INSTRUCTION BOOK
FOR
MODEL 120-D
FIELD INTENSITY METER

NEMS CLARKE, INC.

SILVER SPRING, MARYLAND

INSTRUCTION BOOK

FOR

MODEL 120-D

FIELD INTENSITY METER

Scanned and Prepared by
Dale H. Cook

NEMS-CLARKE, Inc.

Silver Spring, Maryland

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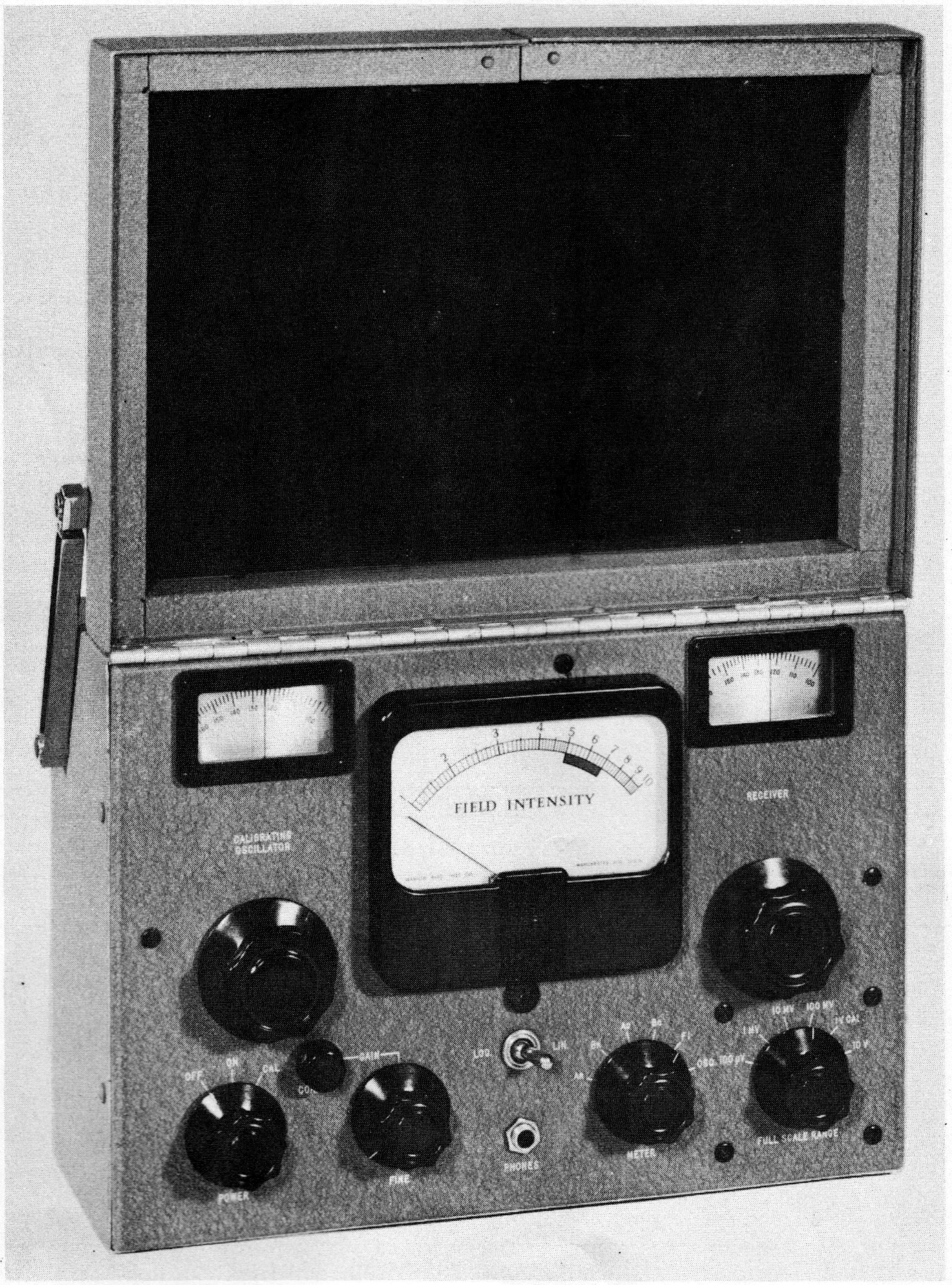

Fig. 1. Field Intensity Meter, Type 120-D, Front Cover Open

Frontispiece

SPECIFICATIONS FOR

120-D FIELD INTENSITY METER

Frequency range	540 to 1600 kc
Field intensity range	10 microvolts per meter to 10 volts per meter
Accuracy of attenuators	2%
Output indicator	Panel meter, direct reading, with logarithmic scale graduated 1 to 10 and HAVING NO ZERO MARK (needle is OFF SCALE when meter is not energized). Provision for using recorder. Headphones, high-impedance (not supplied).
Antenna	Shielded, unbalanced loop
Power supply	Batteries, 5--1 1/2-volt, 2--67 1/2-volt Provision for external power supply. (Batteries not supplied.)
Battery life	500 indications (approx.)
Mechanical specifications	
Overall dimensions, closed	Height 9", width 13", depth 5 3/4"
Weight, including batteries	12 1/2 lbs.

TUBE COMPLEMENT

Symbol	Type	Function
VT-1	1T4	RF amplifier
VT-2	1R5	First detector and heterodyne oscillator
VT-3	1T4	IF amplifier
VT-4	1T4	IF amplifier
VT-5	1T4	IF amplifier
VT-6	1R5	Calibrating oscillator

METERING CRYSTALS

Symbol	Type	Function
X-1	1N34A	Calibrating oscillator output
X-2	1N34A	Receiver signal output

Introduction

The Type 120-D Field Intensity Meter is a compact, light-weight portable instrument for the measurement of a wide range of radio signal intensities in the broadcast band of 540 to 1600 kilocycles. Its range of sensitivity, from 10 microvolts per meter to 10 volts per meter, makes it equally effective for interference studies at low signal strengths and for close-in measurements on high-power directional arrays.

Because of the high selectivity considered necessary in a modern field intensity meter, the overall bandwidth of the 120-D is approximately 7 kc at 1000 kc with one-half voltage response. Image response is approximately 80 db down at all frequencies, and i-f rejection is approximately 80 db down at all frequencies above 600 kc and 70 db at 540 kc.

Accuracy of measurement is assured by a calibration method that compensates for variations in tube characteristics and for voltage variations in the self-contained battery power supply. Operation is simple and measurements can be made rapidly, for the meter is direct reading at all ranges and requires the use of no charts or multiplication factors. Since tubes are of the filament type, no warm-up period is necessary before taking readings.

The added feature of providing both linear and logarithmic indications permits its use with recording equipment for continuous observations. An external amplifier, not supplied, is required to drive a recorder. Provisions are made for the use of an external power supply when conditions require continual operation.

A headset having an impedance of 10,000 to 25,000 ohms is recommended as an aid in identifying signals under observation, and may be used simultaneously while readings are being taken.

Description

The field intensity meter is assembled in a metal case, finished in crackle gray. A convenient carrying handle is provided on the narrow side of the case. The hinged cover is recessed to accommodate the loop aerial and held closed during transportation by spring-loaded telescoping braces at the ends of the case. When the cover is raised, the braces swing up and support the cover and loop in vertical position above the panel.

The rear compartment cover of the case is hinged and can be opened for replacing batteries.

A 1/4 x 20 threaded hole on the bottom face of the instrument case is provided to mount the meter on a tripod, if desired, for convenience in operation. No tripod is furnished with the equipment. Any reasonably sturdy camera tripod may be used.

The panel of the instrument is fitted with the following indicators and controls. Panel designations and function are given below.

FIELD INTENSITY meter, having a 200-microampere movement, indicates field strength directly on a logarithmic scale WHICH IS GRADUATED 1 TO 10 AND HAS NO ZERO POSITION. THE POINTER RESTS TO THE LEFT OF THE FIRST MARK, WITH NO CURRENT INPUT. Full-scale deflection for the highest range setting is 10 V/M. The meter indicates correctly, regardless of whether or not the carrier is modulated, provided the modulation is symmetrical.

RECEIVER tuning control knob for receiver circuits, driving dial visible through rectangular transparent panel opening. The dial is calibrated directly in frequencies, 54 to 160 corresponding to 540 to 1600 kilocycles.

CALIBRATING OSCILLATOR tuning control knob for calibrating oscillator circuits, driving a dial similar to the receiver tuning dial and calibrated in the same manner.

POWER switch, with three positions as follows:

OFF, power off all circuits

ON, power on receiver only

CAL, power on receiver and calibrating oscillator

GAIN potentiometers, COARSE and FINE, to adjust receiver gain for calibration.

METER switch, six-position, to set function of meter so as to indicate values as listed below for the various lettered settings:

AR, receiver filament (A) voltage

BR, receiver plate (B) voltage

AC, calibrating oscillator filament (A) voltage

BC, calibrating oscillator plate (B) voltage

FI, field intensity at range set by FULL SCALE RANGE switch

OSC, output voltage of calibrating oscillator

FULL SCALE RANGE switch, six-position, to adjust attenuation in the receiver circuits and provide full-scale deflection of the meter for the values marked at each switch position, as follows:

100 uV, 1 MV, 10 MV, 100 MV, 1 V, 10 V.

LOG-LIN switch, to provide either logarithmic or linear output of the receiver; the former primarily for use when the meter is to operate a d-c amplifier in connection with recording equipment.

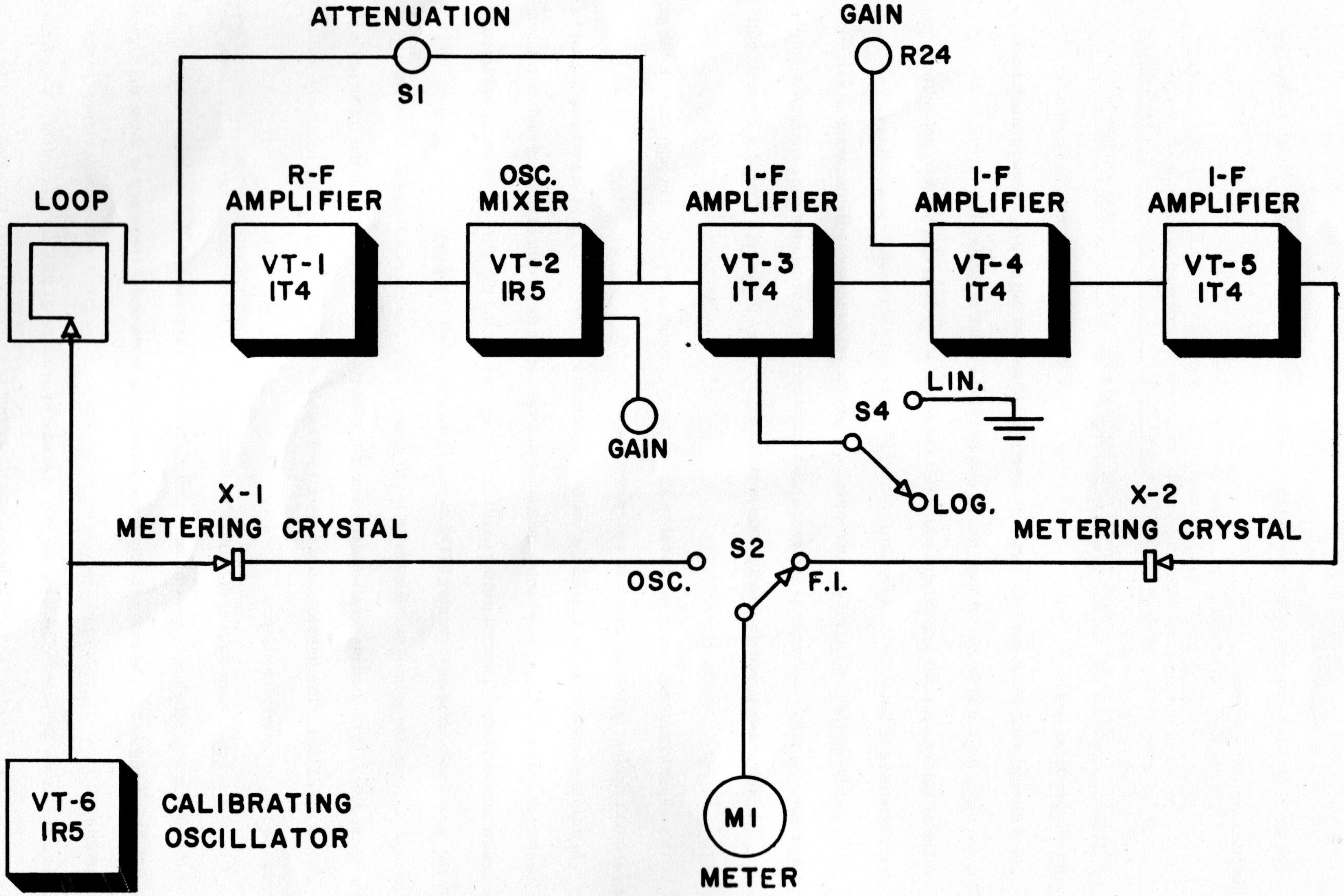

Fig. 2. Block Diagram, Field Intensity Meter

PHONE jack, for insertion of headset when necessary.

An unmarked pin jack, located below the meter, is for connection to d-c amplifier used with recording equipment.

Theory of Operation

The circuit employed in the field intensity meter is shown in detail in the schematic diagram at the end of the book, but the principle of operation is outlined in the block diagram, Fig. 2.

The circuit components are carefully shielded to prevent stray couplings between the circuits, particularly between oscillator and receiver, to eliminate errors in calibration.

The receiver proper consists of a five-tube superheterodyne receiver, with one stage of r-f amplification before the mixer and three i-f stages. Attenuation circuits to obtain the wide range of sensitivities are inserted at two points as shown. The output of the receiver is metered through a crystal rectifier.

The output of the calibrating oscillator is also metered through a crystal. Through careful design, the harmonic content of this oscillator has been kept low.

In use, the receiver section, with the meter connected to the output, is first tuned to the signal to be measured, using the meter as a tuning indicator, and the signal then reduced to minimum by rotating the instrument and loop. The calibrating oscillator is switched on, and the strength of the signal injected into the loop is measured on the meter. The meter is then switched to the output of the receiver and with calibrator still on, the gain of the receiver is set to give a meter reading exactly equal to the oscillator input to the loop. In this manner the receiver output is calibrated to a known input at the frequency on which it is to be used. The field intensity is then read by switching off the calibrating oscillator and orienting the loop for maximum input.

1. Signal input. Considering the circuit in detail, refer to the schematic diagram. The loop, L-1, is of the unbalanced, shielded type with one end connected to L-3 and the high end loaded by a high-Q adjustable inductance L-2. The loop has only a few turns so its fundamental frequency is above the highest frequency to be received. Additional inductance is lumped in L-2 to give a wide enough tuning range when adjusted by section C-2A of the tuning capacitor operated by front panel RECEIVER control. This form of antenna minimizes the effects of distributed capacities, reduces antenna effect, and requires no balancing. The Q of the loop circuit is about 100 at one megacycle. This high Q factor makes for high sensitivity and selectivity and, coupled with the use of an r-f amplifier stage, provides high image rejection.

2. RF amplifier. The loop input is connected through a conventional capacity divider, which forms one section of the r-f attenuator system, to the r-f amplifier VT-1. The attenuator circuit is controlled in six steps by sections S-1A, B and C of the FULL SCALE RANGE switch, and works in conjunction with an i-f attenuator controlled by section S-1D of this same switch. Together these attenuators provide 6 steps of receiver output voltage, each step giving ten times the receiver output of a preceding step.

The attenuator is arranged so that attenuation takes place first in the input to the intermediate frequency amplifier. On the 100 µV/M position, the 1 MV/M position, and the 10 MV/M position of the FULL SCALE RANGE switch the r-f attenuator is out of the circuit. On the 100 MV/M position, the 1 V/M position, and the 10 V/M position the i-f attenuator is maintained at full attenuation, and loss is introduced progressively in the r-f attenuator. With this arrangement, noise originating in the front end circuits has no effect on output meter indications except on the 100 uV/M position. Even on this position its effect is negligible and does not materially affect the accuracy of the indication.

Provision is made in the attenuator to avoid detuning of preceding circuits. The r-f amplifier tube, VT-1, operates with a fixed bias derived from the resistor network R-22, R-23, and R-24.

3. First detector and oscillator. The output of the r-f stage is coupled to the first detector tube VT-2 by a transformer T-1. This same tube, through its associated circuits T-6, operates also as a local heterodyning oscillator. Circuits T-1 and T-6 are tuned, respectively, by capacitors C-2B and C-2C, which are ganged with each other and with the loop tuning capacitor C-2A. The tube acts as a conventional oscillator-mixer to develop an intermediate frequency of 455 kc. Linearity of output of this detector is good since the range of signal inputs over which it has to function is reduced by the fact that there are three steps of attenuation in the input to the r-f amplifier VT-1. The output circuit of VT-2 contains the fixed inductance which is tuned by C-20 to resonance at the intermediate frequency. The COARSE GAIN control is in the signal grid of this stage.

4. IF attenuator. The i-f attenuator circuit functions on the 100 µV/M, 1 MV/M, and 10 MV/M positions of the FULL SCALE RANGE switch S-1 (positions of greatest sensitivity). This circuit is fed by a capacitance voltage divider formed by C-21 and C-22. This prevents changes in the attenuator capacities with setting from affecting the tuning of the choke T-2.

5. First IF amplifier. This is a conventional i-f amplifier stage operating on fixed bias, when the LOG-LIN toggle switch S-4 is in the LIN position, to give linear output. With S-4 in the LOG position, an AVC bias is derived from the d-c output of the metering crystal X-2 which varies the gain in VT-3. The output of the tube is then in approximate logarithmic proportion to the input.

6. Second IF amplifier. This stage of i-f amplification, utilizing VT-4, is of the usual type. It has an adjustable gain control R-24, operated by the GAIN knob on the panel. The purpose of this control is to set the overall gain of the receiver during the calibration procedure mentioned at the beginning of these paragraphs.

7. Third IF amplifier. This is a straight i-f stage with no AVC or gain control, and from which maximum output is obtained at all times to drive the crystal rectifier circuit.

8. Crystal rectifier. The output of the third i-f stage is coupled to the crystal circuit. The use of a crystal, in place of a thermionic rectifier, makes accuracy independent of battery voltages. The crystal circuit is such as to swamp out variations due to temperature. The rectified output of the crystal X-2 is fed directly to the meter through R-20. The crystal output is also capacity-coupled to the PHONES jack J-1 on the front panel, into which a high-impedance headset may be plugged for assistance in identifying the signals being checked.

9. Calibrating oscillator. The oscillator tube VT-6 is operated on a separate set of batteries. The circuit is of the inductive feedback type. The metering crystal, X-1, is connected across the grid and cathode of the tube and prevents the grid from going positive at any time. The grid circuit is tuned by C57, which is coupled to the CALIBRATING OSCILLATOR control on the panel.

The tuned circuit of the oscillator is designed with a high Q factor. The output of the oscillator is taken off the grid through a high resistance R-33, R-35. This produces minimum loading on the circuit, and the output waveform is practically free of harmonics.

After passing R-33, R-35, the oscillator output is divided into two paths:

(1) An r-f path through C-54 which injects the r-f voltage into the loop circuit.

(2) A d-c path to ground through R-26, R-27, and R-28. The rectifying action of the crystal X-1 provides the d-c component of the output and a tap on R-27 feeds the measuring voltage to the panel meter M-1 when the METER switch S-2 is set on OSC. Since the oscillator output is relatively free from harmonics, the meter reading is a true indication of peak voltage of the fundamental oscillator frequency.

10. Switching system. In addition to the FULL SCALE RANGE switch, S-1, two other switching circuits are employed:

(1) METER switch, S-2, connects the meter, M-1, to the output of the receiver or of the calibrating oscillator, as desired. Four other positions of the switch connect the meter, through a suitable multiplier network, to permit reading voltages of the four sets of batteries used in the instrument.

(2) POWER switch, S-3, controls the voltage to the tubes: All tubes are off in the OFF position of the switch; the receiver circuits are on in the ON position; and both receiver and calibrating oscillator are on in the CAL position. A microswitch, S-5, is included in the receiver filament circuit to cut off the filaments when the cover of the meter is closed. However, S-3 must be placed in the OFF position to switch off the calibrator tube.

Installation

The Field Intensity Meter is shipped with all tubes in place, less batteries. Upon receipt of the instrument remove it carefully from its packing and examine for visible damage that may have occurred during shipment. Lay the instrument on its back and check the cover, to see that it opens freely and telescoping braces function. Examine panel and check all controls for free movement. Do not force any control that may stick.

1. Battery installation. Procure five 1.5-volt flashlight cells and two 67.5-volt B-batteries of any of the types listed below:

Quan.	Voltage	Type Numbers			Dimensions (inches)		
		RCA	Eveready	Burgess	Height	Width	Length
5	1.5	VS001	950	2	2 3/8	1 1/4 (dia.)	
2	67.5	VS016	467	xx45	3 11/16	1 5/16	2 11/16

Install the batteries as follows (Fig. 3):

a. FILAMENT (A) BATTERIES. Open the battery compartment lid on the rear of the instrument by releasing the two winged fasteners and swing the lid downward. Unscrew the two captive thumb screws holding the cover on the A-battery compartment mounted on the inner face of the lid. Place the five cells in the compartment with the positive center studs against the terminals located farthest from the hinge and with the bottom of the cells contacting the corresponding retaining springs at the other end. Replace the cover plate and tighten the thumb screws.

b. PLATE (B) BATTERIES. Withdraw the two pairs of wires from the battery compartment in the instrument proper. Connect each pair of wires to a separate battery. Insert the batteries into the spaces provided for them, close the lid on the battery compartment and fasten the two wing clamps.

2. Use of external power supply. When extended observations are to be made or when a recorder is employed, the use of an external power source is recommended. A six-pin receptacle is mounted on the rear of the case to facilitate the connection of external batteries or an a-c power supply unit. The

wiring details of the plug terminals are shown in the schematic diagram. An Amphenol No. 91MPF6L plug is required to make this connection.

To convert the meter from internal to external battery operation, remove the internal A and B batteries and tape up the B-battery connectors individually to prevent shorting to the case. Connect the external batteries to the plug as shown in the schematic diagram, Fig. 6.

For using an a-c power supply unit, refer to the instructions which accompany that unit.

3. Use of recording equipment. For recording field intensities, a pin jack is provided on the panel of the 120-D Field Intensity Meter which will supply 0.5 to 5.0 volts d.c. into a high-impedance input d-c amplifier which is necessary for the operation of a recorder over the range of the meter. Details of installation are furnished with the external amplifier and recording equipment.

Operation

The operation of the 120-D Field Intensity Meter may be divided into three procedures as follows:

a. Checking battery voltages (see paragraph 1)

b. Meter calibration (see paragraph 2)

c. Measuring signal strength (see paragraph 3)

1. Checking battery voltages. The voltage of the batteries should be checked before taking the meter into the field, and it is advisable to replace them before starting a series of measurements if voltages are approaching the minimum permissible value given in the following procedure.

To check battery voltages proceed as follows:

a. Open cover of meter.

b. Move POWER switch to CAL position.

c. Place the meter switch successively in positions AR, BR, AC, and BC, and check that the panel meter indication is within the area of the green band between the "5" and "7" marks on the meter scale. The lower limit of this band corresponds to 1.1 volts for the "A" batteries and to 50 volts for the "B" batteries.

2. Meter calibration. The meter should always be calibrated at the frequency of the signal to be measured, to eliminate any error due to frequency-sensitive components in the circuits. The procedure is as follows:

a. Set up the meter on a flat support or a unipod at the point where signal strength is to be measured. A unipod is preferred to a tripod since the meter can be readily pivoted on a unipod for null setting. Open the cover and swing the loop to a vertical position.

b. Turn POWER switch to ON and place LOG-LIN switch on LIN.

c. Set FULL SCALE RANGE switch to a value approximating the signal strength to be expected. Turn COARSE GAIN control about three-quarters on, and FINE GAIN control about one-half on (if the COARSE GAIN control were turned full on, it may not be possible to reduce the gain to a calibrate level with the FINE GAIN control). Changes in the COARSE GAIN control may have slight effect on receiver tuning; this should be checked before actually calibrating the gain. The FINE GAIN control has a sufficient range to take care of most gain variations. The COARSE GAIN control should require only occasional adjustment.

d. Place METER switch on FI.

e. Adjust RECEIVER tuning to frequency of signals to be measured. Approach the setting from right or left, as desired, to obtain maximum deflection on the meter.

LEAVE AT THIS SETTING FOR SUBSEQUENT CALIBRATION AND FIELD MEASUREMENTS. After signals are peaked, rotate instrument to get minimum meter indication.

NOTE: The instrument tunes very sharply and for maximum accuracy must be tuned carefully to peak response. On some instruments a slightly different meter reading may result, for mechanical reasons, when the resonance point is approached from different sides. If after peaking the tuning is left fixed during calibration and subsequent reading of field intensity, there will be no error in field strength measurements.

A high-impedance headset may be plugged into the PHONES jack to aid in identifying the signals, and left in the circuit while making measurement. When making readings on 910 kc, at low signal intensities with the instrument set at full gain, some trouble may be experienced due to the second harmonic of the intermediate frequency being coupled back to the loop through the headset cord. When this occurs the headset should be removed.

f. Move the FULL SCALE RANGE switch to CAL.

g. Turn POWER switch to CAL.

h. Tune the CALIBRATING OSCILLATOR until an indication is noted on the meter; maximize the deflection.

i. Move the METER switch to OSC position and note the meter deflection.

j. Return METER switch to FI position and adjust COARSE GAIN control to obtain about the same meter indication as in step i. Check by switching back and forth between the FI and OSC positions, adjusting the FINE GAIN control as required. With the COARSE GAIN control setting once established, it should be possible to calibrate by using the FINE GAIN control only.

k. Place METER switch in FI position and move POWER switch to ON position to switch off oscillator.

The meter is now calibrated for the frequency of the signals to which it was origianlly tuned.

3. Measuring signal intensity. With the instrument in position and calibrated for the frequency of the signal to be measured, proceed as follows:

a. Set METER SCALE RANGE switch to some value approximating signal intensity expected, and set LIN-LOG switch on LIN.

b. With POWER switch at ON, rotate instrument to orient loop and obtain maximum deflection on meter, moving METER SCALE RANGE switch if necessary to keep meter pointer on scale. Read field intensity direct from meter, using setting of FULL SCALE RANGE switch as a guide to meter scale values. For example, with the METER SCALE RANGE switch on 100 MV, for which setting the full-scale reading of 10 on the meter means 100 millivolts per meter, a reading of 2.3 indicates a field intensity of 23 millivolts per meter.

4. Operating procedure summary. Use of the Field Intensity Meter involves the three procedures described in paragraphs 1, 2, and 3, which may be summarized as follows:

a. Check voltages before starting a series of field intensity measurements.

b. Calibrate the meter when first set up and check calibration for each measurement.

c. Cut power off tubes by moving POWER switch to OFF immediately upon completing a measurement. This will increase battery life appreciably, for the instrument can be switched on and used instantly, no warm-up period being required.

5. Use of LOG-LIN switch. The LOG-LIN switch is normally in the LIN position for field intensity measurements to obtain meter deflections that are directly proportional to the signal intensity and permit direct reading of the values.

The LOG position of the switch is intended for use when an external d-c amplifier and recorder is used with the equipment. With the switch in the LOG position the effect is to compress the range of the output voltages, being relatively larger for weak signals and smaller for strong signals. Under this condition the rectified output voltage and meter indication are not directly proportional to the input intensity but to a power (log or db) of the field intensity.

The LOG position of the switch may be used to advantage when searching for weak signals, going over to LIN setting for making the actual field measurement.

6. Stopping equipment. When measurements have been completed, turn the POWER switch to the OFF position. Note that closing the lid of the instrument opens the microswitch S-5 and cuts current off

the receiver if POWER switch is accidently left on; but filament circuit of the oscillator is not protected if switch is left in the CAL position. Therefore, make certain POWER switch is OFF before closing cover.

Maintenance

Barring physical derangement due to accidental damage, replacement of batteries, cleaning of the loop contacts, and replacement of tubes or crystals should constitute the bulk of the required maintenance.

Since the loop is in a fairly high Q circuit, the contacts must be kept clean. Erratic operation of the instrument can quite often be traced to dirty loop contacts or plungers. These should be cleaned with carbon tetrachloride and then burnished with a piece of canvas or the paper side of a piece of sandpaper.

1. Tube replacement. Tubes should not be replaced or swapped around unless there is good reason to believe this is necessary. If a tube is replaced, one of RCA manufacture is recommended.

Tube failures may be divided into three classes; namely, complete failures (open filaments, etc.), noisy and erratic operation, and tubes that have served their useful life. Of these three classes, noisy and erratic operation will probably be the cause for most tube replacements.

An erratic or noisy tube can best be located by gently tapping on the tubes with a pencil or "tube tapper" while an unmodulated signal is being received. An audio amplifier will also help in locating the defective tube. Direct substitution is the best method to check a suspected tube. At times the whole instrument may seem to be erratic or microphonic, making it difficult to calibrate the instrument.

Transformer T-5 is adjusted for optimum linearity with the associated tube supplied. Replacing VT-5 may have some effect. A "weak" tube will not supply enough power in this stage to give acceptable linearity.

When replacing a tube under manual gain control (VT-4 and VT-2) it is well to check for an undesirable "cut off" characteristic. A simple method for this is to snap the associated GAIN control to minimum gain and note if the panel meter indication follows without appreciable drifting upscale. (This should not be confused with the symptoms of a bad receiver crystal.)

2. Crystal replacement. Crystal diodes are not uniform from unit to unit. Some crystals develop troubles for which no satisfactory explanation is known.

Type 1N34A crystals, as purchased, are specified to have certain characteristics. They are checked by impressing one volt in the forward direction and must pass a current of at least 5 ma. With fifty volts impressed in the reverse direction, the reverse current must be less than 0.8 ma. The back resistance varies over a wide range from one crystal to another. It is not so important that the crystal have comparatively high back resistance as it is that this resistance remain stable. Replacement crystals should be checked with particular reference to stable back resistance.

a. Calibrating Oscillator Crystal. In the calibrating oscillator, the crystal's back resistance is directly across the tank circuit. Any variation of back resistance in this crystal will produce an apparent drifting of the calibrating oscillator output and more often, also, a frequency change. This effect is greatest at the higher frequencies. This can best be checked by tuning in a signal at the high-frequency end of the band and zero-beating the calibrating oscillator against this signal. Turn the calibrating oscillator off for a few seconds, then switch it on. It should quickly zero-beat with the signal. All these details, actually, do not affect the accuracy of the field intensity meter very much, provided the calibrating oscillator is actually tuned to the frequency of maximum receiver response (the receiver is quite selective) when the GAIN control is adjusted for calibrate gain. If it is not, obviously erroneous readings will result. These will be high because too much gain will be used in the receiver. The replacement of a calibrating oscillator crystal will usually cause less than 2% change in calibration.

b. Receiver Crystal. The symptoms of a defective receiver crystal--that is, the voltmeter at the end of the i-f chain--are quite easy to recognize. With a steady signal (about midscale on the panel meter) from the calibrating oscillator or a broadcast station with negligible carrier shift, switch to the next higher attenuator step momentarily and then back to the original attenuator step. The meter reading should almost immediately return to its original indication. If it settles at another reading (usually higher) and then, over a period of a few seconds, drifts to its original reading, the receiver crystal's back resistance is drifting. This should not be confused with the momentary "overload" effect noted in some crystals, such as that caused by momentary switching to a lower attenuator step.

Another check of the same nature is to adjust the GAIN control for a full-scale indication on a steady signal and then switch to the next higher attenuator step. The meter reading should reach its final value without drifting upscale appreciably. A further check is to adjust for a meter indication on "1" and then switch to the next lower attenuator step. The meter reading should reach its final value without drifting downscale appreciably.

When the back-resistance drift of the receiver crystal is extremely bad, it will be almost impossible to calibrate the instrument. When the meter function switch is moved to the OSC position, the load is removed from the detector. When the switch is returned to the FI position, the meter reading will not repeat immediately but will drift.

A bad receiver crystal will affect the linearity of the instrument, particularly if the crystal has very low back resistance (usually accompanied by extreme drift in back resistance). Replacement of the defective crystal should correct the condition. If there has been any adjustment of the last i-f transformer after the original crystal went bad, the linearity of the instrument should be rechecked.

3. Alignment procedures. Experience indicates that under normal conditions the i-f stages are very stable and require no realignment. The receiver and calibrating oscillator trimmer condensers may require occasional "touching up." As the receiver is very selective, adjustment of the local oscillator trimmer necessitates adjustment of the R-F and loop trimmers. To obtain average conditions for the alignment procedures, it is desirable to use batteries that have dropped to about the center value of their useful range (center of green band on meter scale).

a. Normal Field Realignment

(1) Tune in a signal at a frequency of approximately 1500 kc and adjust for convenient indication on the panel meter.

(2) Adjust C-52 and RECEIVER tuning until dial indicates correct frequency at maximum indication on the panel meter.

(3) This step must be done with the FULL SCALE RANGE switch in the 10 MV position. Set signal generator to 1480 kc and tune the receiver for maximum indication. Adjust C-18 and C-1 for maximum indication on the panel meter.

(4) Tune in a signal of known frequency near the high-frequency end of the band. Set FULL SCALE RANGE switch to CAL. Turn on calibrating oscillator and set dial to read correct frequency. Adjust C-56 for zero beat.

b. Complete IF alignment

(1) With the FULL SCALE RANGE switch on 100 MV and the receiver tuned to the low-frequency end of the dial, away from any other signals, couple a 455-kc signal from an accurately calibrated signal generator to the loop on the instrument by means of a coil placed close to the loop.

(2) Adjust i-f transformers, in the following sequence, for peak reading on the panel meter, adjusting GAIN to keep the pointer as near full scale as is practicable:

T-5: Maximize C-46, then C-47. Recheck C-46, recheck C-47. Continue this procedure until no further increase in output can be obtained. C-46 is an impedance matching adjustment. Mean battery voltages are important for this adjustment. C-47 may require additional "touching up."

T-4: Adjust C-39 and C-40 alternately.

T-3: Adjust C-34 and C-35 alternately.

C-20: Located in the attenuator box.

c. Complete Receiver Local Oscillator Realignment

(1) Set RECEIVER tuning dial to 600 kc.

(2) Couple a 600-kc signal from a signal generator to the loop on the instrument by means of a coil placed close to the loop.

(3) Adjust core of local oscillator coil T-6 for maximum indication on the panel meter.

(4) Set signal generator and receiver tuning dial to 1500 kc.

(5) Adjust C-52 for maximum indication on the panel meter.

(6) Repeat steps (1) through (5) for final adjustment.

d. Complete RF and Loop Alignment

(1) The FULL SCALE RANGE switch must be in the 10 MV position for all RF and loop alignment. Couple the signal generator to the loop as in paragraph c above. 610 kc and 1480 kc are nominal tracking points. Alignment should be made at these frequencies unless there is interference from another signal.

(2) Set signal generator to 610 kc and tune in signal. Adjust GAIN for a convenient indication.

(3) Adjust core of r-f transformer T-1 for maximum indication on panel meter.

(4) Adjust core of loop loading coil L-2 for maximum indication on panel meter.

(5) Set signal generator to 1480 kc and tune in signal. Adjust GAIN for a convenient indication.

(6) Adjust C-18 for maximum indication on the panel meter.

(7) Adjust C-1 for maximum indication on the panel meter.

(8) Repeat steps (2) through (7) until no readjustment is required.

e. Complete Calibrating Oscillator Adjustment

(1) With FULL SCALE RANGE switch on CAL, tune in a signal at 600 kc.

(2) Set calibrating oscillator dial to 600 kc.

(3) Adjust core of T-7 for zero beat.

(4) Tune in a signal at 1500 kc.

(5) Set calibrating oscillator dial to 1500 kc.

(6) Adjust C-56 for zero beat.

(7) Recheck steps (1) through (6).

4. Linearity. Linearity of the instrument is specified as being within 3% of the indicated reading for "A" battery operating voltages from 1.5 to 1.1 volts and "B" battery operating voltages from 70 to 50 volts. Linearity has been adjusted and checked at 1.5 and 70 volts, 1.3 and 60 volts, and 1.1 and 50 volts with a precision 10-step attenuator.

5. Attenuators. The attenuating networks are adjusted at the factory with the aid of high-precision test equipment not usually available in the field.

IT IS RECOMMENDED THAT NO ADJUSTMENT OF THE ATTENUATORS BE ATTEMPTED IN THE FIELD. The substitution capacitor, C-4, plays an important part in the accuracy of the attenuators. It is the proper adjustment of this capacity that renders the attenuators frequency insensitive on the ranges below 100 MV full scale. Inspection of the schematic diagram will show that, when switching from the 100 MV to 10 MV full-scale range, the r-f attenuator is switched out. At this time the "arm" capacity of the r-f attenuator becomes part of the loop tuned circuit, replacing C-4. If these two capacities are not exactly equal, detuning, or more correctly a change of tuning, will result in the loop circuit. Tracking error between the receiver local oscillator and loop circuits makes this adjustment more critical, since the same tracking error must be maintained with the interchange of these capacities. It follows that all lower full-scale ranges would also be affected by a misadjustment of the substituting capacity.

Serious misalignment of the r-f end of the receiver may introduce some frequency error in the attenuator. Realignment as noted in paragraph 3a on "normal field realignment" should correct this.

The procedure used to initially adjust C-4 is quite lengthy and involved. No simple system that will give sufficient adjustment accuracy has been worked out. If this adjustment has been disturbed, even slightly, the instrument must be returned to the factory for readjustment.

For trouble shooting, a rough check of the attenuator ratios can be made by tuning in a signal, adjusting the GAIN control for a reading of 10, and switching to the next higher range. The meter indication should drop back to approximately 1 on the scale (within the tolerances of linearity and attenuator adjustments).

6. Removal of the chassis from the case.

a. Remove the screws holding the ends of the telescoping braces to the cover of the meter.

b. Remove the screws from the top, ends, and bottom of the case that hold the front panel and chassis assembly to the case.

c. Removal of the chassis from the case is now prevented by the three spring-loaded loop-contact plungers in back of the loop hinge. Press these studs down as far as possible and work the chassis out of the case. Do not apply excessive force in removing the chassis, which might stress the leads to the plug in the back of the chassis and bend the plug contacts.

7. Friction clutch on receiver and calibrating oscillator control knobs. Each of the RECEIVER and CALIBRATING OSCILLATOR control knobs includes a friction clutch to drive the corresponding graduated dial. If, due to wear, slippage should develop in either one of these clutches, loosen the set-screw on the shank of the knob by means of an Allen wrench and remove the knob from its shaft. Then tighten the hex locknut on the shaft (front face of instrument panel).

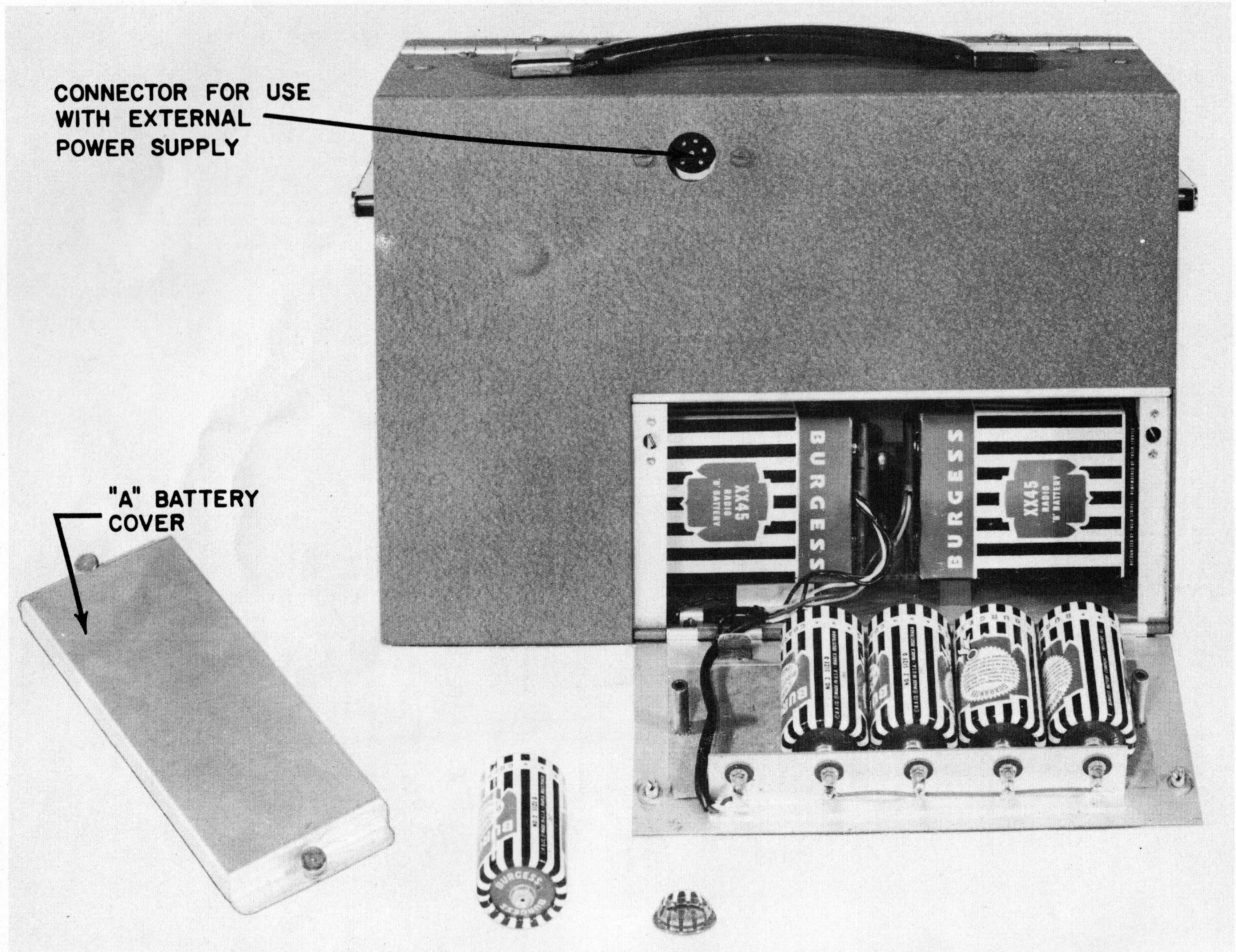

Fig. 3. Field Intensity Meter, Rear View, Battery Compartment Open

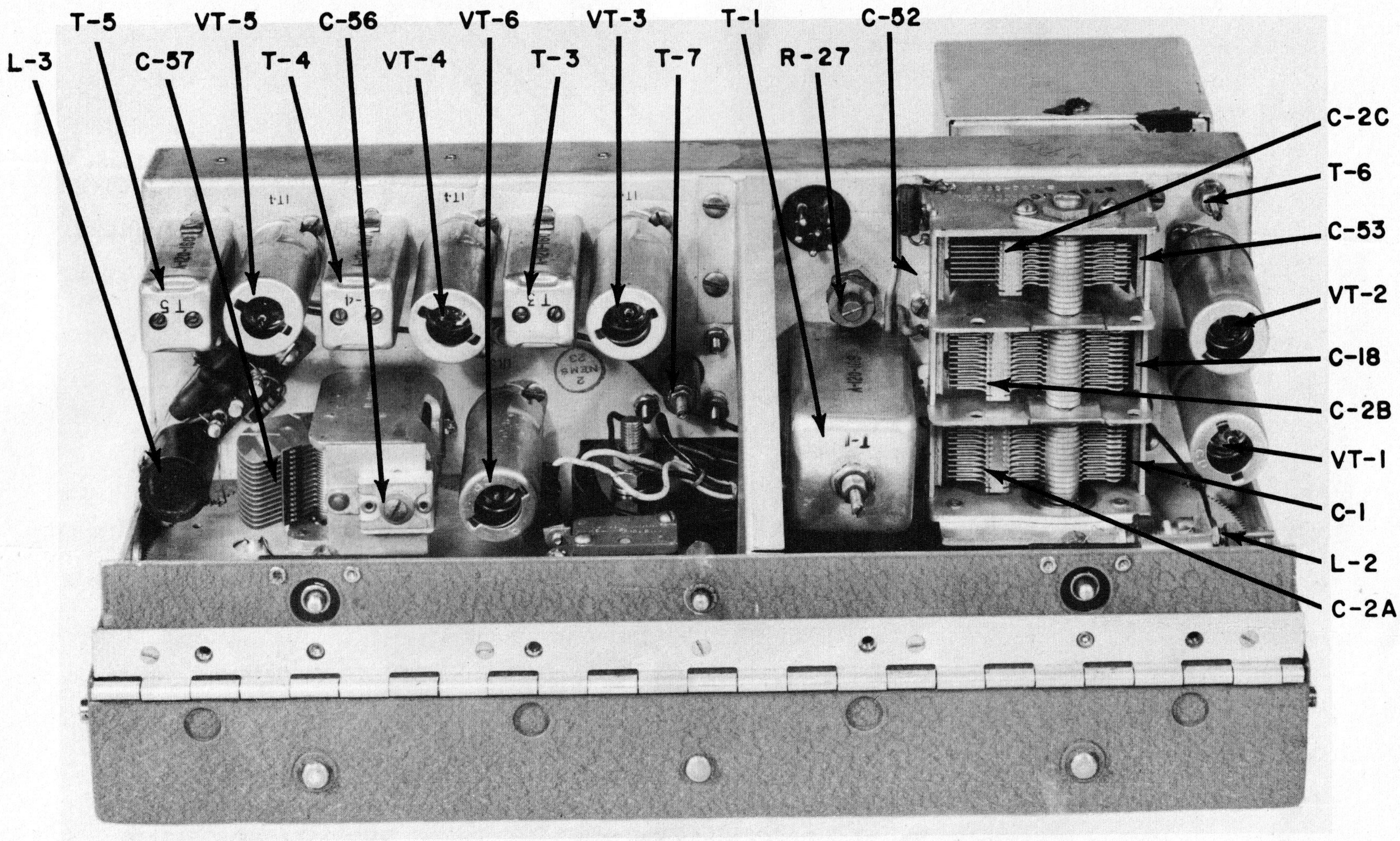

Fig. 4. Field Intensity Meter Chassis, Top Oblique View

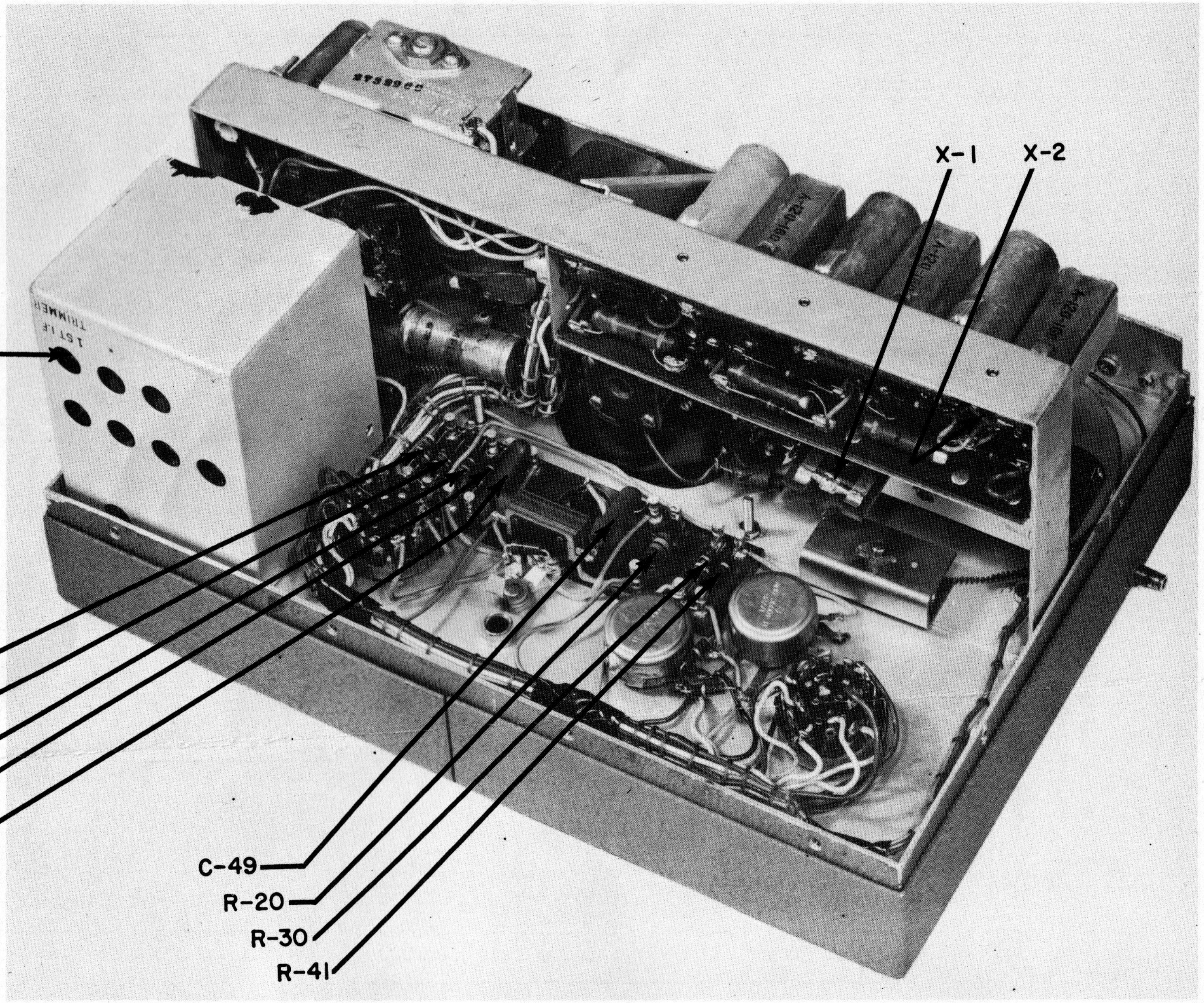

Fig. 5. Field Intensity Meter Chassis, Bottom Oblique View

PARTS LIST

Model 120-D Field Intensity Meter

When ordering replacement parts, give the equipment name and model number, and the symbol number and description of each item ordered.

Replacement parts which will be supplied against an order may not be exact duplicates of the original parts. However, only minor differences in the electrical or mechanical characteristics will be involved and, consequently, will in no way impair the operation of the equipment.

Symbol No.	Description
C-1	Capacitor: Variable, mica, 2-15 mmf, part of variable tuning capacitor C-2A, B, C
C-2A, B, C	Capacitor: Variable, calibrating oscillator, 3-gang tuning
C-3	Capacitor: Fixed, ceramic, 30 mmf, ± 5%
C-4	Capacitor: Variable, ceramic, 4-30 mmf
C-5	Capacitor: Fixed, mica (silvered), 50 mmf ± 5%
C-6	Capacitor: Variable, ceramic, 4-30 mmf
C-7	Capacitor: Fixed, mica (silvered), 70 mmf ± 5%
C-8	Capacitor: Variable, ceramic, 7-45 mmf
C-9	Capacitor: Fixed, mica (silvered), 70 mmf ± 5%
C-10	Capacitor: Variable, ceramic, 7-45 mmf
C-11, 12, 13	Capacitor: Fixed, ceramic, 10 mmf ± 10%
C-14	Capacitor: Fixed, paper, 0.1 mf
C-15, 16	Capacitor: Fixed, ceramic, 0.01 mf
C-17	Not used
C-18	Capacitor: Variable, mica, 2-15 mmf, part of variable tuning capacitor C-2A, B, C
C-19	Capacitor: Fixed, paper, 0.1 mf
C-20	Capacitor: Variable, ceramic, 4-30 mmf
C-21	Capacitor: Fixed, mica (silvered), 82 mmf ± 5%
C-22	Capacitor: Fixed, mica (silvered), 470 mmf ± 5%
C-23	Capacitor: Fixed, ceramic, 0.01 mf
C-24	Capacitor: Fixed, ceramic, 30 mmf ± 5%
C-25	Capacitor: Fixed, ceramic, 33 mmf ± 5%
C-26	Capacitor: Fixed, mica (silvered), 220 mmf ± 5%
C-27	Capacitor: Variable, ceramic, 7-45 mmf
C-28	Capacitor: Fixed, mica (silvered), 270 mmf ± 5%
C-29	Capacitor: Variable, ceramic, 7-45 mmf
C-30	Capacitor: Fixed, ceramic, 0.01 mf
C-31	Capacitor: Fixed, paper, 0.1 mf
C-32, 33	Capacitor: Fixed, ceramic, 0.01 mf
C-34, 35	Capacitor: Variable, mica, part of T-3
C-36	Capacitor: Fixed, ceramic, 500 mmf, 300 volts d.c.
C-37	Capacitor: Fixed, paper, 0.1 mf
C-38	Not used
C-39, 40	Capacitor: Variable, mica, part of T-4
C-41	Capacitor: Fixed, ceramic, 0.01 mf
C-42	Capacitor: Fixed, ceramic, 500 mmf, 300 volts d.c.
C-43	Capacitor: Fixed, paper, 0.1 mf
C-44, 45	Capacitor: Fixed, ceramic, 0.01 mf
C-46, 47	Capacitor: Variable, mica part of T-5
C-48	Capacitor: Fixed, ceramic, 22 mmf ±10%
C-49	Capacitor: Fixed, ceramic, 0.01 mf
C-50	Capacitor: Fixed, ceramic, 0.001 mf
C-51	Capacitor: Fixed, paper, oil filled, 0.1 mf
C-52	Capacitor: Variable, mica, 2-15 mmf, part of variable tuning capacitor C-2A, B, C

Symbol No.	Description
C-53	Capacitor: Fixed, ceramic, 20 mmf ± 10%
C-54	Capacitor: Fixed, ceramic, 0.01 mf
C-55	Capacitor: Fixed, ceramic, 500 mmf, 300 volts d.c.
C-56	Capacitor: Variable, mica, 5-30 mmf
C-57	Capacitor: Variable, air, 0-420 mmf, 27 plates, calibrating oscillator tuning
C-58	Capacitor: Fixed, mica, 500 mmf ± 20%
C-59	Capacitor: Fixed, paper, 0.1 mf
C-60	Capacitor: Fixed, ceramic, 0.01 mf
C-61	Capacitor: Fixed, mica, 50 mmf ± 20%
C-62	Not used
C-63	Capacitor: Fixed, ceramic, 30 mmf ± 5%
C-64, 65, 66, 67, 68, 69	Not used
C-70	Capacitor: Fixed, ceramic, 500 mmf, 300 volts d.c.
C-71	Capacitor: Fixed, ceramic, 500 mmf, 300 volts d.c.
J-1	Jack: Open circuit
J-2	Jack: Single contact pin
L-1	Loop: Antenna and cover
L-2	Coil: Antenna loading
L-3	Coil: Loop injection coil assembly
L-4, 5, 6, 7, 8, 9	Coil: Choke, filament decoupling
L-10, 11	Not used
L-12	Coil: First i.f., tuned by C-20, part of attenuator
M-1	Meter: 200 microamperes, logarithmic scale
R-1	Resistor: Fixed, composition, 3.3 meg. ± 10%, 1/2 W
R-2	Resistor: Fixed, composition, 4.7 meg. ±10%, 1/2 W
R-3	Resistor: Fixed, composition, 33,000 ohms ± 10%, 1/2 W
R-4	Resistor: Fixed, composition, 47,000 ohms ± 10%, 1/2 W
R-5	Resistor: Fixed, composition, 1000 ohms ± 20%, 1/2 W
R-6	Resistor: Fixed, composition, 100,000 ohms ±10%, 1/2 W
R-7	Resistor: Fixed, composition, 2200 ohms ±10%, 1/2 W
R-8, 9	Resistor: Fixed, composition, 1 meg ± 10%, 1/2 W
R-10	Resistor: Fixed, composition, 3.3 meg. ± 10%, 1/2 W
R-11	Resistor: Fixed, composition, 10,000 ohms ± 20%, 1/2 W
R-12	Resistor: Fixed, composition, 1000 ohms ±20%, 1/2 W
R-13, 14	Resistor: Fixed, composition, 1 meg. ±10%, 1/2 W
R-15	Resistor: Fixed, composition, 1000 ohms ±20%, 1/2 W
R-16	Resistor: Fixed, composition, 1 meg. ± 10%, 1/2 W
R-17	Resistor: Fixed, composition, 10 meg. ± 10%, 1/2 W
R-18	Resistor: Fixed, composition, 1000 ohms ± 20%, 1/2 W
R-19	Not used
R-20	Resistor: Fixed, composition, 27,000 ohms ± 5%, 1 W
R-21	Resistor: Fixed, composition, 1 meg. ± 10%, 1/2 W
R-22	Resistor: Fixed, composition, 220 ohms ± 10%, 1/2 W
R-23	Resistor: Fixed, composition, 820 ohms ± 10%, 1/2 W
R-24	Resistor: Variable, composition, gain, 2500 ohms
R-25	Not used
R-26	Resistor: Fixed, composition, 2700 ohms ± 5%, 1/2 W
R-27	Resistor: Variable, composition, 5000 ohms
R-28, 29	Resistor: Fixed, composition, 2200 ohms ± 10%, 1/2 W
R-30	Resistor: Fixed, composition, 560,000 ohms ± 5%, 1/2 W (paralleled as required)
R-31	Resistor: Fixed, composition, 12,000 ohms ± 10%, 1/2 W (paralleled as required)
R-32	Resistor: Fixed, composition, 560,000 ohms ± 5%, 1/2 W (paralleled as required)
R-33	Resistor: Carbon deposited, 50,000 ohms ± 10%
R-34	Resistor: Fixed, composition, 4.7 meg. ± 10%, 1/2 W
R-35	Resistor: Carbon deposited, 50,000 ohms ± 10%
R-36	Resistor: Fixed, composition, 22 meg. ± 10%, 1/2 W
R-37, 38, 39	Not used

Symbol No.	Description
R-40	Resistor: Fixed, composition, 4.7 meg. ± 10%, 1/2 W
R-41	Resistor: Fixed, composition, 2200 ohms ± 10%, 1/2 W
R-42	Resistor: Variable, composition, 10,000 ohms
R-43	Resistor: Fixed, composition, 1500 ohms ± 10%, 1/2 W
S-1A	Switch: Wafer only, ceramic, single circuit, 6 position
S-1B	Switch: Wafer only, ceramic, single circuit, 6 position
S-1C	Switch: Wafer only, ceramic, single circuit, 6 position, shield section
S-1D	Switch: Wafer only, ceramic, single circuit, 6 position
S-2A, B	Switch: Meter selection, 2 pole, 6 position
S-3A, B, C, D	Switch: Power, 4 pole, 3 position (shorting)
S-4	Switch: SPDT, toggle, A.V.C.
S-5	Switch: Micro, double-throw, A-C ratings 110 volt A.C, 10 amps.; 220 volt A.C., 5 amps., frequency 60-400 c.p.s.
T-1	Transformer: Radio-frequency
T-2	Not used
T-3, 4, 5	Transformer: I.F.
T-6	Coil: Local oscillator
T-7	Coil: Calibrating oscillator
X-1, 2	Crystal: Rectifier, 1N34A
	Block: Latch (end), Part/Dwg. A-120-125
	Clip: B battery, Part/Dwg. A-120-105
	Clip: Battery, Part/Dwg. A-120-101
	Detent: Attenuator switch detect assembly, 6 position
	Door: Back
	Knob: Main tuning cond. (large) (special), 1-5/8" O.D. with 3/8" I.D. insert, 2 1/16" dia. skirt, attached with 3 BH screws, C-bored 0.625 x 0.19
	Knob: Coarse gain control (small) (round), fits 1/4" shaft, set screws
	Plunger: Antenna contact, Part/Dwg. A-120-111
	Screw: Latch, Part/Dwg. A-120-121
	Screw: Thumb, Part/Dwg. A-120-141
	Shaft: Latch, Part/Dwg. A-120-126
	Spring: Latch, Part/Dwg. A-120-127
	Spring: Antenna contact, Part/Dwg. A-120-112
	Tube: Latch assembly, Part/Dwg. A-120-124

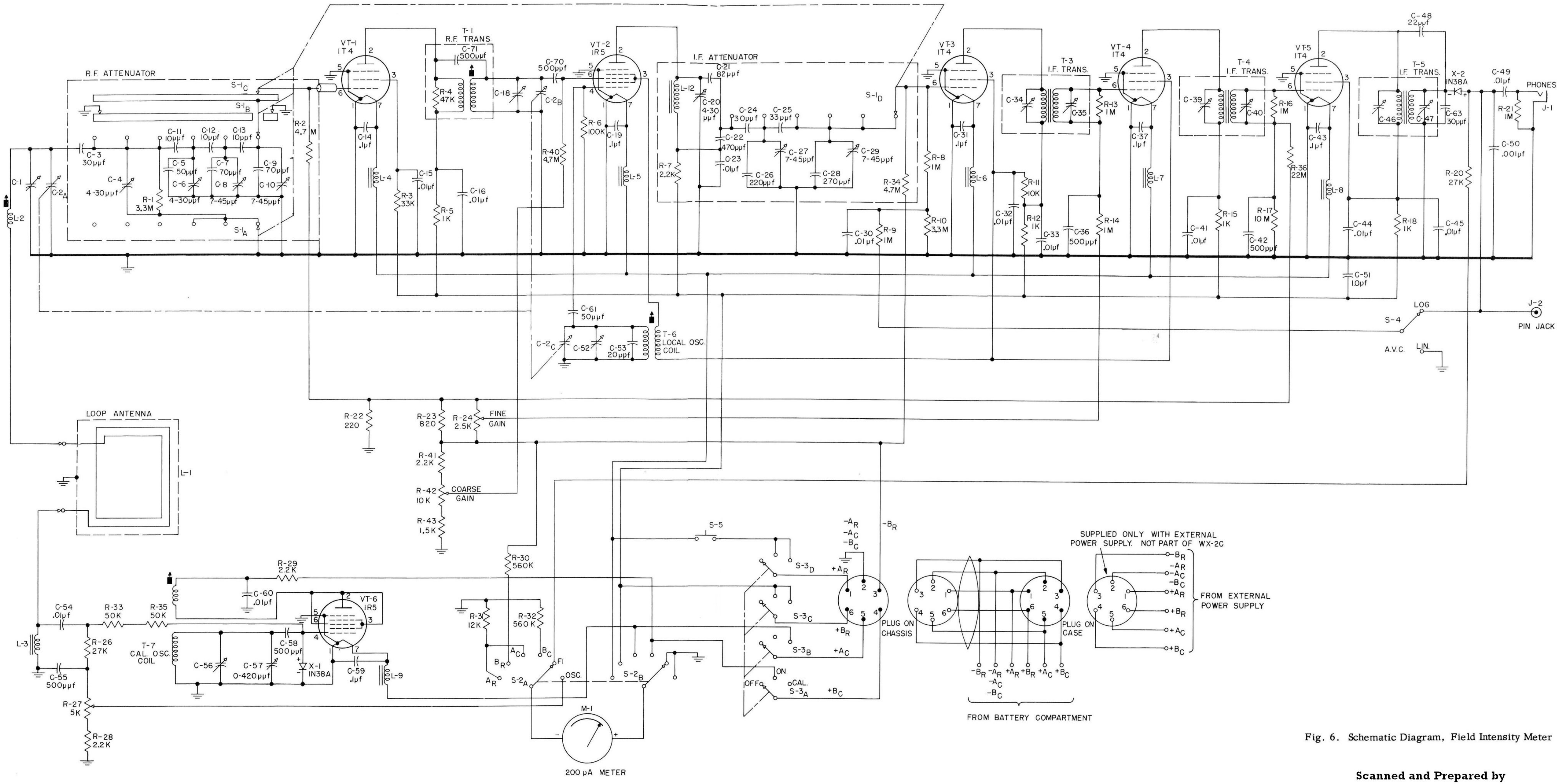

Fig. 6. Schematic Diagram, Field Intensity Meter

Scanned and Prepared by
Dale H. Cook