Radio Editors of magazines and newspapers will be given permission to reprint in whole or in part, with proper credit to the Aerovox Corporation, the contents of this issue of the Aerovox Research Worker, upon written request.

The Aerovox Research Worker

The Aerovox Research Worker is edited and published by the Aerovox Corporation to bring to the Radio Experimenter and Engineer, authoritative, first hand information on capacitors and resistors for electrical and electronic application.

VOL. 25, NO. 7 JULY, 1955 Subscription By Application Only

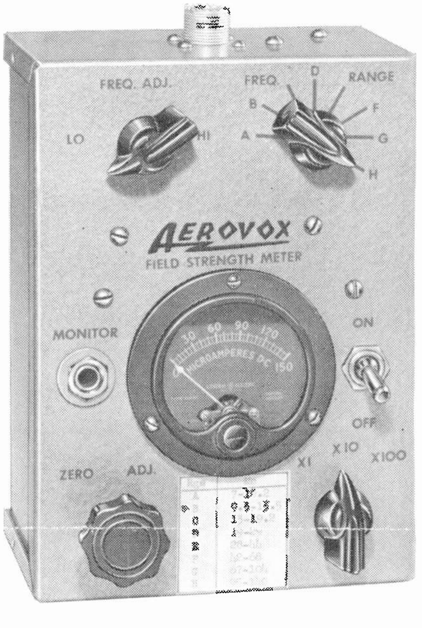
Sensitive Transistorized Field Strength Meter

Part 1: Circuit Description

By the Engineering Department, Aerovox Corporation

THE compactness, low power requirements, and long life of the transistor make it very useful in portable test equipment. A typical application of the transistor, in a sensitive field strength meter, is illustrated in the two parts of this series. Part I, herewith, explains the circuit features and design, with the schematic diagram and parts list. Part II, to follow, gives physical constructional data and information about calibration and use. The instrument is not limited to field strength measurements; it also makes an excellent null indicator for an r-f bridge, can be applied to standing wave measurements, tuning and neutralizing transmitters, and to any other operation in which a sensitive r-f indicator is useful.

Schematic diagrams of field strength meters employing a crystal diode detector and a transistor d-c amplifier have appeared in several publications. The unit described in this article employs the same general scheme, but has been refined to provide much greater sensitivity, self-contained frequency range switching, and a sensitivity multiplier. Because of the use of separate balancing current in the meter, to allow biasing on the "knee" of the transistor characteristic, the weak-signal sensitivity and linearity are especially good. The application of only about 30 millivolts of r-f at the antenna connector (50-ohm source) produces full-scale meter deflection on the XI range. Even more important, signal voltages as low as 7 millivolts produce readable deflections. In addition to the meter indication, a phone-jack output is provided for monitoring AM signals.



The frequency range of the model is about 6 to 200 mc. The range varies with the type of load because of the simple direct antenna connection. However, this is with an 8-position switch, and of course the lower limit could be extended downward by use of a switch with 12 or more positions.

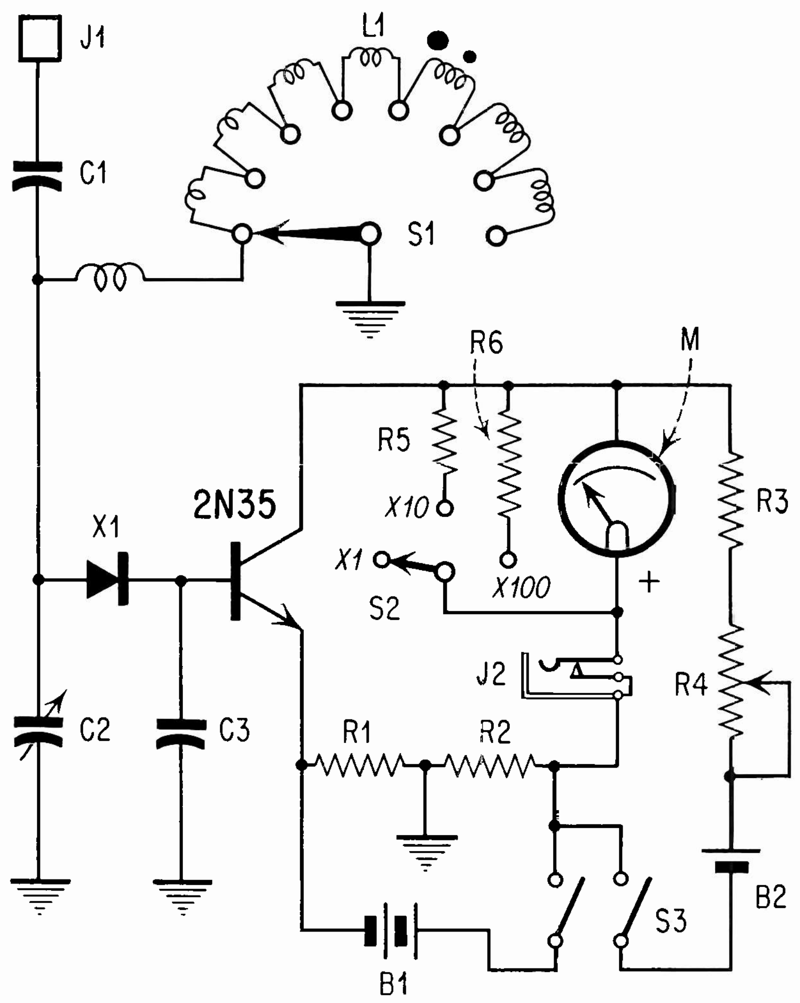
Two small batteries, one for the transistor and one for balancing current, are used. The drain is so low (peak of 1.5 ma and about 0.2 ma respectively) that practically shelf life is realized. Mercury cells are ideal, but the three "pen-light" cells installed in the model have given several months of operation every day with no sign of deterioration.

Circuit Description

The schematic diagram and parts list are shown in Fig. 1. The antenna (or other source of signal to be measured) is connected through C1 to the tuned circuit system L1-C2. C1 is not absolutely necessary, but was used in the model to minimize chances of harm to the crystal detector or transistor because of accidental application of external d-c or power frequency voltages.

The tap-switch arrangement was used because of its simplicity, but other conventional methods of coupling can be employed, and some are discussed later in this article. The coils, through S1, constitute the d-c return path for the base-emitter circuit of the transistor. This circuit should not be interrupted during coil

Printed monthly by Aerovox Corporation. New Bedford, Mass., U. S. A.



SCHEMATIC DIAGRAM
FIG. 1

PARTS LIST

C1 – 0.001 μf disc ceramic (Aerovox type BPD)
C2 – 35 μμf maximum (Cardwell PL6003)
C3 – 0.005 μf disc ceramic (Aerovox type BPD)
J1 – Coaxial connector (Amphenol type 83-1R)
J2 – Phone jack, closed circuit (ICA type 1871)
R1 – 2700 ohms ±5% 1/2 W (Aerovox type 1097)
R2 – 47K ohms ±5% 1/2 W (" " ")
R3 – 1000 ohms ±10% 1/2 W (" " ")
R4 – 5000 ohms, WW control (Clarostat type A43-5000)
R5 – Shunt to provide 100/1 multiplication (See text)
R6 – Shunt to provide 10/1 multiplication (See text)
S1 – SP, 8 pos., shorting, steatite insulation (Centralab PA-2000)
S2 – SP, 3 pos., shorting (Centralab type 1461)
S3 – Toggle switch, D.P.S.T.
Transistor – NPN junction audio type (Sylvania 2N35)
X1 – Germanium diode, type G7A
B1 – 3 volts, "pen-light" cells or mercury type
B2 – 1.5 volts, same as B1
Case, aluminum, 7" X 5" X 3" (Bud type CU-2108)
L1 – Coils wound to resonate over desired frequency ranges
M – Microammeter, full scale reading from 100 to 1000 μa

switching, because this interruption would upset the balance in the meter circuit, causing the meter pointer to kick downward off scale between positions. This is why a shorting type switch must be used for S1.

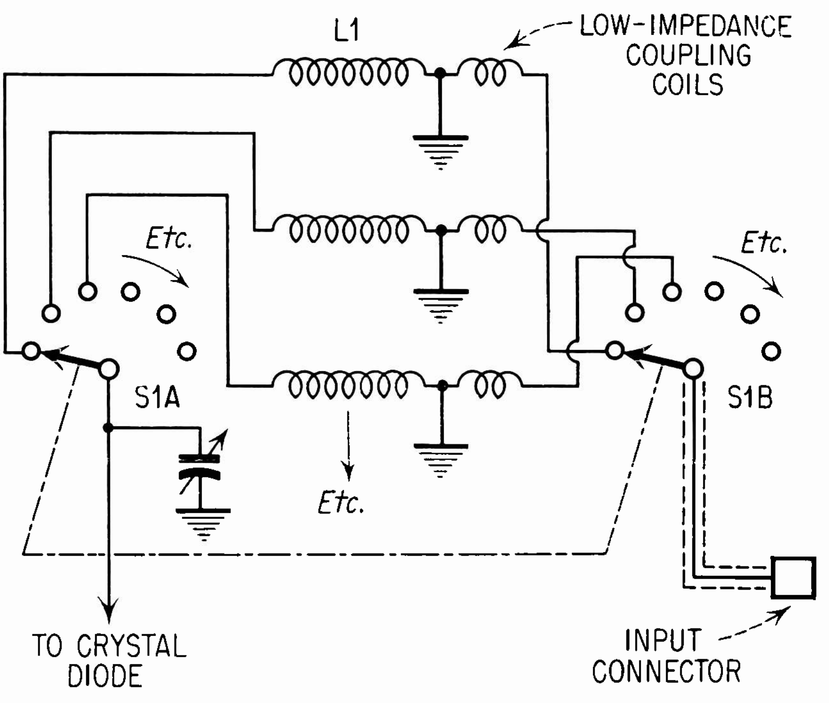
The transistor used is a Sylvania 2N35, but any of a number of others of the low-power audio types of low cost can be employed. The 2N35 is of the NPN junction type; if the PNP type is used, the battery connections are simply reversed. The transistor is connected in a grounded-emitter d-c amplifier circuit. Voltage divider R1-R2 biases the transistor to the "knee" of its characteristic curve for best sensitivity; for other types of transistors, some adjustment of the values of these resistors may be necessary. The base-emitter circuit acts as the load for a G7A crystal diode, which rectifies the input r-f signal.

Special Battery Connections

The battery connections are somewhat unusual, and arise from the operation of the transistor over the sensitive portion of its characteristic. The need for biasing is illustrated in the typical transistor characteristic shown in Fig. 2. Note that the collector does not start to draw current until the base has been biased about 0.5 volts positive. Then the rise is more or less "square-law" for a short distance, then becomes rapid and more linear. Naturally, for both sensitivity and linearity, the last portion of the curve is the one on which to operate.

Proper biasing for this is provided by the way in which battery B1 is connected. R1 and R2 form a voltage divider across B1, with the emitter connected at the negative end and the junction of these resistors grounded. In the design of this unit, the ground tap was made variable, and the ratio of resistances adjusted such that the operating point on the curve of Fig. 2 is proper. The voltage drop across R1 is the bias voltage for the base, making the latter positive with respect to the emitter. Since the emitter is connected to the negative terminal of the battery, the voltage applied to the collector through the meter is not affected by the voltage divider.

The biasing of the transistor to the knee of the characteristic curve makes the indication much more sensitive and the response more linear, but results in a static current through the collector-emitter output circuit and through the meter. With a



ALTERNATE INPUT CIRCUIT FOR LOW IMPEDANCE

FIG. 3

microammeter such as used here, this static current exceeds by several times the full-scale meter rating. To overcome this problem, the unit employs a single battery cell and control resistor in a "bucking" circuit. The current driven backwards through the meter by battery B2 overcomes the static current due to operating point bias. R4 is adjusted until the meter is returned to zero, and constitutes the "zero adjust" agency of the instrument.

Because both batteries participate in the balancing of the meter, removal of either one without the other can cause meter overload. For this reason the on-off switch connects and disconnects both batteries at the same time.

The Meter

The indicating instrument employed in the model is a 150-microampere 2-inch model. Naturally, the more sensitive the meter, the more sensitive the instrument. However, meters with full-scale sensitivities of 50 microamperes or less are less rugged, and this should be considered in the choice.

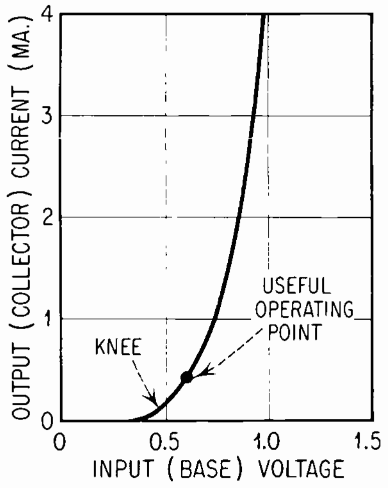
With the 0-150 ua meter used in the model, the sensitivity of the instrument is so great that fields anywhere in the vicinity of a transmitter, even of low power, can cause excessive deflection of the meter and overload it. Thus, in order to provide a wide range of field strength readings, some controlled variation of sensitivity must be provided. Such control can be effected by a continuously-variable shunt across the meter, or by a switching arrangement allowing choice of any of several fixed shunts. Because of its greater stability and potential accuracy, the latter method was employed in the model. A three-position switch allows choice of no shunt (X1), one-tenth sensitivity (X10), and one-hundredth sensitivity (X100). The values of the two shunts depend upon the type and range of meter used; the values are 5.6 ohms and 56 ohms for the 150-microampere meter used in the model. It is recommended that, if standard shunt resistors are not available, the meter resistance be used to calculate the theoretical values. Resistors just below this value can then be obtained, and "trimmed" by addition of resistance wire until the meter readings show the exact desired ratios. One practical note: readings with an actual signal are often unstable due to the motion of the body in the field surrounding the instrument; it is therefore recommended that a d-c voltage in the order of 0.2 volts positive be applied at point *b* with respect to ground, and the resulting meter deflection be used to check shunts.

Alternate Input Connection

As previously explained, the input connection in Fig. 1 was adopted because of its simplicity in the selection of any of a number of frequency ranges. However, in some applications, a high input impedance is undesirable. Optimum low-impedance coupling for each range can be obtained by adding another section to the switch, as illustrated in Fig. 3. A separate coupling link adjusted for best power transfer in each frequency range can then be used. This allows connection of a transmission line to the input connector, and the use of a remote antenna, bridge, or other device. For the higher frequencies, quarter-wave rod antennas can be used, whereas for the arrangement of Fig. 1, half-wave antennas must be employed for optimum pickup.

Construction and Operation

Further details about the construction, and also how to calibrate and use the instrument, will be covered in Part II, the second and concluding article of this series.



TRANSISTOR CHARACTERISTIC SHOWING ADVANTAGE OF PROPER BIASING

FIG. 2

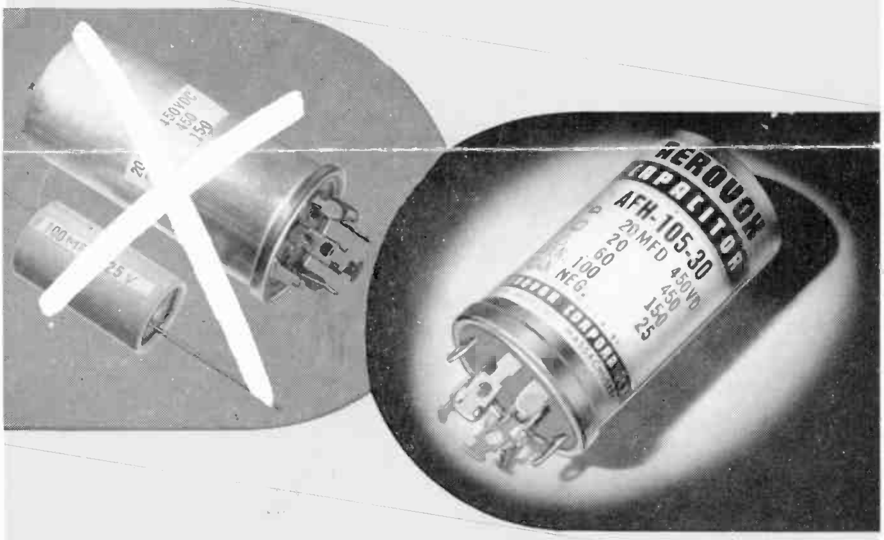
QUESTION:

Why buy TWO when ONE will do?

ANSWER:

Insist on AEROVOX

TWIST-PRONG ELECTROLYTICS



Here's the reason: A popular TV replacement calls for a 4-section unit rated at 20-20/450, 60/150, 100/25. In the absence of such a number, some capacitor lines recommend TWO units in combination — 20-20/450 60/350, list price $5.05, plus a tubular electrolytic 100/25, list price $1.35, for a total of $6.40.

By contrast, AEROVOX offers the identical part number — an AFH-105-30, rated at 20-20/450, 60/150, 100/25, list price $4.25

Why buy TWO when ONE will do? Why $6.40 list when you can get a single-unit replacement for $4.25 — and cut your labor by half? Lastly, you avoid trouble in TV chassis where tight fits are a problem.

With **more extensive listings** (actually 290 to 345 **more numbers** than those of any one of five competing brands*), AEROVOX Type AFH Twist-Prong Electrolytic Capacitors **meet more requirements** with single, economical units in place of multiple-unit makeshifts.

Consult AEROVOX Listings!

Take full advantage of those more extensive listings of ALL types of capacitors. Ask your AEROVOX distributor — or write us.

AEROVOX CORPORATION

**DISTRIBUTOR SALES DIVISION,
NEW BEDFORD, MASS.**

In Canada: AEROVOX CANADA, LTD., Hamilton, Ont.
Export: Ad. Auriema., 89 Broad St., New York, N. Y. • Cable: Auriema, N. Y.

*Details on written request.