RCA
BEAT FREQUENCY OSCILLATOR
Type TMV-52-E
RANGE 20 TO 17,000 CYCLES

MARKED STABILITY ELECTRON-COUPLED OSCILLATORS REDUCE REACTION TO A MINIMUM

WIDE FREQUENCY RANGE LABORATORY CALIBRATED FROM 20 CYCLES TO 17,000 CYCLES

CONSTANT OUTPUT VARIES LESS THAN 10% (± 0.5 DB.) OVER ENTIRE FREQUENCY RANGE

GOOD WAVE-SHAPE PROPER TUBE COMPENSATION REDUCES HARMONIC CONTENT TO LESS THAN 2%

HIGH OUTPUT LEVEL OPEN-CIRCUIT OUTPUT 25 VOLTS, LOAD OUTPUT 40 MILLIWATTS (+ 5 DB.)

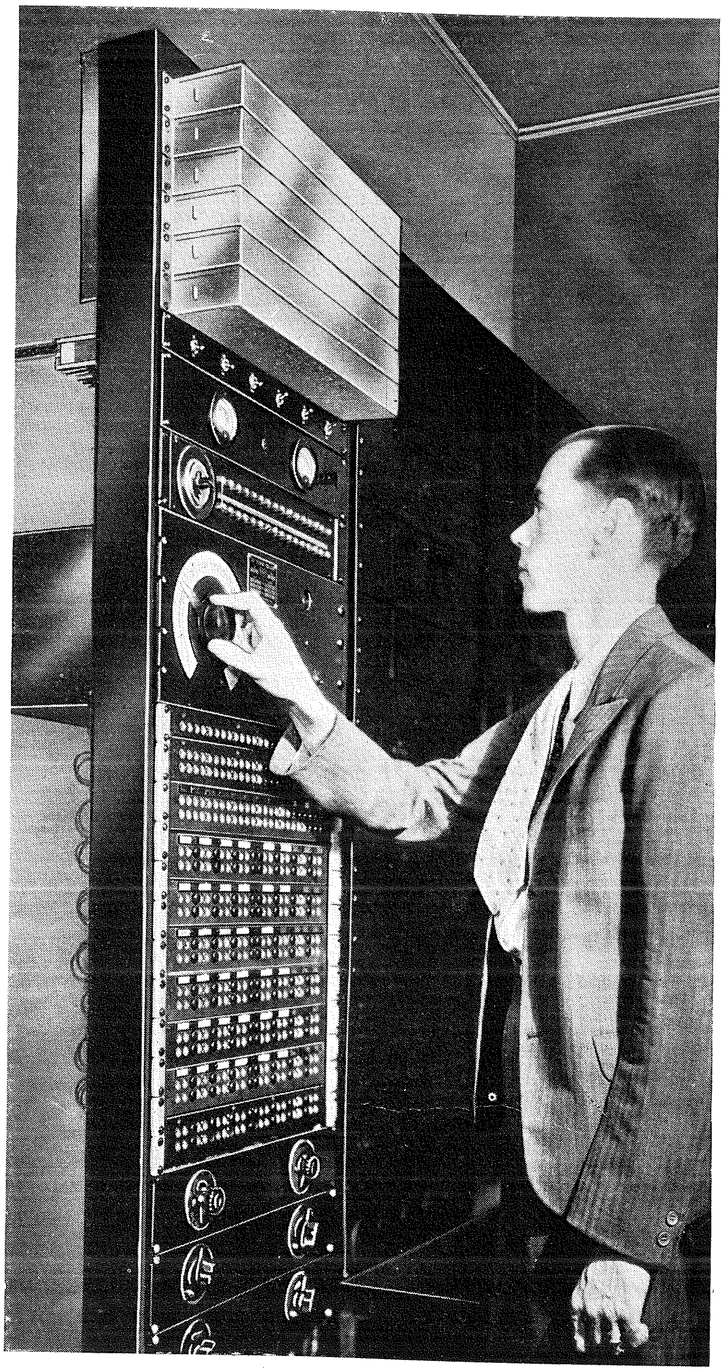
CALIBRATION ADJUSTMENT INGENIOUS REED INDICATOR, QUICK, ACCURATE ADJUSTMENT

UNIVERSAL DESIGN BALANCED OUTPUT TRANSFORMER, 250, 500 AND 5,000 OHM IMPEDANCES

THE TYPE "TMV-52-E" OSCILLATOR

DESIGN THAT DEMANDS ATTENTION — PERFORMANCE THAT PROVES SUPERIORITY

THE RACK MOUNTING MODEL IN THE MASTER CONTROL ROOM OF THE AMALGAMATED BROADCASTING SYSTEM'S NEW YORK STUDIOS



Most beat frequency oscillators have had a certain sameness. The Type TMV-52-E Oscillator is wholly different. At every point it has either entirely new features, or such features as have been available before only in much more expensive equipments. It is much like earlier beat frequency oscillators in that the audio frequency is obtained by beating two radio frequency oscillators, rectified by a detector, and amplified before being fed to the output. It is very different in the manner of accomplishing each step.

Type RCA-840 Radiotrons are employed as radio frequency oscillators. They are connected in electron-coupled circuits of the tuned plate type. The two oscillators are made as nearly symmetrical as possible in order to reduce temperature effect to a minimum. The fixed frequency oscillator is coupled to the detector through a sharply tuned intermediate-frequency transformer, while the voltage from the variable frequency oscillator is fed through a broadly tuned resistance-capacitance circuit. This arrangement tends to eliminate harmonics and aids in preventing coupling between the oscillators. Special band-pass filters and a mixing circuit designed to obtain the proper voltage ratio between the fixed and variable frequency oscillators insure a nearly pure sine wave in the output of the detector. The output of the detector, which is a Type RCA-30 Radiotron, is amplified by a resistance-coupled stage employing a Type UX-112-A Radiotron. The volume control is placed in the grid circuit of this amplifier. The amplifier feeds an output transformer having secondary taps to match 250, 500 or 5,000 ohms and a center-tap for balance to ground.

A reed frequency meter provides for calibration adjustments. The reed is resonant at a low frequency marked "C" on the scale. Adjustment is made by setting the frequency control at this point and tuning the compensating condenser for maximum deflection of the reed.

FREQUENCY RANGE—The frequency control is calibrated from 20 cycles to 17,000 cycles—the oscillator, however, will produce a beat note as low as one cycle without locking in step.

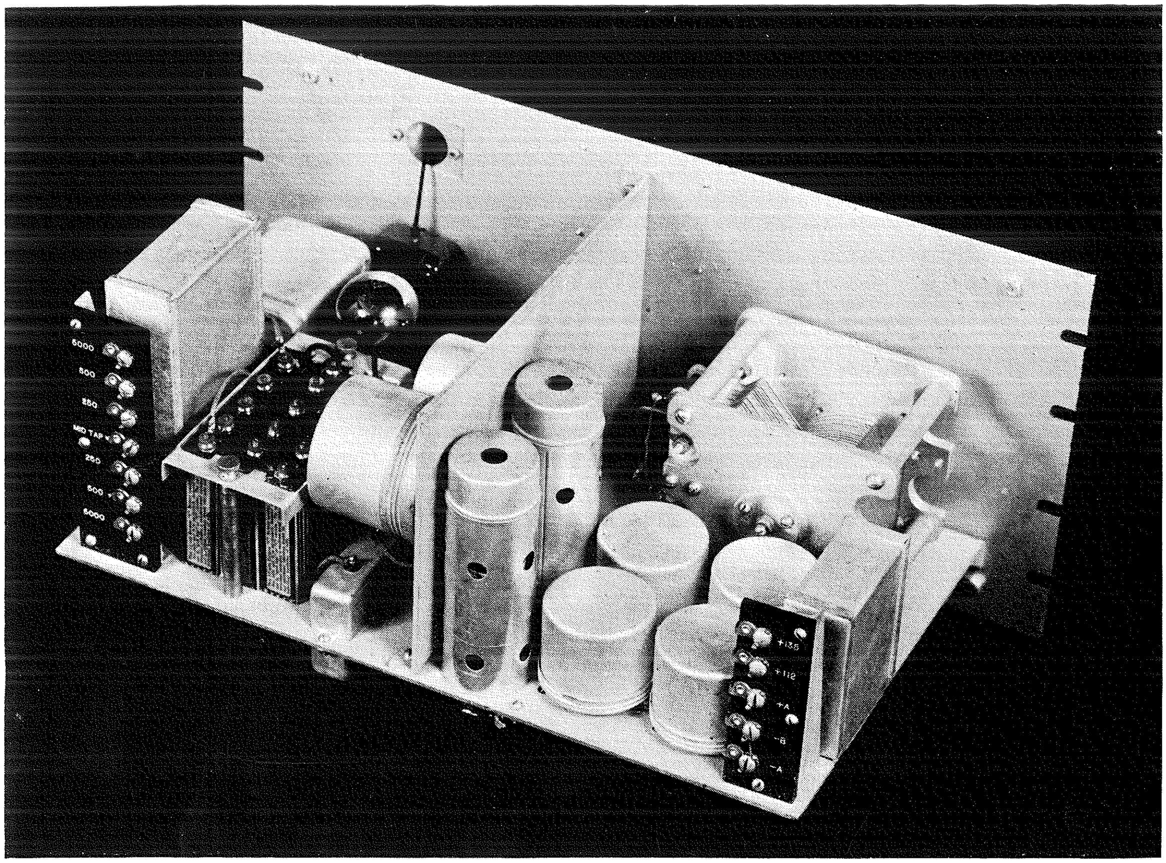
FREQUENCY CALIBRATION—Each Type TMV-52-E Oscillator is individually calibrated against the frequency standards of the RCA Victor Company. Sixty points are calibrated on a scale which extends over more than 15" of a dial 6½" in diameter. When the adjustment has been checked against the reed indicator, this calibration may be relied upon to within 2% over the entire range.

FREQUENCY STABILITY—The oscillators employed are probably the most stable designed to date and they have been made as nearly identical as possible to minimize temperature effect. During ordinary periods of use, the output frequency will not vary more than a few cycles. The drift can, of course, be corrected for at any time by means of the calibration adjustment and reed indicator.

OUTPUT LEVEL—The open-circuit output is 25 volts. The load output is approximately 40 milliwatts. This is equivalent to a +5 db. level as compared to a zero level of 12.5 milliwatts—or a +8.25 db. level as compared to a zero level of 6 milliwatts. The output voltage is constant to within 1 db.—over the entire frequency range.

OUTPUT WAVE-SHAPE—As shipped, and with no further adjustment, the total harmonic content of this oscillator under load is less than 5% over the entire range. However, by adjusting for the tubes used—as detailed in the accompanying instructions—this harmonic content may be reduced to less than 2% above 100 cycles.

OUTPUT IMPEDANCES—A balanced transformer for output coupling is incorporated in this oscillator. Taps on this transformer provide for matching 250, 500 or 5,000 ohm line or input impedances. The oscillator may be used with −A or +A grounded speech systems.



AN OSCILLATOR PARTICULARLY ADAPTED FOR BROADCAST USE

An audio oscillator is one of the most important pieces of test equipment in a modern broadcast station. It is invaluable in determining the frequency response characteristics of amplifiers, volume indicators, studio lines and even of the transmitter itself—in measuring the loss in attenuator networks, station circuits, remote lines, etc. The Type TMV-52-E is probably the first really fine oscillator designed particularly to meet the requirements of broadcasting as well as laboratory use.

RUGGED CONSTRUCTION FOR PORTABLE USE—NEAT APPEARANCE FOR PERMANENT LABORATORY INSTALLATION

Rear of the oscillator assembly showing the neat subpanel construction. The radio frequency oscillators and their associated circuits are at the right—the detector and amplifier stages, and the reed indicator, at the left. Note that all of the oscillator components, except the tuning condenser, are individually shielded to reduce reaction. The aluminum parts are sand-blasted and finished with clear lacquer, which is matched in appearance by the gray opalescent lacquer finish of the other metallic parts. The logarithmic tuning condenser is substantially constructed to insure holding of calibration. The power supply terminals can be seen at the right and the audio output terminals at the left. The whole assembly shown fits into a cabinet for portable use—or, with the addition of four cover supports, into a dust cover for rack mounting.

ELECTRON-COUPLED OSCILLATOR CIRCUITS—THE ANSWER TO THE QUEST FOR STABILITY

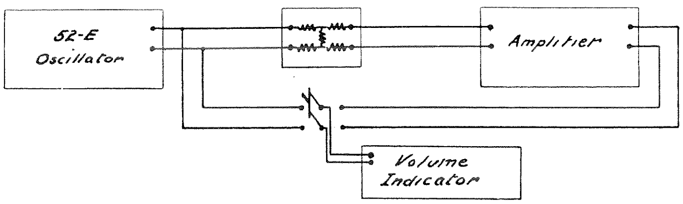
Beating two radio frequency oscillators to obtain a desired audio frequency seems on first thought a simple matter. That it is not is due to the necessity of eliminating reaction between oscillators. The fixed oscillator, for instance, must not change frequency when the variable oscillator is tuned. Similarly the variable oscillator must not lock in step with the fixed oscillator at low frequencies. This cannot be accomplished unless the frequencies of the two oscillators are nearly independent of load conditions.

Commonly used types of oscillators are not independent of load. In practically all of them the output circuit—to which the load is coupled—forms, directly or by inductive or capacitive coupling, a part of the oscillator circuit. Variations in load change the constants of the frequency determining circuit and hence the oscillator frequency. As a result, beat frequency oscillator development has become a search for an oscillator sufficiently stable as to be practically independent of load.

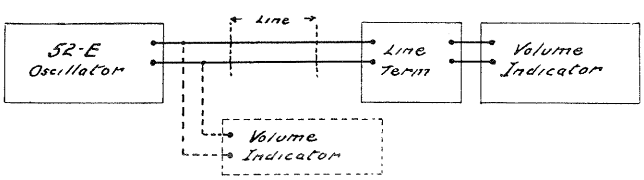
Engineers of the RCA Victor Company believe that in the electron-coupled oscillators used in the Type TMV-52-E Oscillator they have come closer to the solution than ever before. These oscillators are five-element tubes. The third and fourth elements function together as the anode of the frequency determining circuit and also act as an electrostatic shield for the regular plate which is the anode of the output circuit. The frequency of the current in the output circuit is thus determined by the control of electron flow to the plate. No part of the output circuiting forming any part of the frequency determining circuit, load reaction in the ordinary sense is eliminated. The action may be visualized by considering the oscillator tube to be functioning simultaneously as a buffer amplifier—the plate of the oscillator being also the grid of the amplifier. The stability resulting is, in fact, comparable to that which would be obtained if each oscillator were followed by a separate buffer amplifier.

AN AUDIO OSCILLATOR IS INVALUABLE IN TESTING SPEECH INPUT EQUIPMENT

AMPLIFIER FREQUENCY CHARACTERISTIC: The diagram just below indicates the method of obtaining a curve of amplifier gain versus frequency. The pad, which may be either fixed or variable, should have a drop about equal to the gain of the amplifier. With this setup the amplifier gain for any particular frequency equals the pad drop plus the difference in volume indicator readings for the two switch positions. The method may, of course, be used for various equipment items other than amplifiers.



LINE FREQUENCY CHARACTERISTIC: The diagram below indicates a method of determining the frequency characteristic of a line terminating at points separated some distance. Where only relative values are required, a volume indicator is required at the receiving end only, as the oscillator output can be held constant. Where absolute values are needed, an additional volume indicator is required at the sending end.



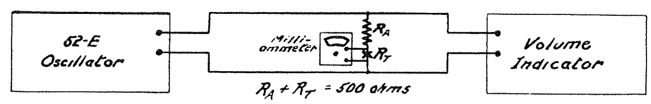
RACK MOUNTING TYPE

When specified for rack mounting, the Type TMV-52-E Oscillator is furnished with cover supports and dust-cover similar to those supplied with other speech input units. The panel is slotted for standard rack mounting and is designed to harmonize in appearance with other standard speech input equipment.

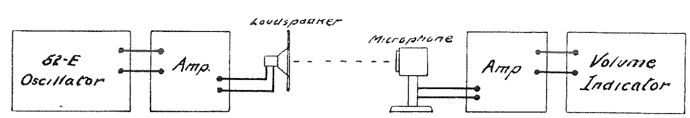
PORTABLE TYPE

Unless otherwise specified, the Type TMV-52-E Oscillator is supplied with a black crackle-finished cabinet fitted with a substantial leather carrying handle. The binding posts on the cabinet are connected by flexible cable to the subpanel. The battery requirements are 6 volts A, 135 volts B, and 22½ volts C.

VOLUME INDICATOR CALIBRATION: The diagram below indicates a method of calibrating a volume indicator using a thermo-couple milliammeter as reference. For a zero level of 12.5 milliwatts, the meter should read 5.0 milliamperes; for a zero level of 10 milliwatts, it should read 4.47 milliamperes, and for a zero level of 6 milliwatts, 3.47 milliamperes. Constant tone is supplied by the oscillator. For such a tone the galvanometer of a volume indicator calibrated to read average levels will show a deflection of 30 on the scale for a zero level input. It should be noted, however, that volume indicators calibrated to read peak levels will show a deflection of only 23 on the galvanometer scale for the same constant tone input level.



MICROPHONE CALIBRATION: The diagram below indicates a method of calibrating a microphone against a loudspeaker which has been previously calibrated by some absolute method. Or, similarly, a loudspeaker may be calibrated against a microphone which has been previously calibrated by some other method, as, for instance, the Raleigh Disc Method. As this method is seriously influenced by acoustical phenomena, the results must be considered only approximate unless full account is taken of the acoustical properties of the room in which the measurements are made.



RCA Parts Division

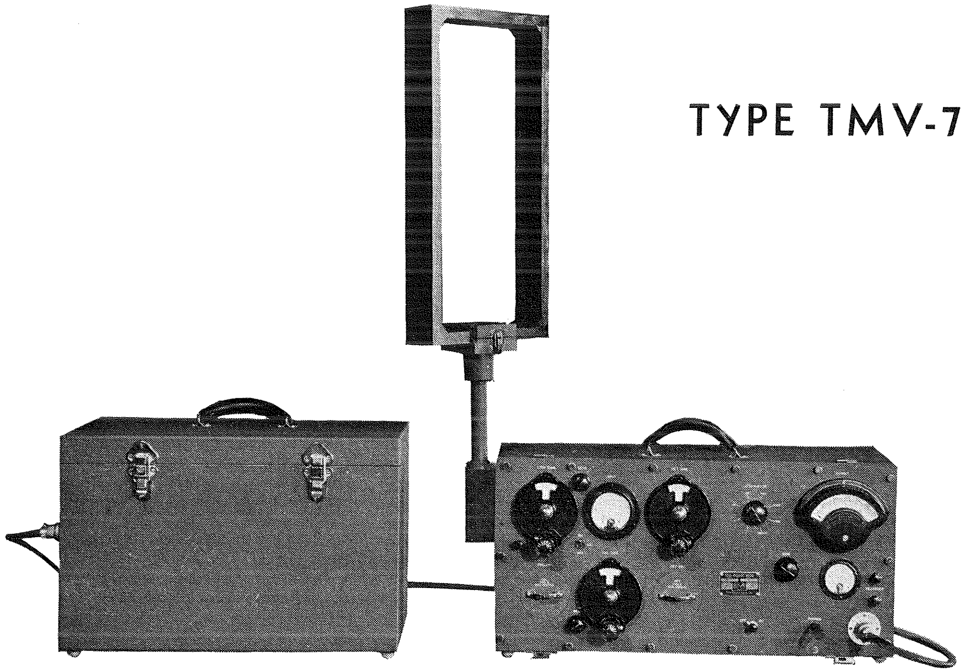
RCA Victor Company, Inc.

Camden, N. J., U. S. A.

RCA FIELD INTENSITY METER

PORTABLE DIRECT-READING SELF-CALIBRATING

TYPE TMV-75-B



COMPLETE EQUIPMENT IN TWO CARRYING CASES, CONSISTING ESSENTIALLY OF AN EXTREMELY SENSITIVE LOOP RECEIVER (OF THE SUPERHETERODYNE TYPE) INCORPORATING A SELF-CALIBRATING OSCILLATOR

FREQUENCY RANGE	500 kc. to 20,000 kc.
FIELD INTENSITY RANGE	20 Microvolts/Meter to 6 Volts/Meter
CONVENIENT OPERATION	Coils Plug in from Front of Panel, Simplified Controls
HIGH ACCURACY	By Means of a Newly Developed Circuit

FOR

BROADCAST STATION SURVEYS

COMMERCIAL STATION SURVEYS

TRANSMISSION TESTS INTERFERENCE LOCATION

RCA Develops New Field Intensity Meter

By **WILLIAM F. DIEHL, Test Methods and Equipment Engineer, RCA Victor Company, Inc.**

(Reprinted from Broadcast News)

DEVELOPMENT and field tests have been completed on a new instrument for measuring the field intensity of all type transmitters. This instrument will be designated as RCA Victor Type TMV-75-B Field Intensity Meter and will replace the well-known TMV-21-A instrument which has been in such demand for the past several years and which has proven exceedingly popular due to its portability, wide frequency range and wide range of field intensity.

The increasing interest in field strength measurements and the widespread acceptance of this type of measurement as a figure of merit of the transmitter have indicated to us that certain new features, such as greater stability, higher accuracy, still wider range of field intensity and carrier frequency, are highly desirable if an instrument of this type is to adequately meet the future requirements.

The front cover shows the complete TMV-75-B equipment, which consists of the Field Intensity Meter proper and a separate carrying case to house the loops, plug-in coils and batteries.

The equipment is self contained in two metal cabinets whose weights, less batteries, are each about 30 pounds. While its weight with batteries is somewhat high it is considered that the stability and extreme range of the instrument justify this weight.

As shown in Figure 2, the controls have been so arranged and grouped as to make the instrument easy and simple to operate. Because of the method of calibration, loop constants do not have to be measured, so several measuring operations have been eliminated from previous equipments of this type.

All tuned circuits are controlled by means of vernier dials whose vernier ratio may be varied between 6-1 and 20-1. This makes possible easy tuning of the various circuits at high frequencies without too great a vernier action at the lower frequencies.

The equipment requires a power supply of 25 M. A. at 135 volts for "B" supply and 1.6 amperes at 6 volts for "A" supply. A choice of batteries may be made, depending upon the battery life desired. The approximate life of the various batteries which may be used is illustrated in the following table:

"A" SUPPLY

Type	*Hours*
Four No. 6 cells	4
Eight No. 6 cells (*series parallel*)	15
Six volt storage cell (*motorcycle type*)	20 (*per charge*)

"B" SUPPLY

Type	*Hours*
No. 4156	7
No. 5308	15
No. 2305	60

The instrument will measure intensities between 20 microvolts per meter and 6 volts per meter at carrier frequencies between 500 kc. and 20,000 kc. It consists, essentially, of a loop receiver using the superheterodyne principle in which the intermediate frequency operates at 300 kilocycles. A resistor attenuator operating at 300 kc. is provided in the intermediate frequency amplifier to control the gain of the receiver and, thereby, permit measurements of field strength over a wide range. In order to measure extremely high field intensities, an additional attenuator is provided by C-2, R-1 and C-3 in the schematic diagram. The switch S-2 is provided for switching the additional attenuator in and out of the circuit. A separate calibrating oscillator and mutual inductor attenuator is provided for the purpose of maintaining the calibration. Four loops are provided to cover the frequency range and four sets of plug-in coils are required, one set for the beating oscillator (shown on the print as detector oscillator), the other set for the calibrating oscillator.

The switch S-1 when open disconnects stator plates from the variable condenser C-1 to permit proper tuning in the high frequency range. The variable condenser C-4 is provided for compensation so that the capacity to ground across each side of the loop will be constant.

The field picked up by the loop at the carrier frequency (500–20,000 kc.) is applied to the grid or input circuit of the RCA-78 detector and the frequency changed to 300 kc. by introducing the voltage from the beating oscillator which uses a tuned grid circuit and an RCA-30 tube. The plate circuit of the RCA-78 is tuned to 300 kc. and the secondary of the I. F. transformer (L-9) is connected to a resistance attenuator, the output of which feeds the input of the first I. F. amplifier consisting of an RCA-36. The signal is then amplified by a second I. F. amplifier (RCA-39) and a third I. F. amplifier (RCA-78), after which it is applied to the diodes of an RCA-85 connected in parallel to supply half-wave rectification and also amplified at audio frequencies by the same tube. For the purpose of listening to the signals a jack (J-1) is provided, connected in the secondary of an audio transformer (T-1). For purposes of measuring the output meter (M-3) it is connected in the diode or detector circuit and remains connected and operates regardless of whether the telephone receivers are plugged in or out of the circuit. The switch (S-4) is an "On–Off" switch and the meter (M-2) is a double range voltmeter. Resistors R-4 and R-5 are provided for the purpose of changing the gain in the I. F. amplifier and thereby performing the functions of a volume control.

The Calibration

The calibrating oscillator utilizes an RCA-30 tube in a tuned plate circuit indicated by L-4 and C-7. The output of the calibrating oscillator is applied to the primary L-2 of a mutual inductor attenuator and a thermo-couple meter (M-1) reads the voltage across L-2. The coupling between L-2 and L-1 is fixed and a definite voltage appears across L-1 which is connected in series with the loop, and this voltage acts in the same manner as the signal and is used for the purpose of calibration. Since the secondary (L-1) of the mutual inductor always remains connected in the circuit, no error results, due to changing impedance conditions with calibration.

When a loop antenna is placed in a magnetic field a voltage is induced in its circuit. The magnitude of this voltage is dependent upon the strength of the field, the effective height of the loop and the angle between the field and the loop. When the loop is so directed as to give maximum induced voltage this induced voltage may be expressed by the formula:

$e = Fh$ (1)

where e = induced voltage in microvolts

F = field intensity in microvolts per meter

h = effective height of the loop antenna in meters

If a variable capacitor is placed across the loop antenna and the circuit tuned to resonance with the frequency of the field, a voltage will appear across the loop antenna and condenser larger than the induced voltage by an amount called here, the step-up of the loop, and expressed by the symbol Q. We now have for the voltage across the loop antenna in the magnetic field a voltage E

We now have a voltage E_d at a frequency of 300 kc., the intermediate amplifier frequency

$$\text{and } Ed = \frac{E}{2}\, Md$$

$$\text{or } Ed = \frac{Q\,F\,h\,Md}{2} \qquad (3)$$

This voltage is impressed across a resistance attenuator network where it may be attenuated by any amount

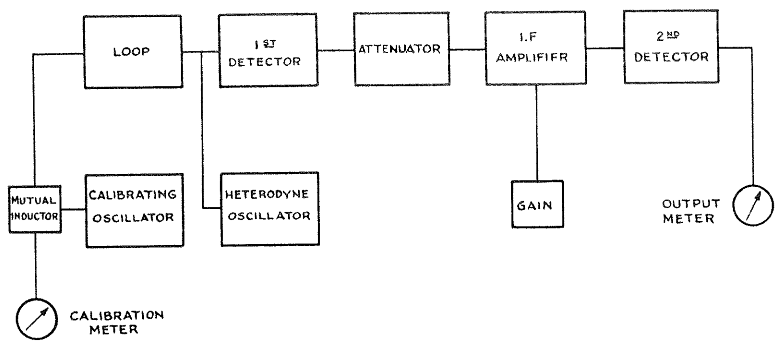


FIGURE 1—BLOCK DIAGRAM OF FIELD INTENSITY METER

expressed by the formula

$$E = Qe = QF\,h \qquad (2)$$

Due to the necessity of balancing the loop to ground to prevent antenna effects, only one-half of this voltage, or $\frac{E}{2}$, is impressed on the grid of the first detector and heterodyned with the heterodyne oscillator. Across the plate load of the first detector will now appear a 300 kc. voltage whose amplitude is dependent on the voltage $\frac{E}{2}$ and a constant, the conversion conductance of the first detector tube designed as M_d. The circuits associated with the first detector are so designed as to make this quantity M_d constant for any input voltage $\frac{E}{2}$ over the range of the instrument at any given frequency and as nearly constant as possible, for all frequencies, without overloading any of the associated tubes.

up to 50,000 in steps of 4 and 5 each, that the attenuation factors are 1, 5, 20, 100, 500, 2000, 10,000 and 50,000. The attenuated voltage is impressed on the grid circuit of the first tube of the intermediate frequency amplifier. The gain of the amplifier may be varied by means of a gain control between rather wide limits. The gain at any constant setting will be designated by M_a and the attenuation of the attenuator will be designated by A_1, A_2, etc. The output voltage of the I. F. amplifier is measured by means of a d.c. microammeter and a diode rectifier. Because of the fact that the diode rectifier is not a true linear device, a marked scale is placed on the meter so that the meter readings are directly proportional to the I. F. output voltage. The output of the I. F. amplifier will be designated as R_1, R_2, etc. Thus

$$R = \frac{E_d \times M_a}{A}$$

$$\text{from (3) } R = \frac{Fh\,Q\,Md\,Ma}{2\,A} \qquad (4)$$

$$\text{or } F = \frac{2\,RA}{h\,Q\,Md\,Ma}$$

In order to be able to calculate the field intensity giving the reading R, it is now necessary to know h, Q, M_d, and M_a. To find these values it is necessary to calibrate the instruments. If a known voltage V is induced in the loop circuit it will be possible to calculate a value which will include all of these constants with the exception of h, which is known from the physical dimensions of the loop. This voltage is introduced in the loop circuit by means of a mutual inductance attenuator.

The mutual inductance attenuator consists of two self-inductances inductively coupled to each other and so shielded as to prevent any capacity coupling. The primary or larger inductance is fed with current from the calibrating oscillator and the voltage across the coil is measured by means of a thermocouple voltmeter. The secondary or smaller coil is connected in series with the loop antenna, opening the loops at their electrical center so that one side of the secondary of the mutual inductance may be at ground potential as well as one side of the primary. The secondary voltage V is proportional to the primary current and the mutual inductance between the two coils,

$$V = 2 \pi f I_p \quad L_m \qquad (5)$$

$$Ep = I_p 2 \pi f Lp \text{ or } Ip = \frac{Ep}{2 \pi f L_p} \qquad (6)$$

$$\text{Thus } V = \frac{E_p}{L_p} Lm \qquad (7)$$

as L_m and L_p are constants, it follows, if E_p is held constant, the secondary voltage V will be constant regardless of the frequency. We thus have a known constant voltage source as long as the primary voltage is held constant by means of the thermocouple voltmeter across the primary coil.

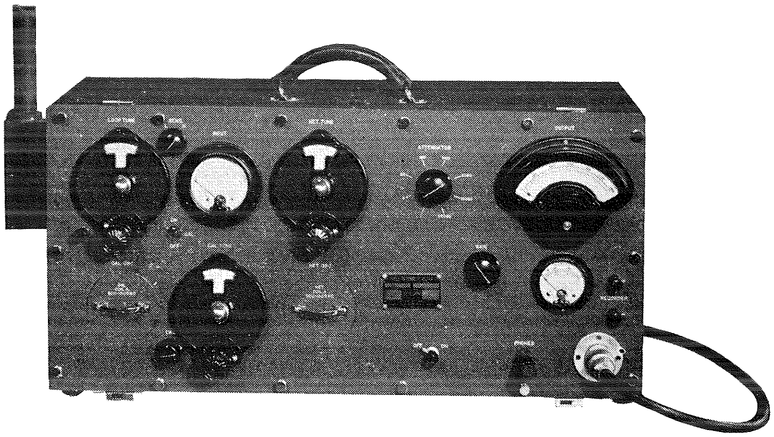


FIGURE 2—A CLOSEUP OF THE CONTROL PANEL ON THE NEW TMV-75-B FIELD INTENSITY METER

If we now introduce the voltage V in the loop circuit as stated we have impressed on the grid of the first detector a voltage equal to $\frac{VQ}{2}$, which will produce an output reading proportional to Md, M_a, and A.

$$R = \frac{VQ\ Md\ Ma}{2\ A} \qquad (8)$$

To calibrate the instrument we will set certain values as calibrating values. These values will be

$$R = R_1$$

$$V = V_1$$

$$A = A_1$$

and will adjust Ma so that these conditions may be met at this frequency. We then have from (8)

$$R_1 = \frac{V_1\ Q\ Md\ Ma_1}{2A_1}$$

$$\text{or } \frac{2A_1\ R_1}{V_1} = Q\ Md\ Ma_1 \qquad (9)$$

If now we place the loop of the instrument in an unknown field of field strength F and allow the gain of the I. F. amplifier to remain Ma_1, but vary the attenuator setting to A_2, the output reading will be some value R_2 and from (4) we have

$$F = \frac{2\ R_2\ A_2}{h\ Q\ M_d\ Ma_1} \qquad (10)$$

Substituting (9) in (10) we have

$$F = \frac{2\ R_2\ A_2\ V_1}{2\ h\ A_1\ R_1}$$

from which the field strength may be calculated, as all quantities are known.

By collecting the terms of the calibrating conditions this formula is simplified to the form

$$F = \frac{R_2\ A_2\ K}{h} \ (11) \text{ where } K = \frac{V_1}{A_1\ R_1}$$

This formula is still further simplified by substituting in it the formula for the effective height of a loop antenna

$$h = 2 \pi S N A F$$

where S = a constant

N = number of turns

A = area enclosed by the loop

For any given loop this becomes

$$h = s^1 f \qquad (12)$$

Substituting (12) in (11)

$$F = \frac{R_2\ A_2\ C}{f} \ (13) \text{ where } C = \frac{K}{S^1}$$

The value C is calculated for each loop so that calculation of field intensities from R_2 and A_2 are very simple, f being a known and constant quantity for many measurements such as making a station survey or when recording fading. It must be remembered that the quantities Q and Md are not constants with respect to frequency, so the instrument must be recalibrated for each different frequency if the frequency difference is greater than a few per cent. Up to 5 per cent change in frequency these quantities do not vary appreciably.

In order that the higher field intensities may be measured it is necessary to attenuate the voltage across the loop to prevent overloading of the first detector. This is accomplished by placing a capacity attenuator in the grid circuit of the first detector. This attenuator may be placed in or out of the circuit, as desired. No attempt has been made to keep the attenuation ratio of this unit constant with respect to frequency, and so when making measurements with this unit in the circuit it will also be necessary to calibrate with like conditions.

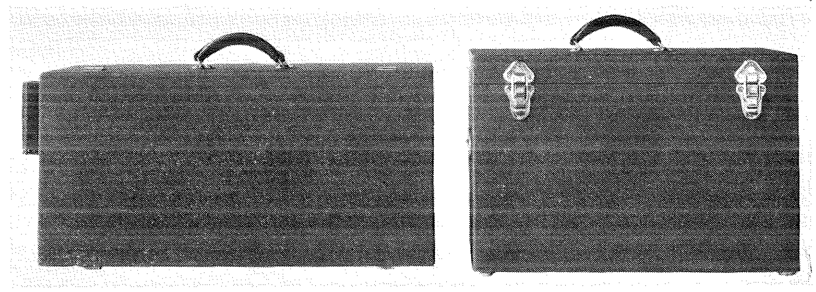
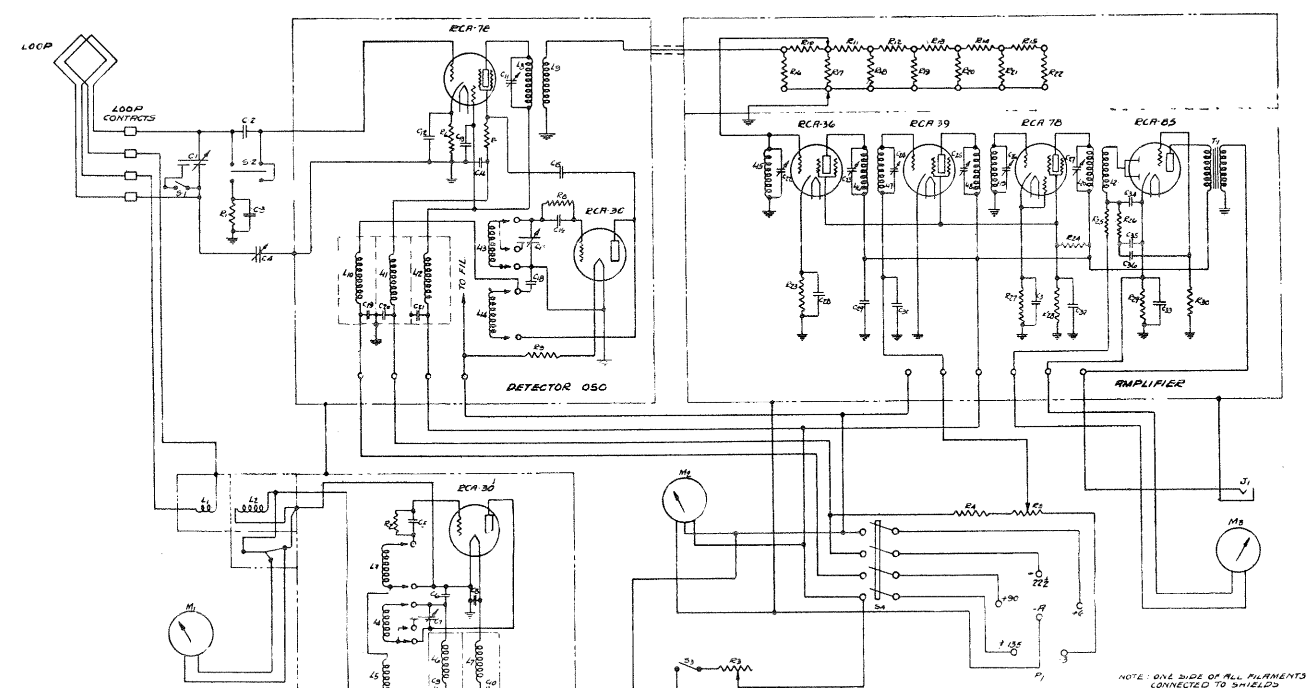


FIGURE 3—THE TMV-75-B FIELD INTENSITY METER EQUIPMENT, CLOSED UP IN ITS CARRYING CASES, READY FOR TRANSPORTATION

When calibrating with the input attenuator in the circuit (position L) it will be found necessary to calibrate with the I. F. attenuator on a different position than when the input attenuator is disconnected (position H). The field strength calculated by (13) must therefore be multiplied by the ratio of the previous I. F. attenuator setting for calibration to the new I. F. attenuator calibrating setting.

The writer wishes to acknowledge the assistance given by Mr. H. E. Ghiring, whose experience in field survey work was invaluable in preparing the original specifications, and credit Mr. H. J. Schrader for his conscientious assistance in carrying through the development and design. The writer wishes also to thank Mr. Raymond Guy, of the National Broadcasting Company, for his excellent co-operation and valuable suggestions during the development, and for his data taken in the field using the first development model.



SCHEMATIC DIAGRAM
FOR TMV-75B FIELD INTENSITY METER

Mechanical Design

The Field Intensity Meter is contained in a rugged aluminum case and is provided with a neatly engraved panel. The case is approximately 9½″ x 24½″ x 11¾″ high. The finish is baked gray crystalline varnish.

The accessory equipment case of the same finish for the coils, loops, and batteries measures 9″ x 20½″ x 13″ high. Clips are provided to hold the 8 coils and 4 loops while not in use.

The weight of both cases exclusive of batteries is approximately 30 pounds each.

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Instruction Books

Each Model TMV-75-B Field Intensity Meter is furnished with a set of instructions for installation, calibration and operation of the equipment, together with detailed wiring diagrams and all data required for satisfactory operation and servicing of the equipment.

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Equipment Supplied

1 Type 75-B Field Intensity Meter with Case
4 Loops
4 Pairs Plug-in Coils
1 Carrying Case for Loops, Coils, Batteries
1 Interconnecting Cable
1 Instruction Book
1 Calibration Chart
1 Set of Radiotrons consisting of
- 2 RCA-78
- 1 RCA-36
- 2 RCA-30
- 1 RCA-85
- 1 RCA-39

Equipment not included but necessary for operation:

1 Set of batteries for A, B and C voltages
1 Set of Headphones