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Television Antenna Installation

Part 2, A TV Field Strength Meter

By the Engineering Department, Aerovox Corporation

THE preceding issue consisted of a discussion on the practical aspects of selecting and installing a television antenna for the fringe service area. Here in Part 2 we will describe the design and construction of a practical battery operated field strength meter for use in obtaining proper orientation of TV antennas. The instrument is simple to construct, using two readily available tubes and a crystal rectifier, and is completely self-contained. Its general appearance is as illustrated in Fig. 1.

Just as the problems associated with the erection of a fringe-area TV antenna differ considerably from those of the primary service zone installation, so do the antenna orientation techniques differ. In a primary zone, where the signals are strong, the major consideration in locating and aligning the antenna is the elimination of "ghosts." Many times the directional bearing chosen for the receiving antenna is not that which gives maximum signal response, but one which places bothersome "ghost" signals in a null of the antenna response pattern. In such cases a field strength meter is of little use. "Ghost" elimination must proceed by the laborious process of testing with an actual receiver and choosing the antenna bearing which produces the best compromise between "ghosts" and signal strength.

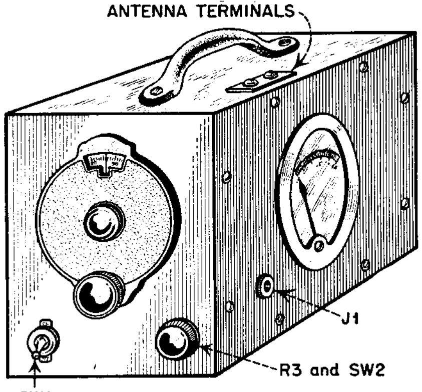


FIG.1

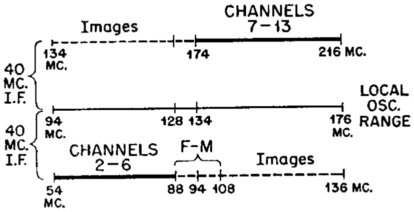
In the fringe area installation, on the other hand, the problem is somewhat different. In most rural, residential districts of normal terrain, reflections and re-radiation from other objects are not so frequently encountered. Here the available signal is weak, so that the antenna must be accurately aligned to produce the maximum signal at the terminals of the receiver. For this purpose, a method of indicating the actual strength of the received signal must be used. Orientation by compass bearing is usually unsatisfactory because the actual pattern of the particular antenna may not be accurately known in many cases and may be very sharp, especially on the high channels. Other means of finding the optimum directional bearing by measurement include:

(a) Connecting a TV receiver to the antenna and finding the best location and direction by communication between the eroof and the set with sound-powered 'phones or other means of signaling.

(b) Reading the rectified video output of the television set at the antenna site by means of a long extension cord and an indicating d.c. meter.

(c) Using a field strength meter at the antenna site to determine the best location and bearing.

Of these three methods (a) and (b) have the disadvantage of requiring a line from the receiver to the antenna. This is sometimes inconvenient and time consuming, especially in cases where a large roof-top area is to be surveyed for the best antenna location. These methods also require the availability of a TV set at the proposed location and preclude the possibility of surveying a



OSCILLATOR TUNING RELATIONSHIPS
FIG. 3

marginal location before the costly delivery of a receiver. Methods (b) and (c), as indicated above, do not give much indication as to the prevalence of "ghost" conditions. In addition, an a.c. powered field-strength meter also has the disadvantage of the other two methods in requiring an extra line to be run to the antenna site.

The ideal antenna siting instrument should be ultra-portable, battery powered, tune all television channels, and be simple to operate. Absolute calibration in microvolts, although desirable, is not as important as stable indication of relative signal strengths. The unit to be described here fulfills these requirements, being sensitive enough to indicate signals of only a few tens of microvolts, and yet requiring less than 4 milliamperes of plate current, and low filament drain.

Design Considerations

To achieve enough gain to actuate a meter of moderate sensitivity on weak r.f. signals, most commercial field strength meters require the use of five or six vacuum tubes. One r.f. stage, a mixer, local oscillator, two or more i.f. stages and a second detector are requently used. Such a line-up usually requires considerable plate and heater current, making the use of a.c. power necessary.

An alternative method of obtaining the high gain required, as well as detection, is through the use of superregeneration. A single stage operating in this manner will provide as much gain as the r.f. and i.f. stages in the above line-up and provide rectified output to actuate an indicating meter. In addition, greater swings in plate current and more positive action may be obtained through the use of a gas-filled triode of the type used for radio control circuits. In this manner the use of a high sensitivity meter is unnecessary; sufficiently large deflections are obtained on an inexpensive 0-1 ma. meter.

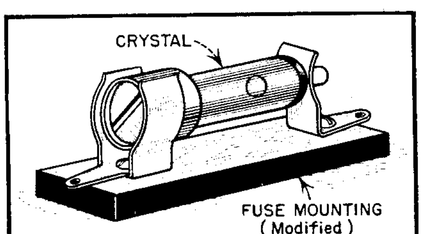
Although it is possible to indicate the relative signal strengths of weak television stations by using a single superregenerative detector, this method is not satisfactory for our present purpose because a "superregen" is critical to antenna loading and apt to differ considerably in sensitivity over the required tuning range. It is also poor engineering practice to couple such a stage directly to the antenna because of the serious radiation produced.

For these reasons, the superregenerative stage is used as the i.f. and second detector of a simple receiver of the superheterodyne type in the present design. A silicon crystal mixer and an acorn tube local oscillator are added to provide some degree of antenna isolation and to allow the superregenerative stage to operate at a fixed low frequency. This circuit is shown in Fig. 2. Good stability and sensitivity are obtained in this manner since this stage requires no adjustment after being set initially for optimum performance. Tuning simplicity is achieved by using an i.f. frequency of 40 mc. and operating the local oscillator above the signal frequency for the lower channels (54-88 mc.) and below the signal frequency in the high band (174-216 mc.). In this manner, a local oscillator tuning range of 94 to 176 mc. tunes all of the presently assigned TV channels continuously. This tuning arrangement is shown diagramatically in Fig. 3.

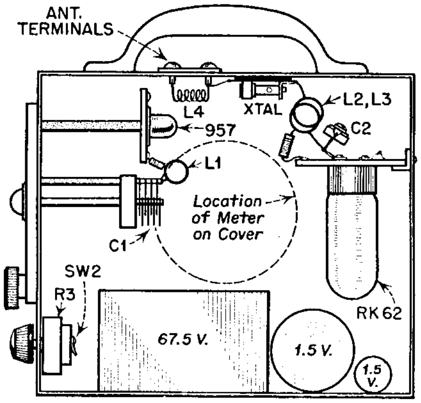
A silicon crystal mixer, readily available on the surplus market, is used to convert the local oscillator and signal frequencies to the 40 mc. i.f. frequency. Sufficient sensitivity is obtained to give readable meter indications on even extremely weak stations. The entire unit is powered by a $67\frac{1}{2}$ volt "B" battery and a size "D" 1.5 volt flashlight cell. A penlight cell is also used to provide a "bucking voltage if upward meter readings are desired.

Construction

The field strength meter is built in a miniature metal cabinet measuring 6"x5"x4". Adequate space is afforded in this compartment for all components, including the batteries. No chassis is used since the parts are mounted on inside surfaces of the box. A metal carrying handle is fastened to the top of the cabinet for portability.



DETAILS OF CRYSTAL MOUNTING
FIG. 5



GENERAL LOCATION OF PARTS
FIG. 4

Fig. 4 illustrates the lay-out of the major components inside of the box. The batteries are mounted on the bottom of the compartment in the positions shown. The "B" unit is of the 12 ounce size, measuring about $2\frac{7}{8}$x$1\frac{3}{8}$x$3\frac{3}{4}$ inches. It is held in place by a metal strap secured by 6/32 screws through the cabinet. The meter is mounted on the 6"x5" cover plate of the cabinet. Clearance for the meter must be provided when placing parts within the box.

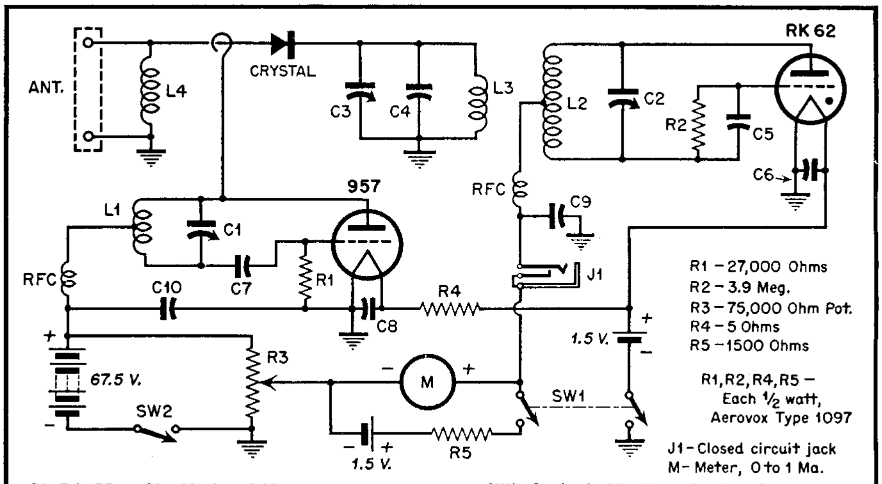
The local oscillator is a 957 "acorn" tube tuned by a 35 mmfd. midget variable condenser (C1). Both the tube socket and the condenser should have high quality ceramic insulation. These components are mounted on a 4" x 5" wall of the box. The tube socket is mounted on 1" stand-off insulators and the tuning capacitor is similarly mounted near the grid and plate connections to the tube. The oscillator inductance (L1) is connected directly to the condenser terminals. A flexible shaft coupler and bakelite shaft are used to couple the condenser to the tuning dial. Since the frequency range covered by the local oscillator is considerable, making station tuning rather sharp, a good "vernier" dial should be used. One having a tuning ratio of 6:1 was used on the experimental model.

The superregenerative i.f. and second detector stage is mounted on the rear 4"x5" wall of the cabinet. All parts are assembled on a four-prong steatite socket which is mounted perpendicular to the cabinet wall by means of a small right-angle bracket. A single 6/32 screw supports this assembly and all grounds for this stage are made to a soldering lug on this screw. The RK62 gas-filled tube is mounted in an inverted position. The smaller RK61 could be used to conserve space but is not supplied with a base. The 40mc. resonant circuit (L2 and C2) is supported by the tube socket terminals and R2-C5. The value of R2 is somewhat critical for maximum sensitivity. Although 3.9 megohms was found to be optimum in the experimental model, other values should be tried if vigorous superregeneration and large plate current changes are not experienced in individual cases. C2 should be a ceramic 5-20 mmfd. trimmer of the rotary or compression type.

The crystal mixer may be any of the silicon types listed in the AEROVOX RESEARCH WORKER for May, 1950. Such types as 1N21, 1N22, 1N23 and other detector crystals available from surplus stocks will perform satisfactorily. A germanium crystal, such as the popular 1N34, should not be used in this application.

The crystal is mounted in a modified cartridge fuse mounting. This fuse holder (8AG size) is converted to a crystal socket by rotating one clip 90-degrees, removing one end of it, and drilling the remaining part of the clip to engage the small end of the crystal cartridge, as shown in Fig. 5. A fuse mounting having bakelite or fiber insulation is satisfactory for this purpose. The i.f. resonant circuit (L3, C3 and C4) is supported between one terminal of the crystal holder and a grounded soldering lug. L3 is concentric with L2 and spaced about ½-inch from its grid end.

The untuned input coil (L4) is mounted on the lugs of a feed-thru type bakelite terminal strip which serves as the external binding posts for the 300 ohm twin-lead line from the antenna. One terminal is grounded while the other connects to the crystal. This circuit is left untuned for simplicity and to afford broadband operation. However, in extremely remote areas where only one or two channels are concerned, additional sensitivity would be achieved by tuning this circuit to the signal frequency. Better image rejection would also result.



C1 – 3 to 35 mmfd. midget variable
C2, C3 – 5 to 20 mmfd. ceramic trimmer
C4 – 100 mmfd. ceramic, Aerovox Hi-Q (C1-1)
C5, C6, C7, C8 – 50 mmfd. ceramic, Aerovox Hi-Q (C1-1)
C9, C10 – .003 mfd. mica, Aerovox Type 1464
RFC – VHF r.f. choke
CRYSTAL – Silicon, 1N21, 1N22, 1N23

SW1 – 2 pole, double-throw toggle switch
SW2 – Switch on R3
L1 – 3 T. No. 14 E., ⅜" I.D. Self-supporting, ¼" long
L2 – 19 T. No. 14 E., ½" I.D. Self-supporting, 1½" long
L3 – 3 T. No. 14 E., ½" I.D. Self-supporting, ¼" long
L4 – 9 T. No. 14 E., ½" I.D. Self-supporting, 1" long

FIG. 2

Adjusting The Circuits

After the components are installed and wired, the local oscillator should be adjusted for smooth oscillation over the range of 94 to 176 mc. The tuning range is regulated by spreading or compressing the turns of the oscillator coil (L1). The frequency of oscillation may be measured by inserting a milliameter in the oscillator plate lead and tuning a closely coupled absorption wavemeter until a sharp maximum is observed in plate current. A grid-dip meter or other reliable method might also be employed. Oscillator injection is provided by a piece of insulated wire from the plate end of L1 twisted once around the lead between L4 and the crystal holder.

The superregenerative i.f. and second detector stage is next adjusted. The regeneration control (R3) is advanced until characteristic superregenerative "rush" is heard in a pair of earphones in the RK62 plate circuit jack (J1). This should start at about 200 microamperes and become quite vigorous at about 1 milliampere plate current. With the "bucking" voltage circuit shown in Fig. 2, this will correspond to zero reading on the plate current meter if a 0-1 ma. movement is used. Under this condition, a signal generator tuned through the operating frequency of the RK62 stage will produce an upward deflection on the meter. If the stage is functioning properly, the deflection should be at least half scale even with the signal generator remote from the meter and no intentional coupling. The meter should also give some indication when the signal generator is tuned to frequencies to which the i.f. frequency is harmonically related. The tenth harmonic of the signal generator used in aligning the experimental model was easily detectable.

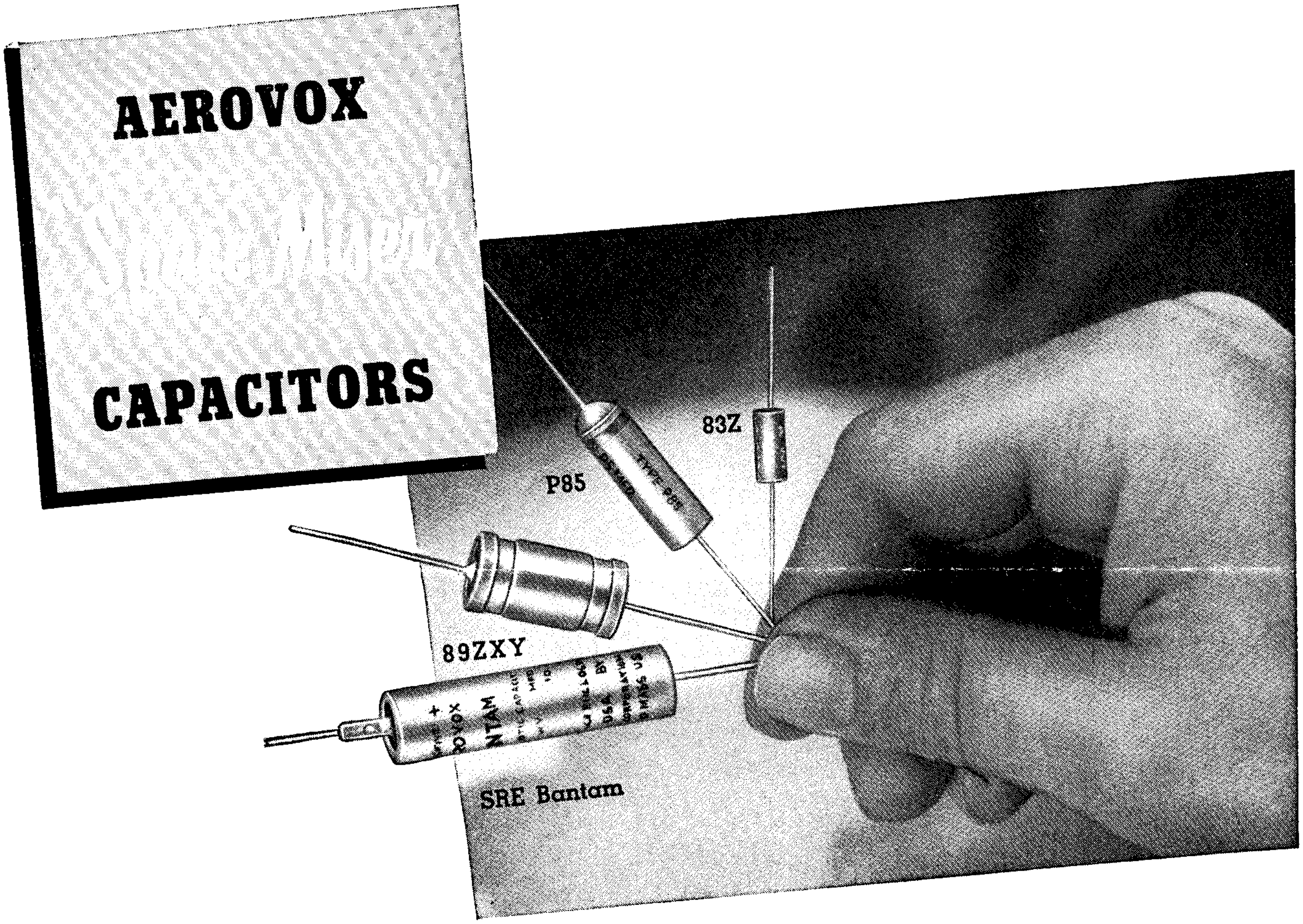
After L2 and G2 have been adjusted to approximately 40 mc. with a signal generator and checked for sensitivity, the i.f. primary circuit (L3, C3 and C4) is set at 40 mc. by tuning the trimmer, C3, for an upward loading effect on the RK62 plate current.

Operation

When these adjustments are completed, the field-strength meter is ready for use. An antenna is connected to the terminals provided and switches S1 and S2 are closed. The meter is then adjusted to zero with R3. Tuning the oscillator throughout its range should then produce many signal indications on the meter. The signals may be initially identified by the use of the earphones and marked on the dial or a calibration chart. In addition to the TV stations, some FM stations will be noted and these may cause confusion since they appear near the same dial settings as channels 7, 8, and 9. This follows since the local oscillator, when tuned to 140 mc. will produce a 40 mc. i.f. by beating with either a 100 mc. FM signal or a 180 mc. TV signal as in Fig. 3. However, once the station has been identified, the local oscillator is sufficiently stable to make the dial calibration entirely dependable.

Because the local oscillator radiates somewhat more than a standard TV receiver due to the absence of an r.f. stage, the meter should be used sparingly during regular program transmission periods, and preferably only during test periods.

In addition to its usefulness in surveying a roof-top location with a test dipole for areas of maximum signal and orientation of the final antenna installation, many other applications for this instrument will suggest themselves to the user. Since it tunes the TV channels and has high sensitivity, amateurs will find it a valuable aid in locating and eliminating sources of TVI.



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