias and AVC voltage from the grid clip. The ground lead from the RF signal generator should, of course, be connected to the ground of the receiver, and a good external ground connection should also be made to this part.

A suitable alternating current meter should be connected from plate to ground in one of the final audio stages of the receiver, so that a definite indication of the transmitted signal may be had. If the meter is not equipped, it is well to use a blocking condenser, of approximately ½ mf. capacity in series with one of the leads to the meter to block out any DC voltage which might otherwise injure the meter movement. This condenser will not prevent reading of the output signal, which is usually a 400-cycle note.

The radio frequency oscillator should be preferably internally modulated with a 400-cycle source for intermediate frequency alignment. The instrument should be set up, as indicated in Fig. 2, and if in good operating condition, a reading should be obtained on the output meter. As the trimmer condensers on the intermediate frequency transformers are adjusted, the output meter rises or falls as the various circuits are brought in or out of resonance. Normal adjustment for intermediate frequency amplifiers of this type is to adjust all of the trimmers until a maximum reading is obtained on the output meter.

frequency amplifier has been aligned, with the signal generator connected in the same manner and set at exactly the same frequency as was used for alignment of the intermediate frequency amplifier. The accompanying diagram, Fig. 6, illustrates a typical discriminator circuit.



DISCRIMINATOR TRANSF.

FIG. 6

The RF output control of the signal generator should be turned to the very minimum setting, and a vacuum tube voltmeter connected between the points marked (X) in the diagram. In this position, the vacuum tube voltmeter will show the voltage developed across the circuit. The vacuum tube voltmeter, when connected in this manner, should be adjusted to show approximately half-scale deflection when the points marked (X) are short-circuited.

Now place the AFC circuit in operation by means of the control provided on the set, and increase the output from the RF signal generator until the indicating pointer of the vacuum tube voltmeter first begins to move. This shift will be in either direction, up or down scale, depending upon the setting of the trimmers in the discriminator.

The secondary trimmer should be backed off and the primary trimmer of the discriminator transformer should be adjusted until the maximum deflection, either plus or minus, is indicated on the meter. It may be necessary to reduce the input from the signal generator to keep the meter from going off scale. The secondary trimmer of the discriminator transformer should now be adjusted until the needle of the vacuum tube voltmeter is returned to the exact center scale reading.

The automatic frequency control circuit on most receivers may be properly adjusted in the manner set forth in the above paragraphs, with the exception that a precision 20,000 ohm-per-volt meter may be used in place of the vacuum tube voltmeter. In this instance, the meter should be connected at the point marked (X) in Fig. 6. The secondary trimmer condenser should be backed off, and the primary of the discriminator transformer adjusted for maximum meter deflection. The secondary trimmer condenser may then be adjusted until the meter indication falls to zero voltage.

While this method is perhaps slightly less sensitive than the cathode-ray or the vacuum tube voltmeter method, it will still give excellent results if care is taken in making the adjustments.

The most rapid and accurate method of adjusting automatic frequency control circuits is to use a frequency-modulated signal and cathode-ray oscillograph. The frequency modulated signal should be set at the intermediate frequency and applied to the first detector tube, as in the alignment of the IF amplifier. The vertical plates of the cathode-ray oscillograph should be connected between the points marked (A) and ground. A rather strong input signal should be fed to the receiver from the signal generator, and, with the secondary trimmer condenser, backed off, adjustments should be made of the primary trimmer until maximum wave height is obtained on the screen of the cathode-ray oscillograph. The secondary trimmer should then be adjusted until the proper automatic frequency control curve appears on the screen of the oscillograph.

The shape of this curve will vary to a considerable extent with different types of receivers, however, if a 60-cycle linear sweep frequency is used, the shape of the automatic frequency control curve will be similar to that shown in Fig. 7. If a harmonic sweep is used to view this curve on the oscillograph, it will be similar to that shown in Fig. 7A, when the proper adjustments have been made. These curves are only indicative of the general shape. Experience with the different makes of radios will give the technician a better idea of the correct curve for each different model.

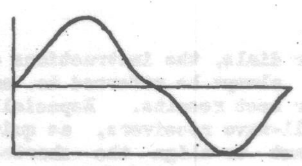


FIG. 7

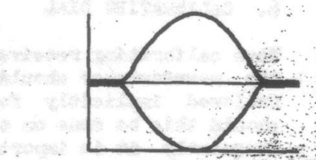


FIG. 7A

Still another method of automatic frequency control adjustment is to make use of two RF oscillators and a suitable output meter. The output meter may be connected at the second detector, or at any of the audio stages. One of the RF oscillators should be set at the IF frequency of the receiver under test and loosely coupled to the grid of the first detector. The RF oscillator should be audio modulated, and the intermediate frequency stages adjusted for maximum gain, following which the audio modulation should be turned "off", with all other connections left exactly the same. Next, the second RF signal generator should be connected to the antenna and ground post of the receiver, and adjusted to some broadcast frequency, for instance 1,000 kc. Next turn "on" the audio modulation of the second oscillator, and throw the line switch of the first or intermediate frequency oscillator "off" temporarily, until the receiver dial is adjusted to the exact frequency of the second or broadcast band oscillator, in this case 1,000 kc. Now, with both oscillators in operation, but with the audio modulation turned off, a beat note or whistle should be heard in the loud speaker, and an indication should appear on the output meter.

Adjust the primary trimmer of the discriminator transformer until a minimum indication is obtained on the output meter. Then adjust the secondary trimmer condenser until the beat note heard in the loud speaker approaches zero beat, and continue until no whistle is heard in the loud speaker or until the pitch has a very low tone. This should complete the adjustment of the automatic frequency control circuit, and the receiver should now be checked on the air for proper operation.

5. I-F REJECTOR CIRCUIT ALIGNMENT

Many of the better receivers are designed with a trap circuit (in the first RF stage) which should be tuned to the intermediate frequency of the receiver. This circuit is designed to eliminate signals at the intermediate frequency which would otherwise pass into the IF amplifier and cause heterodyne and whistles in the output of the receiver. It may very easily be adjusted by connecting the signal generator to the antenna and ground posts, and setting the generator to the IF frequency. The generator should be modulated with a 400-cycle note for this check, which will give a reading on an output meter connected in the audio stages of the set. The IF rejector should now be tuned until the output meter reading is at a minimum.

A faster method of adjusting the IF rejector circuit is to apply a frequency-modulated signal to the antenna and ground posts of the receiver, and to adjust this to the IF frequency. With the vertical plates of the cathode-ray oscillograph connected across the load resistor in the plate circuit of the second detector, a small selectivity curve will be obtained on the screen of the oscillograph. It is now only necessary to adjust the IF rejector trimmer until this curve has reached minimum height.

6. CALIBRATING DIAL

When calibrating receiver dials, the instructions of the manufacturer should always be referred to and followed implicitly for best results. Especially should this be done on all-wave receivers, as quite frequently it is important to align the shortest wave-length coils first, proceeding upward and completing alignment of the broadcast band after all other coils have been adjusted. However, it will be found that most receivers can be adjusted on any band, as follows:

Adjust the tuning dial of the receiver near the low capacity end, say 1400 kc., if alignment is desired in the broadcast band. The RF signal generator should be modulated with the 400-cycle note, and connected through a suitable dummy antenna to the antenna and ground posts of the receiver. If the RF signal generator is now adjusted to 1400 kc., a suitable reading should be obtained on an output meter connected with one of the audio stages of the set. The oscillator trimmer condenser should then be adjusted until maximum output is obtained when the receiver dial is exactly at 1400 kc. and when the oscillator is tuned to exactly 1400 kc. The detector trimmer condenser should next be adjusted for maximum output, and finally, the RF trimmer should be adjusted until maximum output is obtained.

Now rotate the receiver dial to the high capacity end, say at 600 kc. The test oscillator should likewise be adjusted to 600 kc. and a reading should appear on the output meter. Now, by slowly rocking the oscillator padding condenser, a point will be found which will give maximum output. After this has been accomplished, the receiver should again be turned to the low capacity of the dial, 1400 kc., and the oscillator, detector, and RF trimmers again adjusted for maximum output. This should complete the adjustment of the dial for this one band. Similar adjustments may be carried out on the other bands of all-wave receivers in most instances.

A more rapid procedure for calibrating a receiver dial is to use a frequency-modulated signal and a cathode-ray oscillograph. The frequency modulated signal should be applied to the antenna and ground binding posts of the receiver, while the vertical plates of the oscillograph are connected across the resistor in the plate circuit of the second detector. When the receiver and oscillator are adjusted to resonance, a curve should appear on the screen of the oscillograph. The oscillator, detector, and RF trimmer should be adjusted with the receiver tuned to the low capacity end of the dial, until maximum height of the curve on the oscillograph is obtained. At the same time, the curve must be symmetrical. Next turn the receiver dial toward the high capacity end and adjust the oscillator padding condenser for maximum curve height on the oscillograph. <u>It is not necessary to rock the receiver dial in this instance</u> as the frequency modulator automatically varies the frequency of the oscillator back and forth, thus performing this function for the operator.

7. SENSITIVITY MEASUREMENTS

It is difficult to obtain accurate sensitivity measurements of a receiver with the standard radio frequency signal generator and output meter. However, a very good approximation of the receiver's relative sensitivity may be obtained after the technician has had some experience with one particular oscillator and output meter on various receivers, when he will be able to determine the approximate setting of the output attenuator of the signal generator to obtain a certain output meter reading. This setting will, of course, vary with different types of receivers, however, a background of experience will soon allow the technician to determine in an approximate manner whether a receiver has sufficient gain or whether it is lacking in sensitivity.

Similarly, with a frequency modulated signal and cathode-ray oscillograph, the setting of the output attenuator necessary to give a certain curve height on the cathode-ray oscillograph will be indicative of the sensitivity of various receivers. Experience here soon enables the technician to make intelligent comparison between the sensitivities of the various receivers which come to his attention.

The procedure for accurately checking sensitivity with a calibrated output signal generator is to use a suitable power measuring meter in the output of the final receiver stage, and to adjust the calibrated attenuator of the signal generator until the output meter measures the normal test output of the receiver, as defined by the Institute of Radio Engineers, in "Standards on Radio Receivers, 1938," as follows:

(a) For receivers capable of delivering at least one watt maximum undistorted output, the normal test output is an audio-frequency power of 0.5 watts delivered to a standard dummy load.

(b) For receivers capable of delivering 0.1 but less than 1 watt maximum undistorted output, the normal test output is 0.05 watt audio-frequency power delivered to a standard dummy load. When this value is used, it should be so specified. Otherwise the 0.5 watt value is assumed.

The signal generator should be modulated with an audio signal of 400-cycles at 30% for this measurement. When normal test output is obtained in the output of the receiver, the input level from the signal generator is read from the calibrated attenuator. It should be in the order of a very few microvolts. Normally a curve is plotted showing sensitivity against frequency. This will appear much the same as that shown in Fig. 8. By plotting curves of sensitivity vs. frequency for each receiver band, it will always be possible to refer back to the curve, and to determine the exact sensitivity at any

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ulated with a 400-cycle audio note so that a value of approximately 30% is held. A suitable output meter, such as a decibel meter, should be connected across the final stage of the receiver, so that microvolt input can be plotted against watts output. The use of a decibel meter across the output of the receiver allows translation of the receiver power output into watts.

On sensitive receivers, the input should be adjusted to 1 microvolt and the power output reading noted. Similarly, power output readings should be taken at 2, 5, 10, 50, 100, 500, 1000, 5000, 50,000, and 100,000 microvolts input to the receiver. These values may then be plotted on a piece of graph paper and connected by a smooth curved line, which will represent the AVC action of the receiver. A good AVC curve will look similar to that shown in Fig. 11. The curve should be relatively flat as the microvolt input is increased.

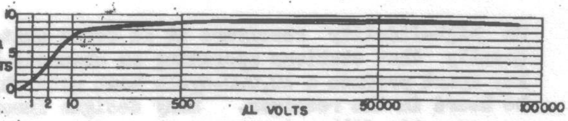

FIG. II

A more rapid check of AVC action is by cathode-ray oscillograph. The RF signal generator for this test <u>must have</u> pure sinusoidal modulation, and should therefore be tested, unless its waveform is known to be first class.

The RF signal generator should be modulated with an audio signal of 400-cycles, and applied through a suitable dummy antenna to the antenna and ground binding posts of the receiver. The cathode-ray oscillograph should be connected across the second detector output.

Tune the receiver and signal generator to any broadcast frequency where there is no local broadcast interference, using the lowest practical output from the signal generator. A pattern of the rectified signal should appear on the screen of the oscillograph.

Gradually increase the output from the RF signal generator. The pattern will grow in size, rapidly at first until the AVC action takes hold, then less rapidly. As the pattern enlarges, hold it on the screen by reducing the vertical gain control of the oscillograph.

If the AVC circuits are functioning properly, the pattern will maintain its sinusoidal shape <u>right up to the maximum output of the signal generator</u>. If distortion appears, due to a leaky or shorted AVC condenser or an open AVC resistor, the actual defect is then quickly located by a resistance analysis of the AVC circuit portion.

12. STAGE-BY-STAGE ANALYSIS

When experiencing intermittent trouble in a receiver, or open circuits, shorts, or other difficulties of this nature, it is far more rapid and profitable to determine exactly which stage is in difficulty, rather than to test numerous suspected parts or to make a systematic test of all the component resistors, condensers, coils, etc. in the receiver.

The signal generator should be connected through a suitable dummy antenna to the input binding posts of the receiver under test, and a vacuum tube voltmeter may be used to check the various stages. For instance, the vacuum tube voltmeter should be connected across the second detector circuit, and if no signal is coming through, it is obvious that the difficulty lies between the input to the receiver and the second detector. Likewise, if there is an intermittent between the input and the second detector, it will cause fluctuation in the reading of the vacuum tube voltmeter. The vacuum tube voltmeter should then be connected ahead one stage until it is across the secondary of the last IF transformer, and if the signal is still non-existent or showing intermittent trouble, the vacuum tube voltmeter should be connected farther towards the front end of the receiver by one stage. By checking the various stages in this manner, it is very easy to isolate receiver trouble to one particular tube, or one particular stage, where there are only some four or five parts which may easily be tested in the routine manner to clear up the trouble.

Most rapid and effective of all, for stage-by-stage analysis work, is a frequency-modulated signal and cathode-ray oscillograph, however, the procedure is slightly different than that described in the preceding paragraph. The vertical plates of the cathode-ray oscillograph should be connected across the load resistor in the plate circuit of the second detector during all tests that are to be made on the RF section of the receiver. It will be well to apply the frequency-modulated signal through the dummy antenna to the grid of the first detector tube, setting the signal at the IF frequency. If a suitable curve is obtained on the oscillograph, it is evident that the trouble is not in the intermediate stages but in the oscillator, first detector stage, or RF stage. The frequency-modulated signal may then be removed to the antenna and ground binding posts, and set to resonance with the receiver on some broadcast frequency to determine if the intermittent or trouble is in one of the first stages. If, when the signal (at RF frequency) is applied to the grid of the first detector tube, it is not received through the intermediate frequency amplifier, it is evident that the trouble must lie some place between the first detector and the second detector. It is then a simple matter to apply the signal (at IF frequency) across the various IF stages, or across primary or secondary of the IF transformers, until the trouble has been localized to one section of one stage. When this has been done it will be found that there are only a few component parts, usually not more than three or four, that need to be checked for the trouble.

A similar procedure may be used in the audio stages of a receiver, however, in this case it is necessary to see that the RF sections are working in the proper manner before continuing test in the audio circuit. The RF signal generator should be audio frequency modulated with approximately a 400-cycle note, and connected through a suitable dummy antenna to the antenna and ground binding posts of the set to be tested. The vertical plates of the cathode-ray oscillograph may then be connected to various sections in the audio amplifier of the receiver, and any intermittents, shorts, or trouble may definitely be localized to one stage or a portion of a stage. When this has been done, it is only necessary to check in a routine manner the few parts which are intimately connected with the stage known to be at fault.

particular frequency of the receiver in question. When making measurements of this type, a standard dummy antenna should always be used between the calibrated output signal generator and the receiver under test.

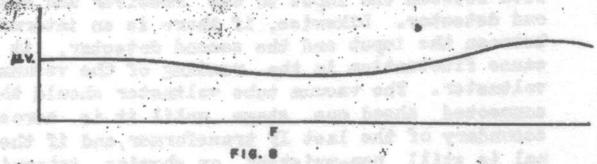

FIG. 8

8. OVER-ALL DISTORTION

Over-all distortion of a radio receiver may be checked by connecting a radio frequency signal generator through a suitable dummy antenna to the antenna and ground binding posts of the receiver. A signal generator should be modulated approximately 30% by a pure sine-wave audio frequency of approximately 400 cycles. The cathode-ray oscillograph should be connected with a vertical plate across the voice coil of the loud speaker, and the instrument placed in operating condition. A good RF signal generator, properly modulated with a pure sine-wave audio frequency, should give a signal which, when passed through to a receiver and delineated upon the screen of the oscillograph, appears as a pure sine wave on the screen. If distortion is present, either in the RF sections of the receiver or the audio frequency sections, the wave form appearing on the screen of the oscillograph will not be of pure shape. See Fig. 8A.

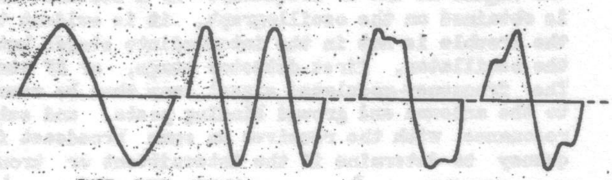

FIG. 8A

9. OVER-ALL FREQUENCY RESPONSE

After a receiver has been properly aligned, it is often of great importance to know exactly how much fidelity may be expected. In order to run a complete fidelity test on a receiver, it is necessary externally to modulate an RF signal generator with a continuously variable audio frequency oscillator. The output from the RF signal generator is then fed through a suitable dummy antenna to the input of the receiver under test.

The variable frequency audio oscillator should be capable of supplying a sine wave at any frequency between 25 cycles per second and 15,000 cycles per second, and have sufficient power to modulate the RF signal approximately 30% to 50%. The output voltage of the oscillator should remain reasonable constant between the limits of 25 cycles and 15,000 cycles per second. The output of the receiver should be measured with a decibel meter, so that the output at various audio frequencies can be determined and plotted on a suitable chart.

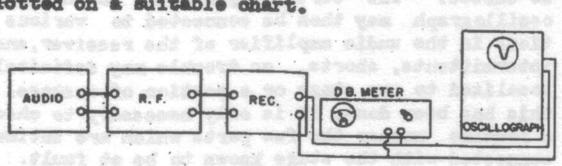

FIG. 9

It is well to connect the vertical plates of an oscillograph across the voice coil of the receiver and observe the output wave form at the various frequencies, to check for wave form distortion which may occur only at certain frequencies and not entirely across the audible range. A suitable set-up for this type of measurement is shown in Fig. 9. The output reading in decibels may be plotted against settings of the audio frequency signal generator, and the over-all frequency response curve of the receiver thus obtained, as shown in Fig. 10.

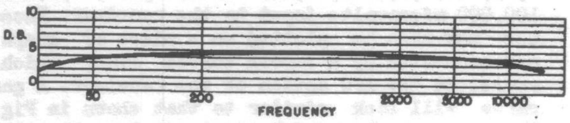

FIG. 10

10. ACOUSTIC FILTER ADJUSTMENT

On high-fidelity receivers it is found quite frequently that stations operating on channels only 10 kc. apart produce a 10,000-cycle beat note which may be heard in the receiver. Many designs incorporate an acoustic filter in one of the audio stages, designed to eliminate this objectionable 10,000 cycle note.

This acoustic filter may be adjusted by externally modulating an RF signal generator with a variable frequency audio oscillator set at 10,000 cycles. The output from the RF signal generator should then be fed through a suitable dummy antenna to the antenna and ground binding posts on the receiver under test. An output meter or oscillograph should be connected across the final audio stage of the receiver. When the acoustic filter is out of adjustment, the output meter will show a reading, or a 10,000-cycle sine wave will appear on the screen of the cathode-ray oscillograph. When the acoustic filter trimmer condensers have been adjusted until the output meter shows a minimum, or until the wave form on the oscillograph is at a minimum height, the acoustic filter is properly adjusted.

11. AVC ACTION

Automatic volume control action on a receiver may be checked by connecting an RF signal generator through a suitable dummy antenna to the antenna and ground binding posts of the receiver. The RF signal generator should be modulated with an audio signal of approximately 400 cycles for this type of test. An output meter should be connected to the output of one of the audio stages of the receiver, and the receiver and signal generator tuned to the same frequency. Input to the receiver on the signal generator should be increased until a normal volume level has been reached. If the RF signal is then increased by approximately ten times its former value, the output meter needle should increase its reading only slightly. If the RF signal from the oscillator is increased approximately 100 times the original level, the output meter should not show an increase greater than 25%. The AVC action will then be quite satisfactory.

If a signal generator is available with the output attenuator calibrated in microvolts, it is possible to plot a curve showing the AVC action in accurate detail. The signal generator should be connected through a suitable dummy antenna to the input binding posts of the receiver and tuned to the same frequency as the receiver. The RF output should be mod-and the oscillator turned on. For this test it will be best to use the unmodulated RF output from the signal generator. If the receiver dial is approximately calibrated in frequencies, the test oscillator should be set at the dial frequency, and the tuning condenser then rotated slowly until a whistle or beat note with the incoming signal is heard in the receiver. When this whistle has reached its lowest point or is at practically zero pitch, the signal generator will be in tune with the incoming or transmitted signal. It will then only be necessary to refer to the frequency calibration of the signal generator to determine the exact frequency setting.

If the receiver used in this measurement does not incorporate a calibrated dial, the same procedure should be followed, however, the signal generator should be set at a frequency known to be higher than the incoming signal and slowly tuned toward the lower frequencies until the first whistle or beat note is heard. This then will be the exact frequency of the incoming signal. Should the signal generator be tuned considerably lower than the incoming signal, it is possible that a harmonic of the signal generator combined with the incoming signal might be mistaken for the fundamental.

Transmitters may be monitored in much the same manner, however, a receiver will seldom be satisfactory for carrying out this measurement unless it is located at some distance from the transmitter. Usually a monitor is used which will tune to the frequency of the transmitter. The output from the RF signal generator should then be loosely coupled to the input of the monitor, and the tuning dial slowly rotated as described above until a beat note is heard between the signal generator and the transmitter in the monitor. At this point the signal generator will be at the transmitter frequency, and it is only necessary to refer to the signal generator calibration to determine the frequency.

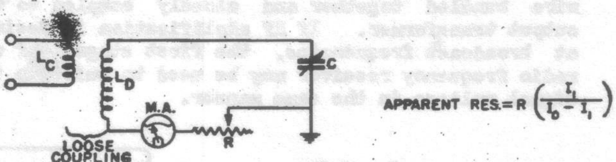

FIG. 13

17. RADIO FREQUENCY RESISTANCE

The radio frequency resistance of tuned circuits may be effectively measured as shown in Fig. 13. Coupling between the signal generator output coil "L_C," and the tank circuit under test should be rather loose so that the voltage developed across "L_C" will not vary as the loading in the tank circuit is changed. One side of the tank circuit should be grounded, and a variable resistor which is non-inductive and calibrated in ohms resistance should be connected in the circuit on the grounded side. A thermo-millameter should also be connected in series with a circuit on the grounded side as shown. The resistance "R" should be turned to 0, and the tank circuit tuned to resonance with the oscillator output frequency. The current in the milliammeter then observed should be designated as "I_0." The resistor "R" should then be increased to some known value, the circuit retuned to resonance as necessary, and the current MA again noted and designed as "I_1." The apparent series resistance of the tuned circuit to the radio test frequency is equal to $R \times \text{quantity } \frac{I_1}{I_0 - I_1}$

If the capacity "C" is kept large with respect to the distributed capacity of the coil "L_d," the error in this type of measurement will be extremely small. It may be necessary to use an amplifier with the signal generator, as mentioned under Topic 15, to supply sufficient power for tests of this nature.

18. OSCILLATOR CALIBRATION

Signal generators may be checked with reasonable accuracy by beating them in a receiver against an incoming signal of known frequency. A tuned radio frequency receiver will be found superior to the ordinary superheterodyne type for measurements of this nature, and there is no confusion of beats due to the oscillator in the receiver. With due care it is possible to use superheterodyne receivers and obtain very satisfactory results. The receiver in question should be tuned to a broadcast station of known frequency, for instance Station WHO, operating at 1000 kc. If a signal generator is now loosely coupled to the antenna of the receiver and tuned until it is exactly 1000 kc., a beat note will then be heard between the signal generator and the incoming signal.

When this beat note has reached its lowest pitch, the signal generator will be in exact tune with the broadcast station of known frequency.

It is quite frequently rather difficult to check harmonics of signal generators unless a very sensitive receiver is available, as the better engineered signal generators have an RF output approaching a pure sine wave which is not very rich in harmonics. It will frequently be found, however, that with a good receiver second and third and sometimes even higher harmonics may be picked up in the receiver. If the receiver is left tuned to a station on 1000 kc., as above, the oscillator may then be tuned to 500 kc., and the second harmonic checked for zero beat with the broadcast station. When zero beat is obtained, the oscillator will be set exactly on 500 kc. Similarly, beat notes will be heard when the oscillator is set at 250 kc. Other stations may be used likewise for checking the oscillator in a similar manner. For instance, a station operating on 700 kc. would allow the operator to check the oscillator at 700 kc., 350 kc., and 175 kc.

On the high frequency bands, it is advisable to check the signal generator against the government frequency standards broadcast by Station WWV three days a week, between the hours of 12 noon and 3:30 P. M. Eastern Standard Time. The first third of this period the transmission is on 5000 kc., during the second third of this stage it is on 10,000 kc., and during the last portion of this period on 15 mc.

Heterodyne signal generators, such as the frequency-modulated type, cannot be satisfactorily checked except in the laboratory or at the factory where they were originally calibrated. Due to the heterodyne feature in these instruments, a considerable number of beat notes are produced in a receiver, and it is virtually impossible for even an expert to carry out an accurate calibration, unless special procedure and laboratory methods are used.

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13. MICROPHONIC CONDITIONS

Microphonic conditions in receivers, due to bad tubes, loose tube elements, etc. can usually be determined by applying an extremely strong, unmodulated RF signal to the antenna and ground binding posts. When this has been done, the various tubes should be tapped lightly to determine which one is causing the microphonic condition. It may frequently be found that some other portion of the receiver, such as a tuning condenser or some of the other component parts, is causing difficulty with reception which will cause much the same effect as microphonic tubes.

Rattles in the loud speaker, or cabinet rattles at certain frequencies, and other difficulties of this nature, may be determined by connecting an RF signal generator through a suitable dummy antenna to the input of the receiver and externally modulating the RF signal generator with a continuously variable frequency audio oscillator. As the audio oscillator is varied across the audible band, certain points will be found at which the speaker rattle will take place, or at which the cabinet will buzz or sing if there are any loose sections. This is a type of trouble which is frequently very hard to locate, but resolves itself into a simple analysis when proper equipment is used.

14. INTERMITTENTS

Intermittent trouble in radio receivers may be located very readily with either a frequency modulated signal or with a signal modulated by a 400-cycle audio sine wave. The frequency-modulated signal should be applied to the input of the receiver under test and the cathode-ray oscillograph connected across the load resistor in the plate circuit of the second detector. When the instruments are set in operation, the normal selectivity curve will appear on the screen of the oscillograph. If the intermittent causes only a drop in signal level, it will be found that the curve on the oscillograph will decrease in height proportionately. If the intermittent causes the receiver to become completely dead, the curve will disappear entirely from the screen.

By applying the frequency-modulated signal to various stages, as described in Section 12, it will be easy to determine in what stage the intermittent is occurring. When the stage causing the trouble is located, it is possible to apply a 400-cycle audio-modulated signal to various portions of the stage, and thus trace the trouble down until it is confined to two or three parts of one circuit.

If the intermittent trouble does not show up with the oscillograph connected across the second detector, and still is evident when listening to the loud speaker, then the signal generator should be modulated with an audio frequency of approximately 400 cycles and the vertical plates of the oscillograph hooked in the various stages of the audio amplifier until the intermittent trouble shows up on the oscillograph. By checking at various places in the audio stages, the trouble can be isolated to a few parts of one circuit in the same manner as would be done in locating the intermittent in the RF stages.

Intermittent trouble in the RF sections of the receiver can frequently be found by applying an extremely strong, unmodulated radio frequency signal to the antenna and ground binding posts. The volume control of the receiver should be turned full "ON" and the various sections of the set, as well as various condensers, connections, resistors, etc., tapped lightly while listening to the output. Intermittent troubles when the set is tapped in this manner will cause loud noises in the speaker, or cause the receiver to sing every time a defective part is jarred slightly.

15. RADIO FREQUENCY AMPLIFIERS

It is frequently desirable to have a rather strong radio frequency signal for various types of testing and measuring. A strong RF signal is of advantage in measuring gain per stage in matching coils, measuring radio frequency resistance, and carrying out impedance measurements at radio frequencies. If a signal generator is designed to have a high RF output voltage, it will be found that it is very difficult to attenuate the signal sufficiently for the modern sensitive receivers. In making precision signal generators for accurate servicing of the more sensitive receivers, it is therefore absolutely necessary that the maximum RF output voltage of the instrument be kept to a fairly low value, on the order of 100,000 microvolts. When it is desired to use the signal generator for matching coils, measuring gain per stage, etc., it will be well to amplify the RF output of the instrument until the maximum power obtainable is 1 or 2 volts.

In making radio frequency resistance measurements, it may be desirable to have an amplifier capable of delivering even more power. If amplification of the RF signal is desired at IF frequencies, one may very easily press into service the IF amplifier of any radio receiver, as illustrated in Fig. 12. The signal generator should be connected to the grid of the tube preceding the IF stage, and the output from the IF amplifier may be obtained by coupling to the last IF transformer with a coil made up of a few turns of wire bundled together and closely coupled to the output transformer. If RF amplification is desired at broadcast frequencies, the first stages of any radio frequency receiver may be used to build up the signal voltage in the same manner.

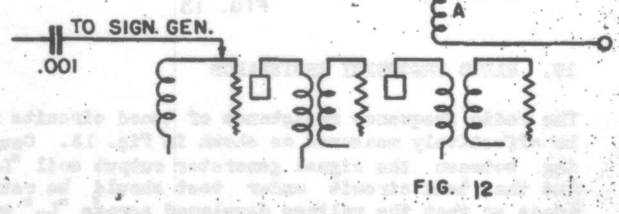

FIG. 12

It should be noted that the IF amplifier or the radio frequency section of the receiver should be tuned to exactly the same frequency as the RF oscillator output which it is desired to amplify. Nominal RF output voltages may thus be built up very readily to a satisfactory level for virtually all types of measurements.

16. HETERODYNE FREQUENCY METERS

It is often desirable to know the exact frequency of some received signal, and a well calibrated signal generator can be used for this measurement. The receiver should be tuned to exact resonance with the incoming signal whose frequency is to be measured. The output from the RF signal generator should then be loosely coupled to the antenna of the receiver