

INSTRUCTION MANUAL No. 3

FOR

INSTALLING, OPERATING and SERVICING

THE A. V. C. MODEL

HAMMARLUND COMET "PRO"

This manual is intended to provide information, even to a novice, for the successful installation and operation of the Comet "Pro" receiver. Experienced operators will necessarily find some of this information superfluous but it is nevertheless suggested that this material be read through carefully. Much useful technical information concerning the circuit design will be found in the descriptive booklet which, together with this instruction manual, accompany each Comet "Pro" receiver.

INSTALLATION

The "Pro" is designed to operate with any type of antenna, including those employing two-wire "balanced" leads. The primary of the antenna coupler is isolated from the chassis and its two terminals are brought directly out to the antenna-ground terminal block at the center of the chassis. If an antenna having a transposed, parallel or other type of double lead-in is employed the leads are connected to the two "A" screw terminals. If the antenna is one having a single lead-in, it is connected to one of the "A" posts and a jumper connected between the other "A" and the "G" terminals to complete the circuit.

With either of these types of antennae the "G" terminal should be connected to a good ground -- and emphasis should be placed on the "good". If there are two or more possible means for grounding the receiver it is well to try them all, singly and in combination, to determine the most effective arrangement. In some cases it may be found that grounding offers no noticeable advantage but even in such cases it is usually considered best practice to ground an A.C. operated receiver.

TUBES

Where the tubes are provided with the receiver they are carefully tested RCA or Cunningham tubes and therefore carry the assurance of correct operation. Where the receiver is purchased without tubes it is recommended that the tubes employed be of a standard, recognized make and that they be carefully checked to avoid any that are actually defective. While the "Pro" is not critical in its tube requirements it must be remembered that a single tube that is below standard in quality may seriously impair the operating efficiency, just as it would any other highly sensitive receiver.

The tubes required are 4 type 58's, 2 type 57's, 1 type 2B7 1 type 2A5 power tube and 1 type -80 rectifier tube. Each of the tube sockets is clearly marked with the type number of the tube to be used in it. Be certain that tubes are inserted in the proper sockets.

The first step in the actual installation of the receiver is to remove the caps and then the body sections of all tube shields. This uncovers the sockets and their markings, and the 57's and 58's may be inserted in their respective sockets. The 2A5 and -80 tubes should be left out of their sockets for the time being or they will be in the way when making the antenna, ground and loudspeaker connections.

With these 7 tubes in position the body sections of the shields may be replaced, with the notches in their lower edges over the heads of the socket mounting screws. Then connect the grid cap leads to the top terminals of the tubes. When the receiver leaves the factory each of these leads is run into the proper tube shield but should there be any confusion concerning the proper connections when making the installation it will be cleared up by referring to the view of the chassis top. After the grid caps are pressed down securely on the top terminals of the tubes, the shield caps may be placed in position.

The loudspeaker may next be connected to the screw terminals at the rear left-hand corner of the chassis. Polarity is immaterial as these are the terminals of the output transformer winding.

This transformer is designed for a 4000 ohm load, which means that a magnetic type speaker may be connected direct, or any other type of speaker may be employed provided its rated impedance is between 2000 and 8000 ohms. This wide leeway is accounted for by the fact that, while the ideal impedance match would be provided by a 4000 ohm speaker, the actual losses resulting from the use of a 2000 ohm speaker or an 8000 ohm unit are so slight as to be scarcely perceptible to the ear. The Comet "Pro" speaker is of the permanent-magnet dynamic type rated at 4000 ohms. It offers the advantage of the moving coil type of speaker, without the disadvantage of requiring a source of field-current supply. If it is desired to employ an electrodynamic speaker with the "Pro" it must, of course, be provided with its own field supply as the "Pro" is not designed to supply this current.

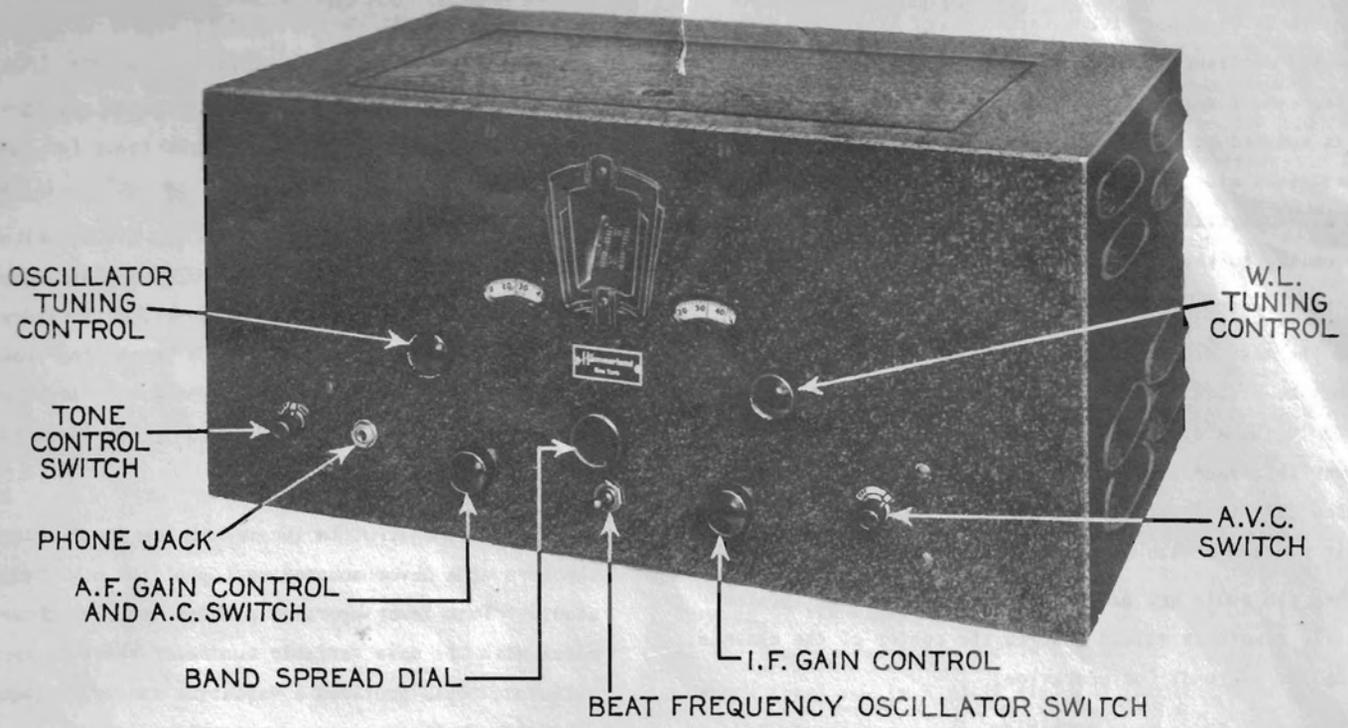
Inasmuch as the receiver is equipped with transformer output, there is no direct current present in this circuit and therefore no possibility of damaging the windings of a magnetic speaker connected direct to the output terminals.

Provision for connecting headphones is made in the form of a jack located on the front panel. When a plug is inserted in this jack the loudspeaker is automatically cut out. A study of the jack circuit shown at the lower right in the circuit diagram will disclose a 25,000 ohm series resistor; also that the headphones are connected across only a part of the output transformer. This arrangement, combined with the inherent characteristics of the headphones, results in the attenuation of both the extremely low and the extremely high audio frequencies. Thus the last vestige of a.c. hum is eliminated as well as a good part of the high-frequency noise which may be so troublesome when receiving weak signals.

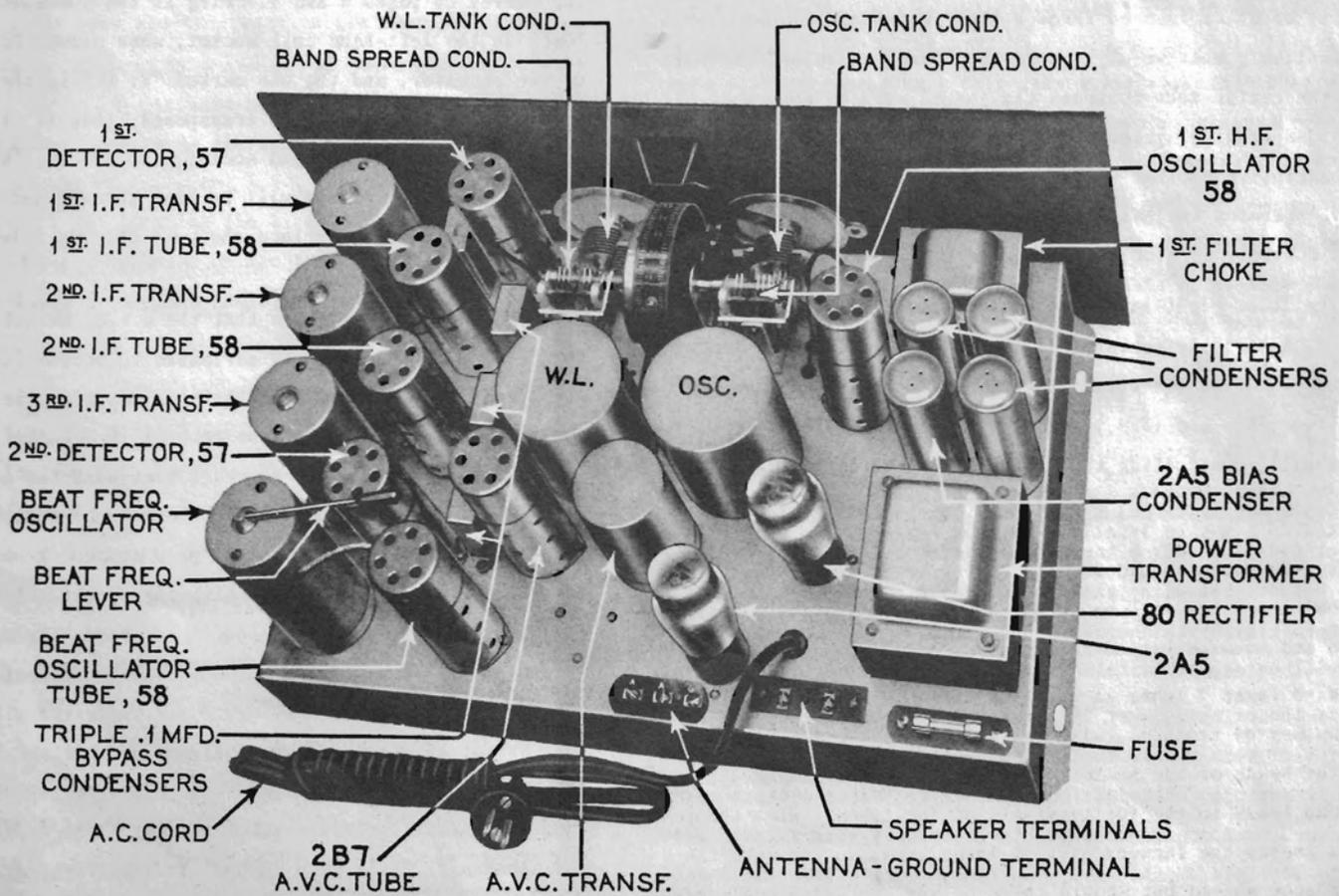
A loudspeaker will not sound well if plugged into the headphone jack because in the first place the volume of output will be subnormal and second the attenuation of the extremes of the audio range will appreciably affect the quality of reproduction.

POWER SUPPLY

The "Pro" is designed for operation from a 110-120 volt, 60 cycle, a.c. line, and should never under any circumstances be plugged into high-voltage a.c. circuits or d.c. circuits of any type. Where 110-120 volt a.c. supply is not available there are various makes of converters and motor-generators on the market which derive their power from d.c. lines or a storage battery, and provide an output of 110 volts, 60 cycles, alternating current suitable for the operation of the "Pro". Such a motor generator should be capable of continuously supplying 100 watts. Where the supply is alternating current but of different voltage or frequency than called for, special



Front View



Top View

models of the "Pro" can usually be provided. One of these special models is equipped with a tapped power transformer which permits the receiver to be operated from 115, 125, 140, 230 or 250 volt, a.c. lines. Adjustment is made at a terminal box which is mounted on top of the power transformer. In it is a terminal block with a terminal marked for each of the above voltages. A pigtail lead is simply connected to the terminal corresponding to the existing voltage.

A battery operated model also is available.

As the next step in the installation, the 2A5 and -80 type tubes may be placed in their sockets, then the plug should be inserted in the a.c. line and the switch, which is operated by the lower left-hand knob on the front panel, turned on. Should the tubes fail to light examine the line fuse (1½ ampere rating) which is mounted at the rear of the chassis, at the left.

When the coils are plugged into their sockets, located within the removable shield cans in the center of the chassis, the receiver is ready for operation.

OPERATION

There are, in all, ten controls provided to enable the operator to obtain absolutely maximum efficiency and effectiveness in the reception of even the weakest signals. The three upper knobs in the center of the front panel are the tuning controls. The upper left knob tunes the oscillator tank circuit, the calibrated dial of which rotates behind the left-hand window. The upper right-hand knob tunes the r.f. input circuit, the dial of which is seen through the right-hand window. These two constitute what we might term the "range selector" controls while the center knob controls the ganged vernier condenser of the band-spreading system which is described in some detail in the descriptive booklet which accompanies each receiver. This control operates the main, center dial and in effect provides single control, vernier tuning of the two tank circuits.

The lower right-hand knob is the manual gain or sensitivity control, a variable resistor in the cathode circuits of the two i.f. tubes, which functions to vary the control-grid bias on these two tubes and thus provides a smooth and dependable means for manually controlling the gain of the i.f. amplifier.

The lower left-hand knob is the combination audio volume control and line switch knob. This is used for the control of audio output when using the a.v.c. system. When the a.v.c. system is not in use this control knob is left full on for reasons that will be explained later.

At the extreme lower left is the tone control switch. The function of this switch is to permit attenuation of the higher audio frequencies when desired in order to reduce certain types of background noise when tuning for extremely weak signals. It is normally left in the "off" position, which allows the use of the full audio range. To attenuate the higher frequencies it is thrown to the "on" position.

The toggle switch located immediately below the band-spread tuning knob in the center of the panel, serves to cut the c.w.

beat oscillator in and out of the circuit. It accomplishes this by cutting off the screen-grid supply to this tube, when in the "off" position. This prevents the tube from oscillating yet, inasmuch as both the heater and plate voltages are always connected, the tube remains warmed up ready for instant operation when the switch is thrown to the "on" position.

At the extreme lower right is the a.v.c. switch. When thrown to the "off" position the receiver functions exactly like the standard model "Pro," the i.f. grid returns being direct to ground. When the switch is in the "on" position the grids are returned to a point in the a.v.c. network which provides the biasing voltages required in the automatic regulation of the receiver sensitivity.

The last control is located inside the receiver and takes the form of a lever mounted on top of the c.w. beat-oscillator shield. This lever operates a midget vernier condenser in parallel with the main variable condenser which tunes the beat oscillator. This provides a variation in the audible beat note, an important factor in c.w. reception, for reasons that will be explained in detail later.

So much for the description of the controls. The next step is to gain some practical experience in its operation.

First select the pair of coils to cover the range in which it is desired to tune. The approximate range of each coil set is marked on the tops of the coils and is also shown in the tuning curves on pages 6 and 7. Plug in the coils; the one marked "Osc" in the left-hand coil socket, when viewed from the front of the receiver, and the one marked "W. L." in the right-hand socket. If these coils are transposed, that is, the "Osc" coil plugged into the right-hand socket, the receiver will not operate properly. No damage will be done through such an oversight however. Be sure to replace the coil shields after the coils are plugged in.

For the time being see that the a.v.c. switch is turned to the "off" position as it is advisable to become familiar with the operation of the set without this feature, the advantages and operation of which will be covered in detail later. It might be said in passing, however, that when the a.v.c. system is not in use the audio volume control knob at the left should be turned on full and the manual gain control knob at the right should be employed for controlling the output volume. When the a.v.c. system is in use the procedure is usually just the opposite. More about this later but for the present set the various panel controls as follows: a.v.c. switch-off, tone control switch-off (this allows full audio register), beat-oscillator switch-on (right), audio volume-control knob-full on to the right (this operation automatically turns on the line switch and the dial light), gain control knob-half way on. These adjustments leave the receiver ready for tuning in c.w. signals. If, in tuning, 'phone or broadcast signals are encountered they will be heard with a heterodyne whistle caused by the beat oscillator. This whistle can be eliminated by turning this oscillator off.

TUNING

The first step in familiarizing yourself with the tuning procedure is to carefully read over the description of the "Pro" band-spreading system in the descriptive booklet which came with the receiver. From this description it becomes evident that the "Pro" may be tuned like any other two-dial superheterodyne, if only the upper right and upper left controls, which tune the w.l. and oscillator tank circuits, are employed. However, by using the main, central control, which operates the ganged vernier band-spread condensers, one obtains an excellent degree of band-spreading with substantially single control.

In actual practice the two tank controls are used only for setting the receiver to the desired frequency band, then the precise tuning within this band is accomplished by means of the band-spread control. Thus if one desires to tune in the 40-meter amateur band the "BB" coils are plugged into their sockets and the two tank condensers are tuned to the approximate middle of this 40-meter range, with the band-spread dial set at 50. Then the actual selection of individual stations within this band is accomplished with the utmost simplicity using the band-spread dial only. This band will be found to cover approximately 90 degrees on the band-spread dial, with the stations as easy to tune as broadcast stations normally are on a broadcast receiver.

Another practice common among "Pro" users is to set the band-spread dial at zero and then tune in the lowest frequency station of a desired group by means of the two tank controls. Thereafter all the other stations of the group will be tuned in by running from zero upward on the band-spread dial. Or the opposite procedure may be followed; i.e., by setting the band-spread dial at 100 and locating the highest frequency station within a given range, by means of the two tank condensers, thus spreading the stations of that range, downward from 100 on the main tuning dial.

Each of the three dials is marked off into 100 divisions, zero representing the maximum capacity of the respective condensers, or the lowest frequency. Thus to tune up in frequency the dial readings will increase, and to tune down the readings will decrease.

On pages 6 and 7 will be found the tuning charts for the four standard coil sets. These charts show the approximate setting of the oscillator tank condenser for any given frequency or wavelength. The heavy black curve represents the dial setting for the oscillator tank condenser for any given frequency, when the band-spread control is set at 50 on the main dial. The lower broken line shows the same when the band-spread dial is set at zero, and the upper broken line when this dial is set at 100. The vertical distance between the two broken lines therefore shows the frequency range covered by the band-spread condenser alone, for a given setting of the oscillator tank condenser.

spread condenser increases appreciably at the high-frequency end of each coil range. For this reason it is desirable to set the band-spread dial at 100 when tuning the tank condensers to any desired range, which will mean, of course, that the tank condensers should then be tuned to the highest frequency station in that range. Then for a given frequency separation, the stations within the range will be spread further apart on the band-spread dial.

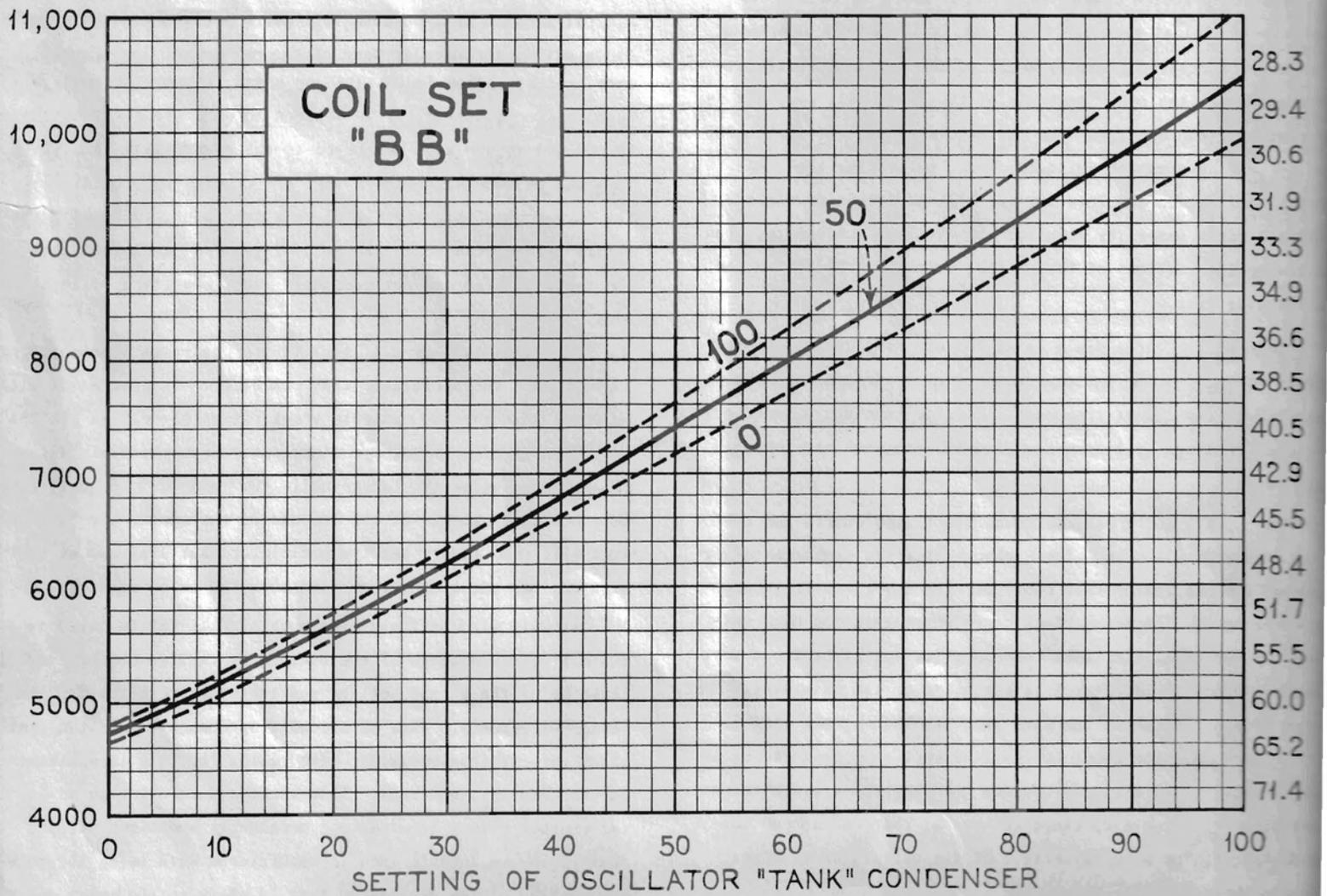
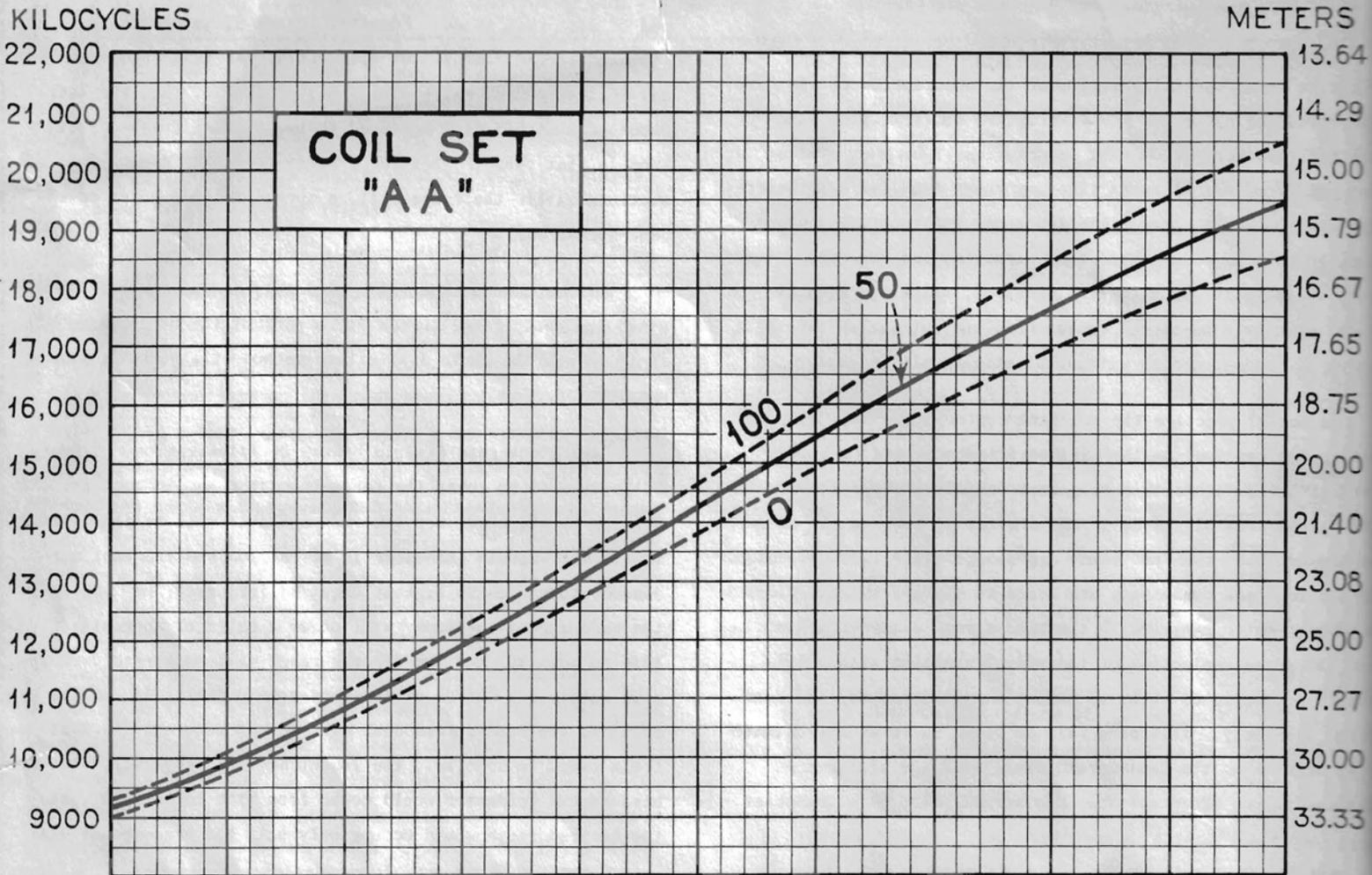
This recommendation holds good only in cases where the desired frequency range covers but a part of the band-spread dial. If it covers the whole dial either method will give the same results.

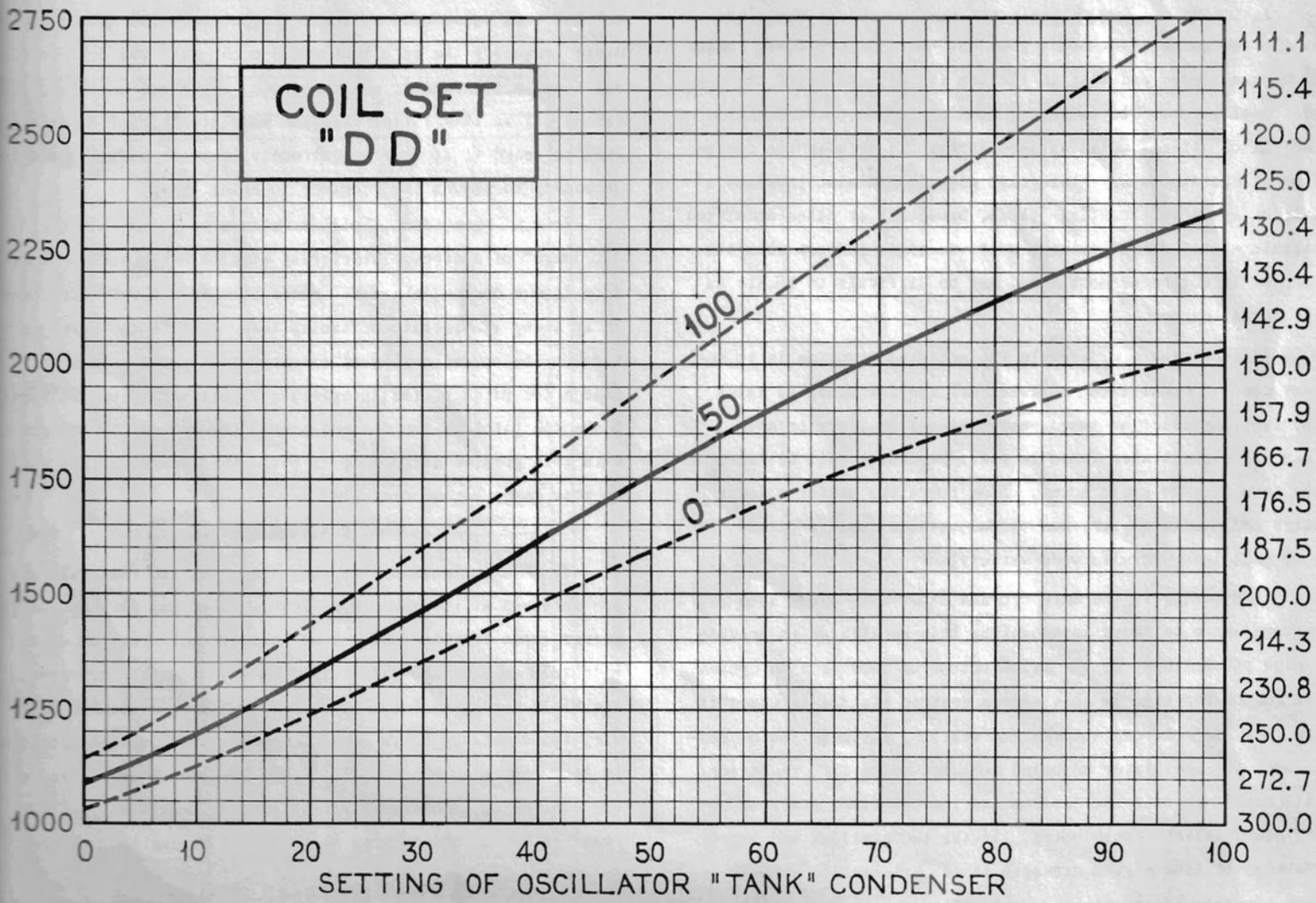
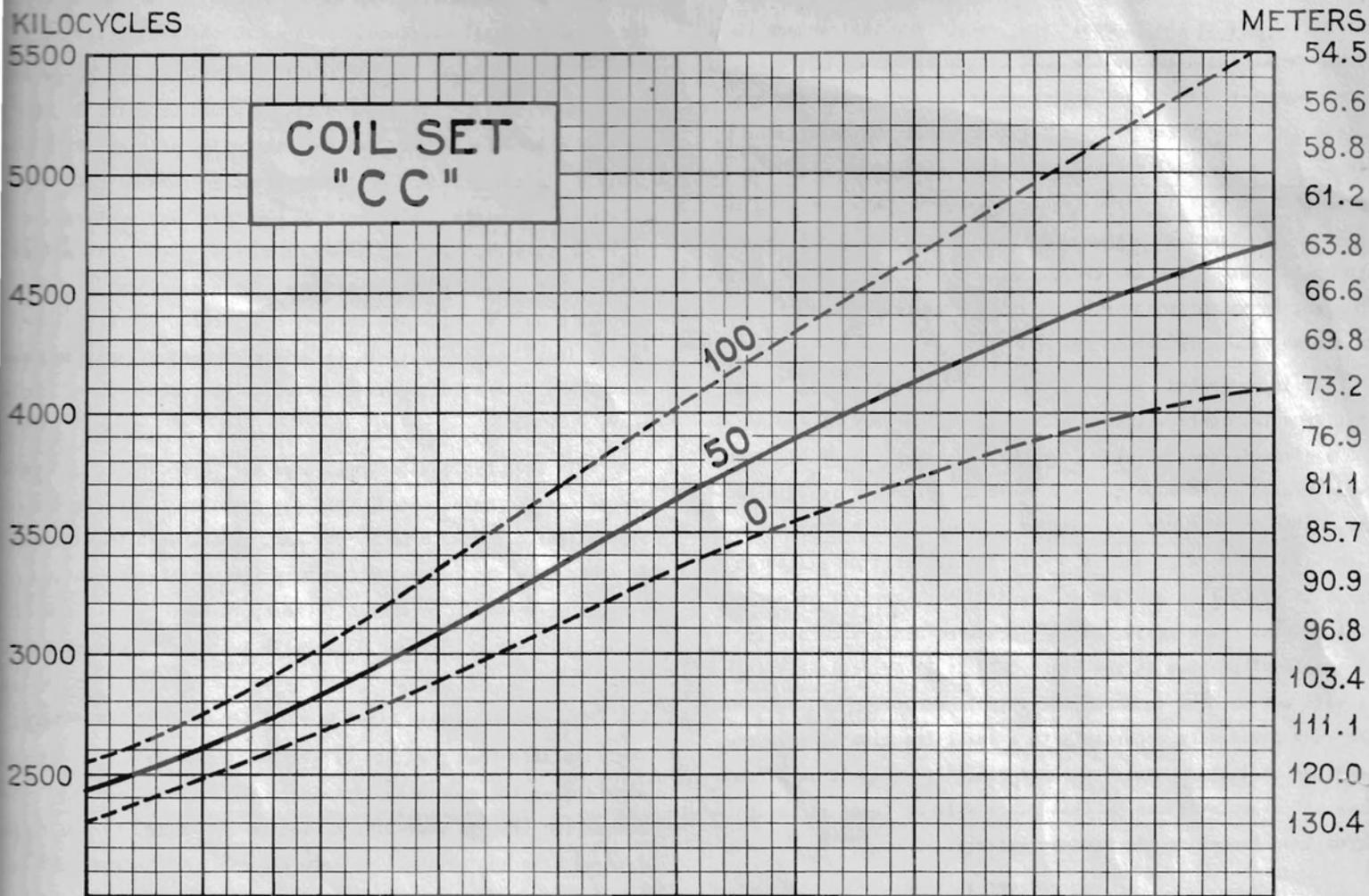
Take a concrete example by way of illustration. Suppose it is desired to cover the range from 1750 kc. to 2000 kc. Referring to the chart for the "DD" coils it will be seen that if the band-spread condenser is set at 100 and the tank condensers tuned to the highest required frequency, or 2000 kc., the band-spread condenser will cover a range of approximately 1620 to 2000 kc. and the desired range will be spread over approximately two-thirds of the band-spread dial. If, on the other hand, the band-spread dial were set at zero and the tank controls tuned to 1750 kc., the lowest desired frequency, then the band-spread condenser would cover from 1750 to 2250 kc., and the desired range would occupy only half the band-spread dial range.

It is also well to note that where a given desired range falls within the overlap band of two sets of coils, the most open band spreading is obtained by using the smaller coils. Suppose, for instance, it is desired to work the range between 10,000 and 10,300 kc. Reference to the charts will show that this can be done with either the "AA" or the "BB" coils. In the former case this range will be spread over practically the entire band-spread dial, whereas, if the "BB" coils are used the range will spread out over only about one-third of this dial.

The right-hand or w.l. tank tuning condenser tracks approximately with the oscillator tank condenser. In general it will be found that the two controls track rather closely in the "AA" and "BB" ranges, the average discrepancy being within 5 divisions. When using the larger coils "CC" and "DD" the difference is somewhat greater. At the low end of the scales the r.f. tank dial will read lower than the oscillator tank dial and at the high end the oscillator tank will show the lower readings.

It will also be found that most signals can be tuned in at two different settings of the oscillator tank condenser, one of these being the normal setting and the other representing the "image" frequency. This is a condition common to all two dial short-wave superheterodynes. The reason for this is explained in the descriptive manual. This phenomena is often an advantage rather than a disadvantage because it sometimes happens that if severe interference is encountered when using the normal setting of the oscillator tank, a shift to the image setting will completely eliminate the trouble.





The "Pro" is designed to use the higher of the two oscillator settings as the "normal" frequency. For that reason there should be no confusion on the part of the operator. Furthermore, repeat points do not generally occur when using the band-spread dial for tuning because the r.f. input and oscillator are being tuned simultaneously with the result that when the oscillator circuit is tuned to the image frequency the r.f. input has been tuned off resonance with the station whose image appears at that point and the signals of this station will therefore not be heard except perhaps in rare instances when the signal is an unusually strong one.

It is suggested, in concluding the instructions for tuning, that when the correct tank settings have once been determined for a given frequency range, they be definitely recorded so that range can thereafter be quickly tuned by reference to this record. This is best done by selecting some definite "key" station within the range and recording the settings of all three dials at which this station is heard. Then, when it is desired to tune this range again, adjust the three dials accordingly. If the "key" station is not heard, and it is quite likely that it will not be, due to the difficulty in recording and resetting the tank condensers accurately to a small fraction of a degree, vary the oscillator tank condenser slightly until it is heard. Then all other stations in that range will be found at their accustomed places on the band-spread dial.

C. W. RECEPTION

In tuning for c.w. signals the tuning process described in the foregoing still holds good but there is one other factor to be considered and that is the use and adjustment of the c.w. beat oscillator. The technical booklet points out that this oscillator offers two advantages in that it permits the reception of continuous wave telegraph signals and also provides a helpful means for locating 'phone, broadcast or other modulated signals which, due to extreme weakness or to periods when the carrier is not being modulated, may be difficult to locate in the normal manner.

In receiving c.w. signals the accepted practice is to adjust the i.f. oscillator somewhat off the frequency to which the i.f. amplifier is tuned, say 1 kilocycle, for instance. Then all signals when tuned to exact resonance will be heard in the form of 1000 cycle notes. Some operators prefer a lower pitch and others higher, and the adjustable feature of the "Pro" i.f. oscillator permits wide variety.

When tuning in the more crowded short-wave bands some advantage is to be found in adjusting this oscillator to provide a high pitched beat in the neighborhood of 2000 or 2500 cycles. The reason for this is that when a desired station is tuned in, and there is a strong interfering station, say 2 kc. below resonance, the oscillator adjusted to 1 kc. below i.f. resonance will result in both the desired and the undesired stations being heard as 1000 cycle notes. If the two stations had approximately the same signal strength at the antenna the signals from the interfering station would of course be noticeably attenuated due to the inherent selectivity of the "Pro" but in

spite of this the interfering signal would in all likelihood be the desired signal unreadable because of the similarity of pitch.

If, on the other hand, the i.f. oscillator were adjusted 4 kc. below resonance the desired signal would be heard in the form of a 2000 cycle note and an interfering station which would produce an "audio image" of this frequency would have to be 8 kc. below resonance. Reference to the selectivity characteristic of this receiver, as shown on page 9, shows that selectivity is nearly five times as great for a signal 4 kc. off resonance as for one which is only 2 kc. off. The effective "audio image" selectivity is therefore correspondingly increased when the i.f. oscillator is adjusted to provide the 2000 cycle beat.

This 2000 cycle adjustment need not be accurate, of course and is easy to make. First tune the receiver to any modulated signal that happens to be on the air. Then, when this signal is tuned to exact resonance, turn on the oscillator and swing its tuning lever to zero beat. The approximate position will be with the lever pointing diagonally away from the rear right hand corner of the cabinet. Now swing the lever either way until the ascending audio pitch reaches the desired frequency.

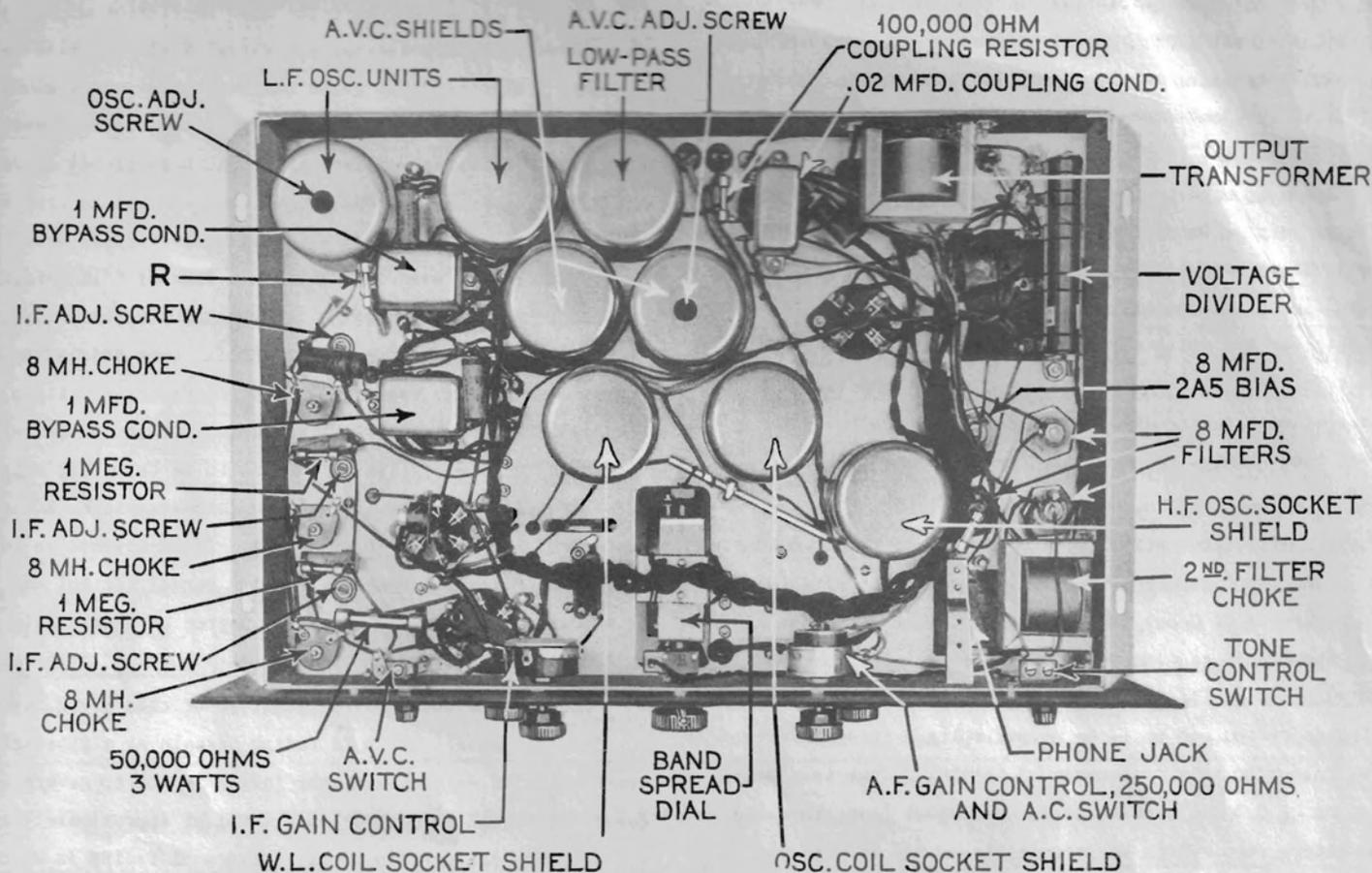
The zero beat position of the oscillator lever is employed when tuning for modulated signals by the "birdie" method. The reason for this is that when a station is located by the heterodyne whistle and is tuned to zero beat it will necessarily be tuned to exact resonance. If, on the other hand, the oscillator had been tuned 2000 cycles off resonance with the intermediate frequency the zero beat would occur with the desired signal tuned a like amount off resonance. When the oscillator is turned off in this latter case the modulated signal might not even be heard if it were an extremely weak one and it would be necessary to retune the receiver to bring it in.

In c.w. reception it will sometimes be found that the "audio image" of a strong interfering station may break up reception from a desired station. Where this is the case the remedy is to swing the oscillator tuning lever over to the same position on the opposite side of the zero-beat point. This will change the pitch of the interfering signal very materially but leave the pitch of the desired signal the same as before and with this greater difference in pitch the desired signal will in most cases become readable.

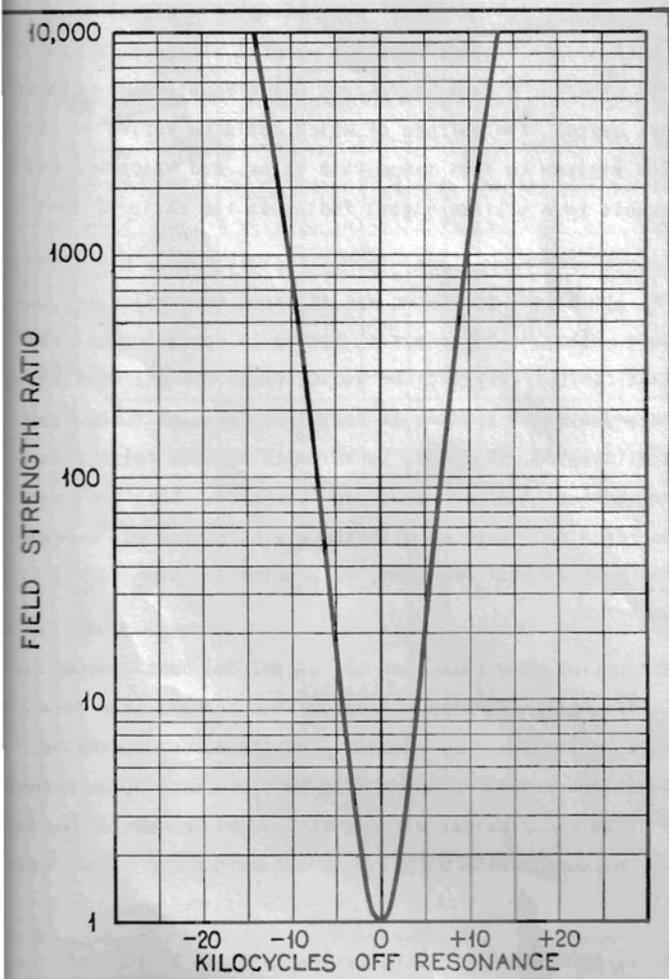
AUTOMATIC VOLUME CONTROL

It is a recognized fact that almost no two radio signals are received at the same input level. They may vary at the receiver input anywhere between an infinitesimal fraction of a microvolt to several hundred thousand microvolts. Moreover, the field strength of the signals from a single station may vary (particularly if it is a short-wave station) very decidedly from minute to minute. It is the purpose of automatic volume control to automatically regulate the sensitivity of the receiver circuits according to the field strength of the received signal.

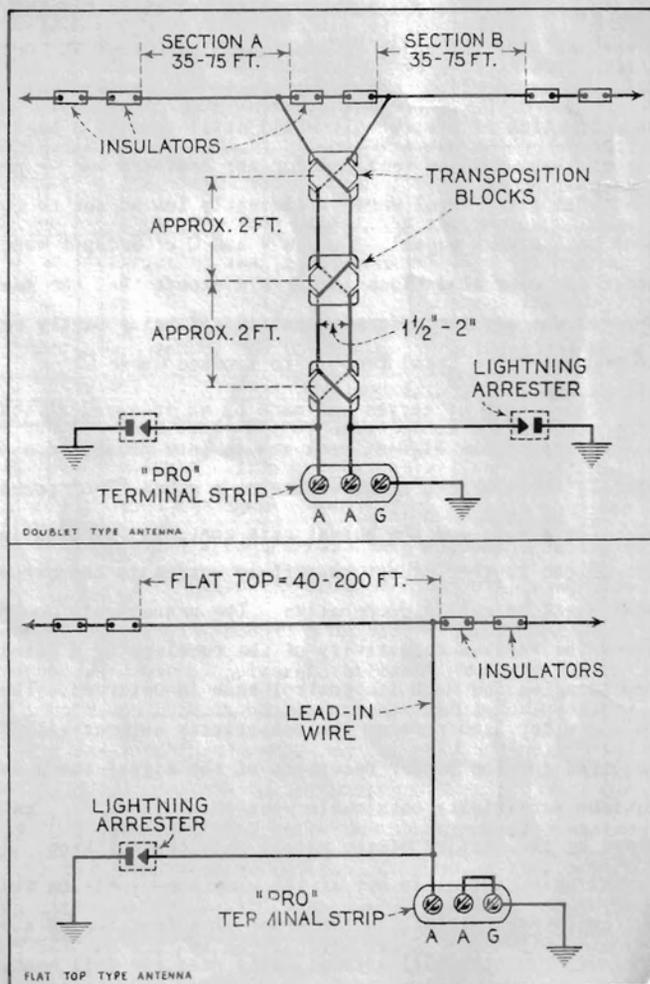
It is not the purpose here to go into detail as to just how this is accomplished. Suffice it to say that the A.V.C.



Bottom View



Selectivity Graph



Antenna Systems

system developed in the Hammarlund Laboratories and incorporated in the "Pro" receiver is an unusually effective one. Most systems of this kind are incapable of properly controlling wide variations in signal input because they do not develop sufficient controlling voltage. To accomplish this in the "Pro" the equivalent of another stage of i.f. amplification is employed in the a.v.c. system, thus building up a relatively high regulating voltage to actuate the diode circuit which supplies the controlling voltage for the i.f. tube grids. This controlling voltage is therefore of such a high order that it throttles down sensitivity to a point that prevents overloading of the second detector and audio circuits even in the case of signals from powerful local stations. At the other extreme there is no reduction of sensitivity when extremely weak signals are being received, thus permitting advantage to be taken automatically of the full sensitivity of the receiver when required.

Instructive illustrations of the effectiveness of the a.v.c. system in the "Pro" are shown in the two groups of curves on page 11. Curve A of Group 1 shows the variation in output voltage with input voltages (modulated 40%) from 1 microvolt to 100,000 microvolts. It will be noted that with an input voltage change ratio of 100,000 to 1 the output voltage changes in the ratio of only 2.75 to 1. In terms of decibel output this means a variation of 8.8 decibels which is only about four times the minimum change required to be perceptible to the average ear. The output voltage at which the receiver would show signs of overloading is somewhat higher than 110 volts and it will be noted on this curve that with increasing input the output gradually rises until it reaches 110 volts and there flattens out, never reaching the point of overload. Also that at the 1 microvolt end the decline is still gradual, indicating that signals of a fraction of a microvolt would still provide a high output -- higher than would be required for any ordinary use -- provided the local noise level were sufficiently low as not to completely mask such a weak signal. Curves B and C of Group 1 were made under the same conditions as Curve A except that the manual gain control was set for reduced sensitivity, being partly retarded to produce Curve B and further to produce Curve C.

This group of curves was made by an independent testing laboratory of the highest rank and is here presented as completely unprejudiced measurements on a stock "Pro" receiver.

The a.v.c. and the manual gain controls function independent of one another except that their action in the circuit is what might be called cooperative. The manual gain control reduces the maximum sensitivity of the receiver by a fixed amount, depending on how much its control knob is retarded. The a.v.c., on the other hand reduces the sensitivity automatically to that required for the proper reception of the signal tuned in but the maximum sensitivity obtainable when using the a.v.c. is determined by the setting of the manual gain control knob. If the manual gain control is set at the wide open position then on an extremely weak signal, in the order of a fraction of a microvolt, the a.v.c. system will automatically make the full sensitivity the receiver available for amplification of that signal. But,

on the other hand, if the manual control were set to limit the receiver sensitivity to 10 microvolts the a.v.c. system could not increase the sensitivity beyond this point.

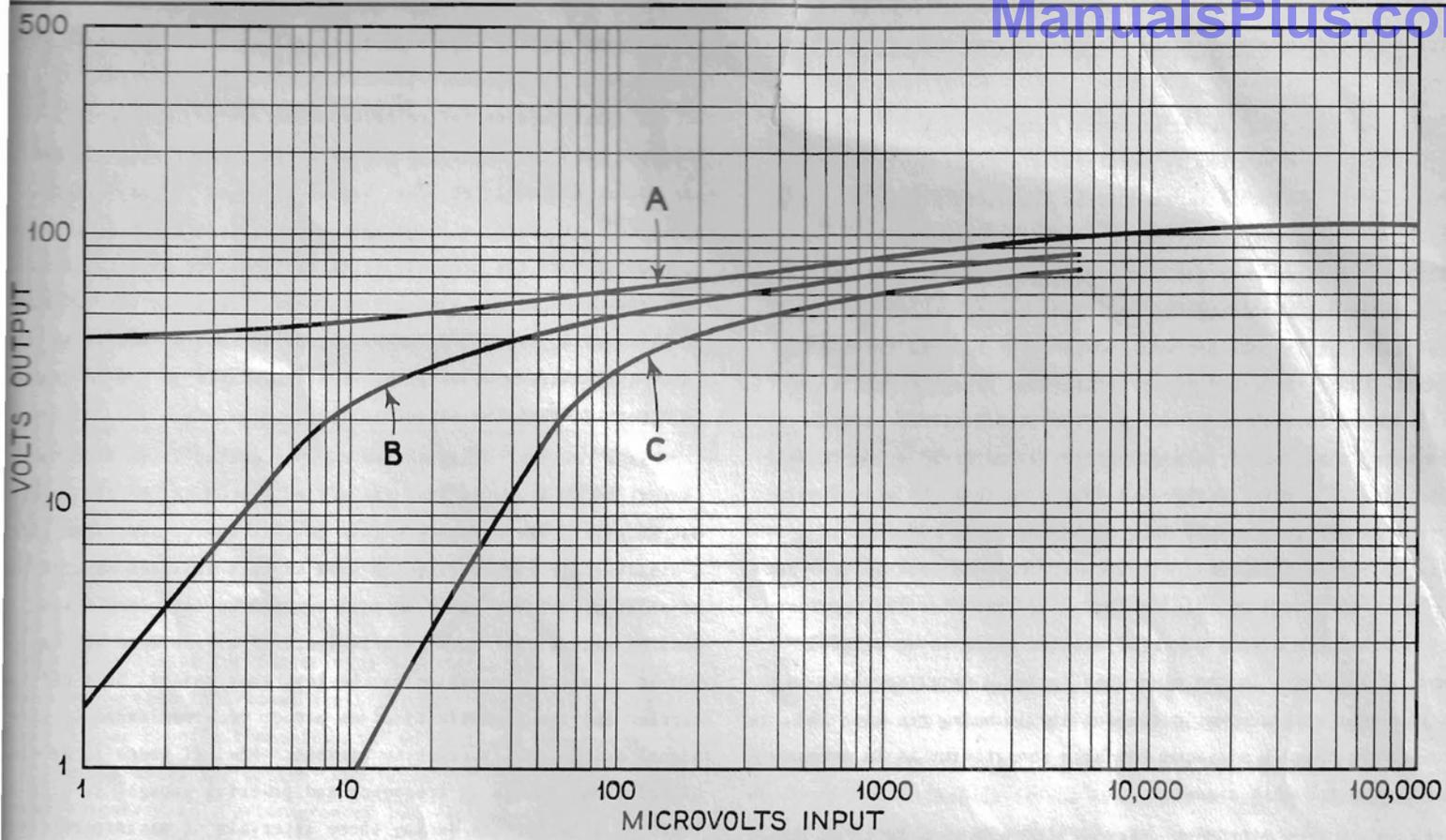
These facts immediately suggest a method for elimination of "between station noise." With the manual gain control wide open and the a.v.c. switch in the "on" position even the best location will produce some noise, if there is no signal tuned in. Now, under these conditions, if the manual gain control is retarded just enough to eliminate this noise the tuning of the receiver thereafter will be noiseless. Thus by this simple adjustment perfect "squelch" action is obtained with the A.V.C. "Pro" without the necessity for the additional tube and another complicated circuit as employed in some receivers to attain the same end. Such retardation of the manual gain control will, of course, eliminate signals so weak as to be below the degree of sensitivity provided but this is no loss because such signals would be buried in the noise anyway. If an attempt is to be made to receive such weak signals the manual control may be set at a point which provides a higher degree of sensitivity but still not enough to make "between station noise" unbearably high.

Perhaps the outstanding advantage of this a.v.c. system is found in its ability to hold fading signals at a substantially constant value -- providing the fading is not so severe as to cause the signal to drop below a level of approximately 1 microvolt. There are certain peculiar types of fading in which the a.v.c. system is ineffective, as in "selective" fading, for instance, where the carrier and side bands do not fade in unison. But where the entire signal fades excellent stability of output is provided by the A.V.C. "Pro," even though the signal fades through such a wide voltage ratio as several thousand to one. The curves of Group 2 show the output measurements made with an artificial signal, the voltage of which could be varied in steps from a low minimum to 1000 times this value, and which was exactly comparable to a station signal fading in the ratio of 1000 to 1.

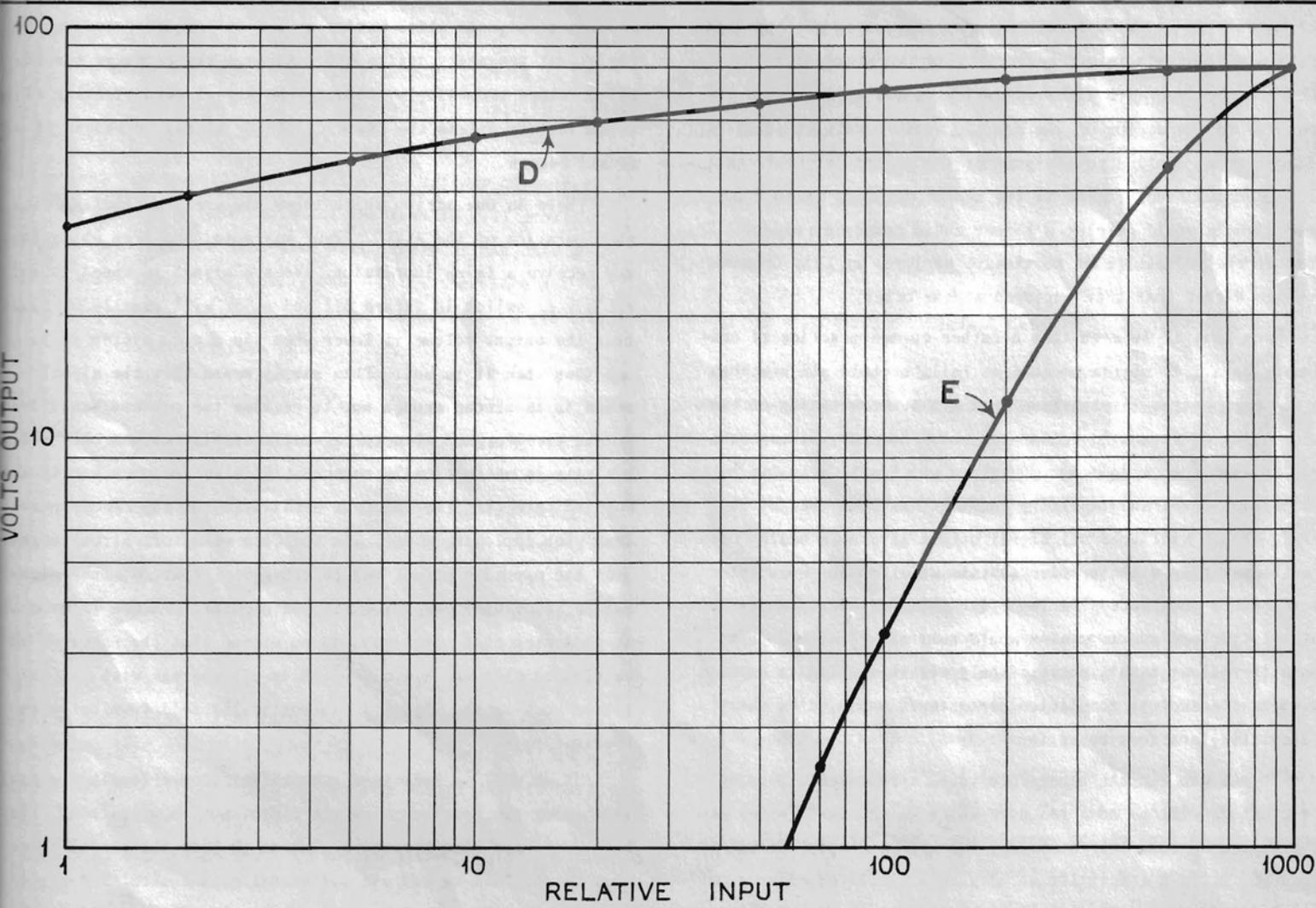
First the signal generator was adjusted to provide the maximum voltage. Then with the a.v.c. system in operation and the manual gain control full on, the audio volume control of the "Pro" was adjusted to provide an output of 80 volts. The signal was then attenuated, in steps, to 1/1000th of this voltage, and output voltages read after each step (Curve D). Then the same thing was repeated (Curve E) with the a.v.c. system cut out and the manual gain control retarded, to provide the same 80 volt output as before.

These curves show that when the signal had been reduced to 1/10th of its original value the output had dropped from 80 volts to 3.4 volts without a.v.c. whereas with the a.v.c. system in operation the output had dropped only to 70 volts. At an attenuation of 20 to 1 the signal without the automatic control passed out of the picture, while with a.v.c. the output had fallen only to 65 volts.

A still more striking illustration is found in the fact that in Curve E a reduction of 3 to 1 in signal voltage resulted in a



Group 1



Group 2

great a reduction of output as a 1000 to 1 reduction produced in Curve D.

So far this discussion has been limited largely to the effect of the a.v.c. system in maintaining approximately constant output in spite of wide variations in the field strength of signals from a single transmitter, a condition commonly known as "fading." Another very decided advantage is likewise found in the tendency of the system to level out the output of the receiver on all signals, whether weak or strong. Thus as the A.V.C. "Pro" is tuned through a group of stations, they are all heard with more or less the same volume, the main distinction between them being that the signals of extremely low field strength will be heard with a noise background (assuming that the manual gain control is set at maximum) due to the automatic increase in sensitivity, whereas powerful signals will be free from noise. Not the least advantage of this condition is that when the receiver is tuned through a very powerful station there is no painful blast of volume as is the case when tuning a receiver which is not equipped with automatic control and is being run with the manual gain control advanced for high sensitivity as is necessary when tuning for weak signals.

Signals from different stations will not be held to as constant an output as will the varying signals from a single station because the factor of modulation enters into the question. Stations employ widely differing percentages of modulation and inasmuch as this is an audio function, compensation is not provided by the a.v.c. system in a receiver. Thus two stations might reach the receiver with almost identical field strength and therefore, due to the action of the a.v.c., would result in equal voltages being applied to the grid of the second detector. But in the demodulating process in the second detector circuit one of these signals would develop a higher audio component than the other if the percentage of modulation employed at this transmitter were higher than that employed at the other.

From this it is seen that a rather common practice of condemning an a.v.c. system because it fails to hold all stations to the same output level arises from a misunderstanding of the functioning of automatic volume control. However, it nevertheless follows that a good a.v.c. system which will actually hold the carrier level substantially constant, as does that of the A.V.C. "Pro," will hold all signal output at a more nearly constant level than will inferior systems which do not even hold the carriers constant. The important point is that even an absolutely perfect a.v.c. system would hold the receiver output (on different signals), constant only within the limits imposed by the difference in modulation percentages employed by the transmitting stations tuned in.

To one who has not heretofore tuned a receiver employing a.v.c. there will be some features which may at first appear to be disadvantageous. For instance, tuning will appear to be broader. It is not actually so because a little experience or actual measurement will show that selectivity is not affected. The illusion comes from the fact that as a receiver is tuned slightly off signal resonance the voltage impressed on the re-

ceiver input by the signal is decreased and, if the receiver employs a.v.c., the sensitivity is automatically increased as it occurs, thus holding the receiver output up to the normal level obtained when the signal is tuned to exact resonance. However, the moment a closely adjacent signal is tuned in its voltage, added to that of the off-resonant signal, causes the a.v.c. system to cut down the sensitivity of the receiver with the result that the off resonant signal disappears. If it is not successful in eliminating the off resonant signal in such a case it is because the inherent selectivity of the receiver is not adequate to separate these two signals.

In a receiver designed for c.w. reception it is important that it be so arranged that the a.v.c. system can be cut in or out at will. The reason for this is that a.v.c. sometimes offers a disadvantage when tuning for weak signals inasmuch as a strong adjacent signal may under certain conditions interfere with a desired weak signal more than it would if a.v.c. were not employed. In c.w. transmission the key, when raised, cuts off the carrier and the sensitivity of an a.v.c. receiver tuned to the signal automatically rises to maximum. Now, if there is another signal close enough in frequency and powerful enough, it will be heard as interference during these intervals of maximum receiver sensitivity and its signals will run in with the desired signal making the latter difficult to read.

On the other hand a.v.c. offers a distinct advantage in reception of signals which wander around in frequency because as the signal frequency drifts off resonance the receiver sensitivity increases accordingly, holding the signal automatically within audibility unless the tendency of the signal to wander is of all reason.

There is one action which those who are not familiar with the operation of the A.V.C. "Pro" may note, and from which they may receive a false impression. When a signal is tuned in and the a.v.c. switch is turned off and on it will usually be found that the output volume is lower when the a.v.c. system is in use than when it is not. This simply means that the signal tuned in is strong enough not to require the maximum sensitivity of the receiver and when the a.v.c. switch is turned on the sensitivity is automatically reduced. This action does not in any way indicate that the inherent sensitivity of the receiver is less when employing a.v.c. In the case of a very strong signal just the opposite effect may be noticed -- that is, the volume may be lower when the a.v.c. is switched off. Where this occurs it indicates that the signal is so strong that the receiver is overloaded when the a.v.c. switch is off whereas with the a.v.c. system working the signal is automatically held down below the overload point.

It is well to keep this possibility of overloading in mind when using the receiver with the a.v.c. not in operation. The best procedure when operating thus is to keep the manual volume control set full on and use the manual gain control for regulating gain (and therefore output volume). This permits the circuits ahead of the second detector to operate at a sufficiently low gain to avoid overloading the detector in the case of

strong local signal yet, because of the high audio-frequency amplification provided with the volume control set at maximum, the full output which the power tube is capable of handling may be obtained. If, on the other hand, the audio volume control were partly retarded, it would be necessary to increase the gain ahead of the second detector, with the resulting possibility of overloading this tube on these strong signals.

Overloading of the detector will cause distortion or, if severe, will partially or entirely block the second detector tube. However, by keeping the audio volume control turned up all the way this condition will not be encountered because under these conditions the output power tube will overload before the second detector and the resultant distortion will be ample warning that the operator is endeavoring to obtain a higher volume output than the output stage is designed to deliver.

ANTENNA SYSTEMS

The best length for the antenna depends on the conditions pertaining in each individual installation. Even with a small indoor antenna excellent results will be obtained because of the extreme sensitivity of the "Pro." On the other hand a large outdoor antenna will provide greater pick-up and therefore stronger signals from distant stations. It is probably safe to say that an antenna 100 feet in length overall represents reasonable proportions for the average location. In rural sections where there are no powerful transmitters nearby to cause severe interference this length may logically be doubled if it is so desired. In urban locations where interference conditions are likely to be severe it may be found desirable to limit the overall length to 70 feet or even less.

The important consideration is that an antenna of moderate length, say 90 or 100 feet including the lead-in will provide ample pick-up and at the same time will permit of adequate selectivity under almost any conditions. It is therefore not of any great importance that special effort be devoted to the erection of a larger antenna than this.

DOUBLETS

Doublet antennas have enjoyed a considerable amount of popularity, the merits claimed for them being their directional and noise reducing qualities. They find their most advantageous application in cases where they are designed for reception of stations on one particular wavelength and lose much of their effectiveness when it is desired to receive stations of other wavelengths.

Such an antenna, employing a transposed lead is shown on page 9. The length of the two equal top sections cannot be given here as this will vary depending on the wavelength at which the antenna is to be operated. Roughly, the combined length of the two wires in meters can be made to equal half the wavelength at which it is desired to work. If it is to be used to cover a wide range of wavelengths the plan usually recommended is to make the combined length of the two sections as great as conditions will permit, up to 1/2 the longest wavelength to be worked.

This type of antenna provides the best reception for signals approaching it broadside and is considerably less effective for signals approaching its ends. Thus the doublet should be erected broadside to the direction from which desired signals come. These signals and those from the opposite direction will then be most effectively received while interfering signals and atmospheric disturbances having their source in the directions toward which the ends of the antenna point will be reduced.

Inasmuch as this antenna employs a balanced type double lead-in, it has some effect in reducing pick-up of purely local noise such as that arising close to the ground or within the building where the receiver is installed. This type of lead-in, particularly if transposed, has less pick-up than a single wire lead-in. Therefore if the flat top of such an antenna can be kept well away from sources of noise, better signal to noise ratios are obtained than with a similarly located antenna having a single lead-in.

Where the "Pro" owner has the time, facilities and patience to experiment with antennas, it is logical for him to do so. However, it is well to bear in mind that special antennas on which so much attention is now centering do not by any means prove universally beneficial. One which may be highly effective under one set of conditions may offer no appreciable benefit under other conditions.

In general the ordinary inverted "L" type antenna as discussed in the early part of this section will provide highly satisfactory all-round results. For best results it should be kept as high up and clear as possible. All joints should be soldered, or better still, avoided by making the flat-top and lead-in one continuous wire. Insure good insulation throughout by using plenty of insulators. A lightning arrestor should be made a part of every outdoor antenna installation, and should be grounded outside if practical.

SERVICE DATA

Should it be necessary to remove the Comet "Pro" chassis from its shield cabinet it is easily accomplished by removing the four machine screws which extend through the bottom of the cabinet and the twelve screws around the edge of the front panel. The entire panel and chassis assembly may then be slipped out of the cabinet by drawing it forward. When thus removed all parts and wiring located beneath the chassis are exposed for examination or test. The shield cans found under the chassis may be removed if necessary by pulling them off.

The voltage values at various points of the circuit and the values of all resistors and condensers are shown on the circuit diagram.

Should the "Pro" fail to function in its normal manner at any time the recommended procedure is to first carefully check up on the antenna and ground. Then check the tubes as they are, of course, the most vulnerable part of any well-designed and well-built receiver. Beyond this the entire receiver should next be checked for "shorts" or "opens" and in this a test of the voltages as shown in the circuit diagram will be simple and

helpful. The voltages shown are those read on the 10 volt a 500 volt ranges of a standard meter having a sensitivity of 100 ohms per volt. If a meter offering lower resistance is employed in checking, some of these readings will vary considerably and due allowance must accordingly be made for this factor of error. In making these tests the sensitivity control should be set at the full "off" position, and the a.v.c. switch turned "off."

It is also desirable to disconnect the antenna - or at least detune the receiver so that no signal is present in the circuits under measurement. In measuring cathode voltages on the two i.f. tubes the gain control should be swung through its entire range to show minimum and maximum bias. The voltage should vary from approximately 3 volts to 50 volts, respectively.

I.E. ALIGNMENT

While the use of air-dielectric variable condensers for tuning the i.f. and beat-frequency oscillator transformers provide an exceptional degree of permanence of adjustment, it is of course possible that eventually some of these circuits may become slightly detuned. In such an event they may be realigned in the following manner, with the a.v.c. switch "off."

First remove the chassis from the cabinet and prop it up on its rear edge so that both the top and bottom are accessible. Then connect the 10 ohm range of a 1000 ohm per volt voltmeter across the 25,000 ohm resistor between the cathode of the second detector and ground. This resistor is marked "R" in the view of the bottom of the chassis, as shown on page 9. This meter will function as a resonance indicator, showing maximum deflection when exact resonance is obtained.

Next provide a signal source. If an oscillator is available, tune it to 465 kc. and couple it to the receiver. If such an oscillator is not at hand the carrier of a fairly powerful station may be employed provided the station selected is one which is free from fading and interference. This signal should be tuned in on the receiver in the usual way and the gain control adjusted to cause an increase of about 2 volts in the voltmeter reading.

The actual alignment can now proceed. First adjust the bottom condensers of the three i.f. transformers. These are accessible from the under side of the chassis. Adjust them one after the other until maximum deflection of the resonance indicating meter is obtained. If the meter reading increases materially during this process retard the gain control to bring it back to the original plus 2 volts reading. Then make a similar adjustment of the condensers at the tops of the three i.f. transformers. Finally repeat this whole process, readjusting each condenser a second time to insure exactness of resonance.

After the i.f. stages are thus accurately lined up, turn on the heterodyne-beat oscillator and set its top lever so that

it points diagonally away from the rear right-hand corner of the chassis. Then adjust the bottom adjustment screw on this transformer for exact zero beat. When this has been accomplished the receiver is in accurate alignment.

In rare instances it may be found that some nearby powerful commercial code station operates on the frequency to which the i.f. amplifier is tuned. In such a case, if the station is powerful enough, its signals may force their way through the input tuning circuit. This is only likely to occur when the special broadcast-band coils (EE) are plugged in and the receiver is tuned to the low-frequency end (600 kc. or lower) of this range. Should this occur, the remedy for such interference is found in retuning the i.f. amplifier a few kilocycles higher or lower than 465 kc.

SPECIAL COILS AVAILABLE

The standard coil equipment supplied with the Comet "Pro" receiver consists of four pairs which provide continuous coverage (with ample overlap) of frequencies from 1200 kilocycles to 20,000 kilocycles, the equivalent of 250 meters to 15 meters. Inasmuch as this range includes all of the more popular short-wave broadcast, amateur, police, aviation and other commercial bands it is adequate for most users of the "Pro." For those whose requirements extend outside of this range, however, there are two pairs of special coils available, one pair covering from above 1200 kc. to below 540 kc., the other pair covering from 20,000 kc. to 37,500 kc. Thus all of the broadcast band, and the new high-frequency bands which are being opened up between 8 meters and 15 meters, are made available to "Pro" owners.

CRYSTAL FILTER MODEL

A new crystal filter system has also been developed which not only provides an astonishing degree of super-selectivity but also an "interfering station rejector" feature has been developed for the "Pro" receiver. This combination permits intelligible reception of c.w. and speech under interference conditions which would in many instances completely blanket the desired signal. This crystal filter is particularly advantageous in the crowded amateur bands inasmuch as it permits maintenance of many contacts which would be utterly impossible otherwise.

This Crystal feature is included in the Crystal and Crystal A.V.C. Models of the "Pro." It can be added to existing "Pro" receivers, both Standard or A.V.C. Models, such installations being made at the factory. Write for information and prices.

Further technical information on the crystal filter system will be found in the descriptive booklet which accompanies each "Pro" receiver. Still further details will be found in "Pro" Manual 2 (Crystal "Pro"). This manual is available at a price of ten cents a copy.