INSTRUCTION MANUAL
HVI-582

THE AUTOMATIC TRACKING NMR FLUXMETER

HIGH VOLTAGE ENGINEERING CORPORATION
BURLINGTON, MASSACHUSETTS
6603

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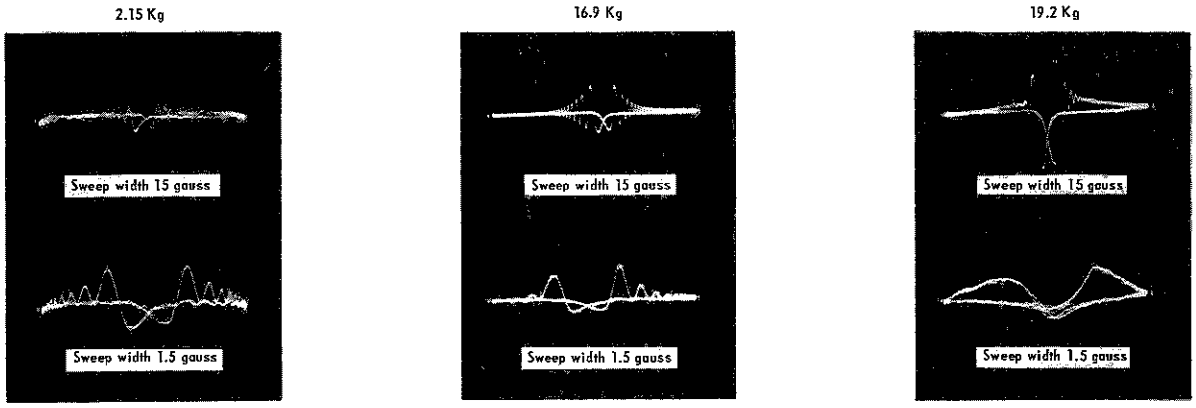
REFERENCE

Number	Title	HVEC Designation
1	CONVERSION TABLE: FREQUENCY TO FLUX DENSITY	HVI-1088

TYPICAL DISPLAY



Activates a rotary solenoid which turns the band change switch, selecting the proper oscillator and radio-frequency amplifier tuning coils.

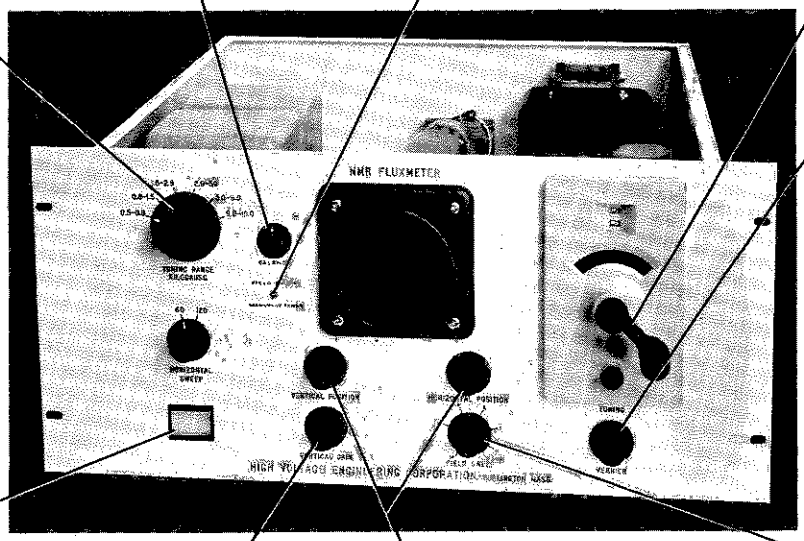
Compensates for circuit asymmetry or power line waveform distortion.

Operating Mode Selector Switch

MANUALLY TUNED: Used to locate a resonance point in any one of the fluxmeter's six bands.

FIELD LOCKED: Used to lock the fluxmeter frequency after a resonance point had been located.

Varies the frequency between the limits indicated on the TUNING RANGE KILOGAUSS selector. The motor will tune the oscillator over any one of the six ranges in one minute.



Connects the horizontal deflection plates of the CRT to the power line frequency or twice the power line frequency.

At power line frequency the pip on the CRT is easier to tune. At twice the power line frequency, two nearly superimposed images will be formed. A very high degree of resolution is possible with the switch in this position.

A ten-turn potentiometer which varies the voltage on a voltage-variable capacitor.

Power Control Pushbutton

A narrow sweep will improve the resolution of the display but will make it difficult to find the pip. A wide sweep will reduce the amplitude. Generally the sweep most convenient is 15 gauss on the highest flux range and 3 gauss on the lowest range. Once the pip has been located the sweep width should be adjusted for best resolution.

— NOTE —

Calibration must be divided by two when the horizontal sweep control is in the twice power line frequency position.

Homogeneity of the magnetic field, amount of field modulation used, and the signal-to-noise ratio of the oscillator all influence the size of the display.

Moves the Resonance Display on the CRT

1929

FIGURE 1. THE DISPLAY AND CONTROL UNIT

SECTION I -- INTRODUCTION

1. GENERAL

The Automatic Tracking NMR Fluxmeter, designed and manufactured by High Voltage Engineering Corporation, is a precision instrument capable of accurately measuring magnetic flux densities from 500 gauss to 19 kilogauss. This instrument utilizes the basic principle of nuclear magnetic resonance to determine the strength of magnetic fields. It is designed for laboratory use and is compatible with existing Van de Graaff controls. Six frequency bands are provided for higher resolution. In addition, an automatic tracking feature allows the fluxmeter frequency to be locked when a resonant point is located in any one of the six bands. In this way, the fluxmeter provides a more reliable and continuous indication of field strength by following the changes in the magnetic field of the selected band.

2. DESCRIPTION

Major components of the precision fluxmeter are: a sensing probe, an oscillator unit, a display and control unit, and a 100-foot cable for interconnecting the oscillator and control units. Optional components include: a frequency counter, a 100-foot coaxial cable for interconnecting the counter and oscillator units, and cable lengths up to 300 feet for interconnecting the oscillator and control units.

a. THE PROBE

The probe contains a proton-rich nuclear sample enclosed in a solid mechanical structure which permits the measurement of the magnetic field of a magnet to within 1/2-inch of the beam path over the entire flux density range. The rigidity of the structure makes the probe noise-free. Three coils are located within the probe. Two of these coils operate in conjunction with mechanically-driven switching contacts in the oscillator unit to provide proper band selection; the remaining coil is used for modulation purposes. The probe is available in three lengths: 19.5 in., 25.5 in., and 31.5 in.

b. THE OSCILLATOR

The oscillator is a self-contained unit especially designed to sense small changes in the absorption energy of the nuclear sample. It has a frequency range of 2 to 81 megacycles and has six bands over that range corresponding to the magnetic flux densities of 0.5 to 19 kilogauss. Amplitude control of the oscillator is accomplished by a regulator circuit that is designed to maintain the amplitude of the oscillator at a very low level, providing maximum sensitivity of the unit. The oscillator is remotely tuned from the display and control unit.

c. THE DISPLAY AND CONTROL UNIT

The display and control unit contains the entire complement of controls required to operate the fluxmeter. The function of each of these controls is identified in Figure 1, page 0 .

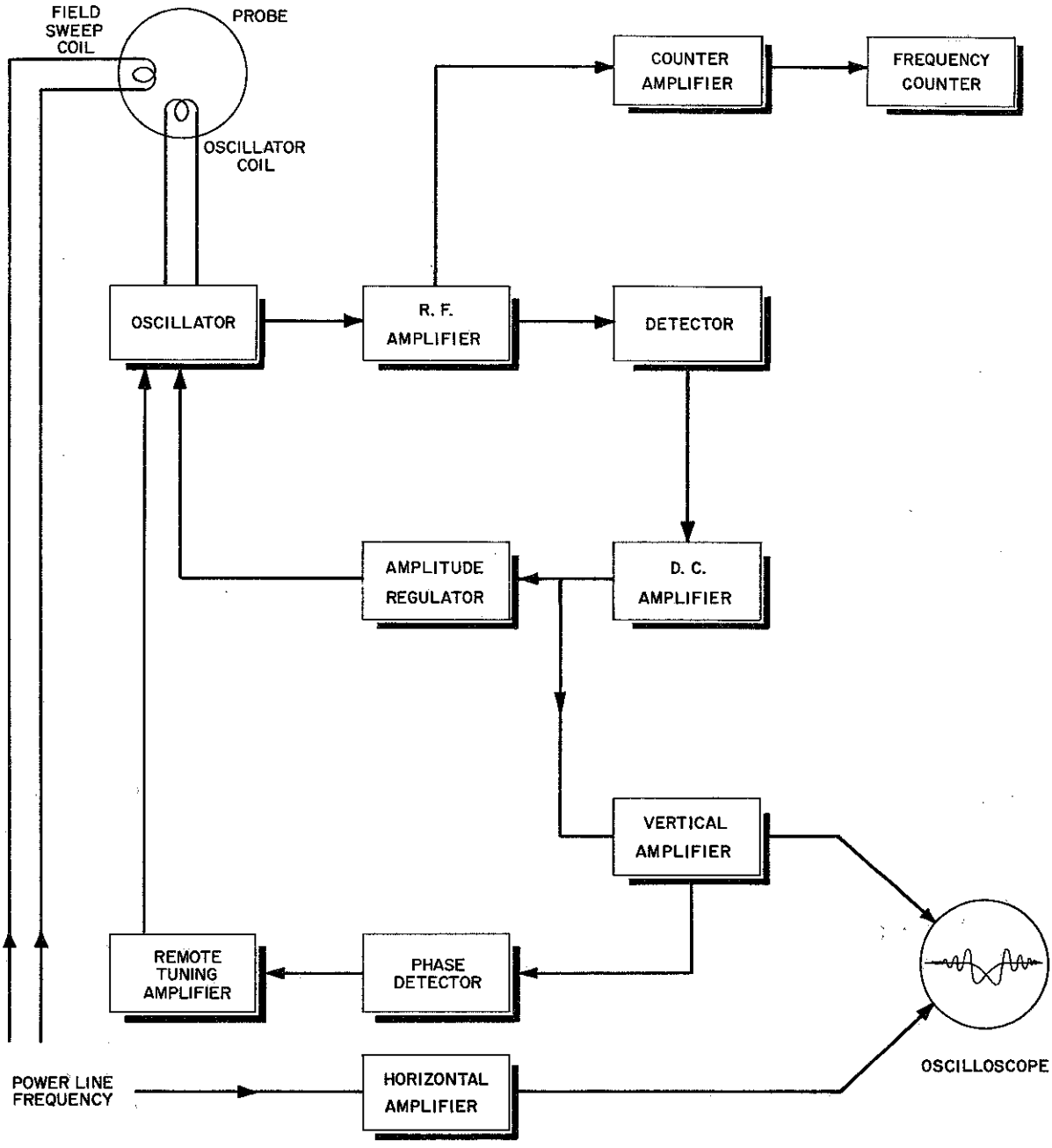


FIGURE 2. BLOCK DIAGRAM

3. FUNCTIONAL DESCRIPTION (Refer to Figure 2, page 2 .)

a. Part of the oscillator-tuned circuit is immersed in the proton-rich solution at the end of the probe. This small coil serves to couple the oscillator energy to the precessing protons.

b. This same small sensing coil is connected through a tuned radio frequency amplifier to a detector and then through a direct-coupled amplifier back to the oscillator. The gain and phase of these circuits permit the amplitude of oscillation to be maintained at a very low level. The oscillator is operated in this "marginal state" and thus the sensitivity is very high.

c. The output of the direct-coupled amplifier is connected through audio amplifiers to the vertical deflection plates of the cathode ray tube, providing a visual indication of the resonance phenomenon.

d. The output of the audio amplifiers is also connected to a phase-sensitive detector which provides an error signal for the remote tuning amplifier and serves to maintain the display centered on the oscilloscope screen.

e. Located within the probe and surrounding the oscillator coil is the field sweep coil. This coil modulates the magnetic field in the vicinity of the oscillator coil. The very narrow absorption band width makes it very difficult to tune through resonance without the aid of this modulating coil. The modulation frequency is 50 or 60 cps with a maximum sweep width of 15 gauss.

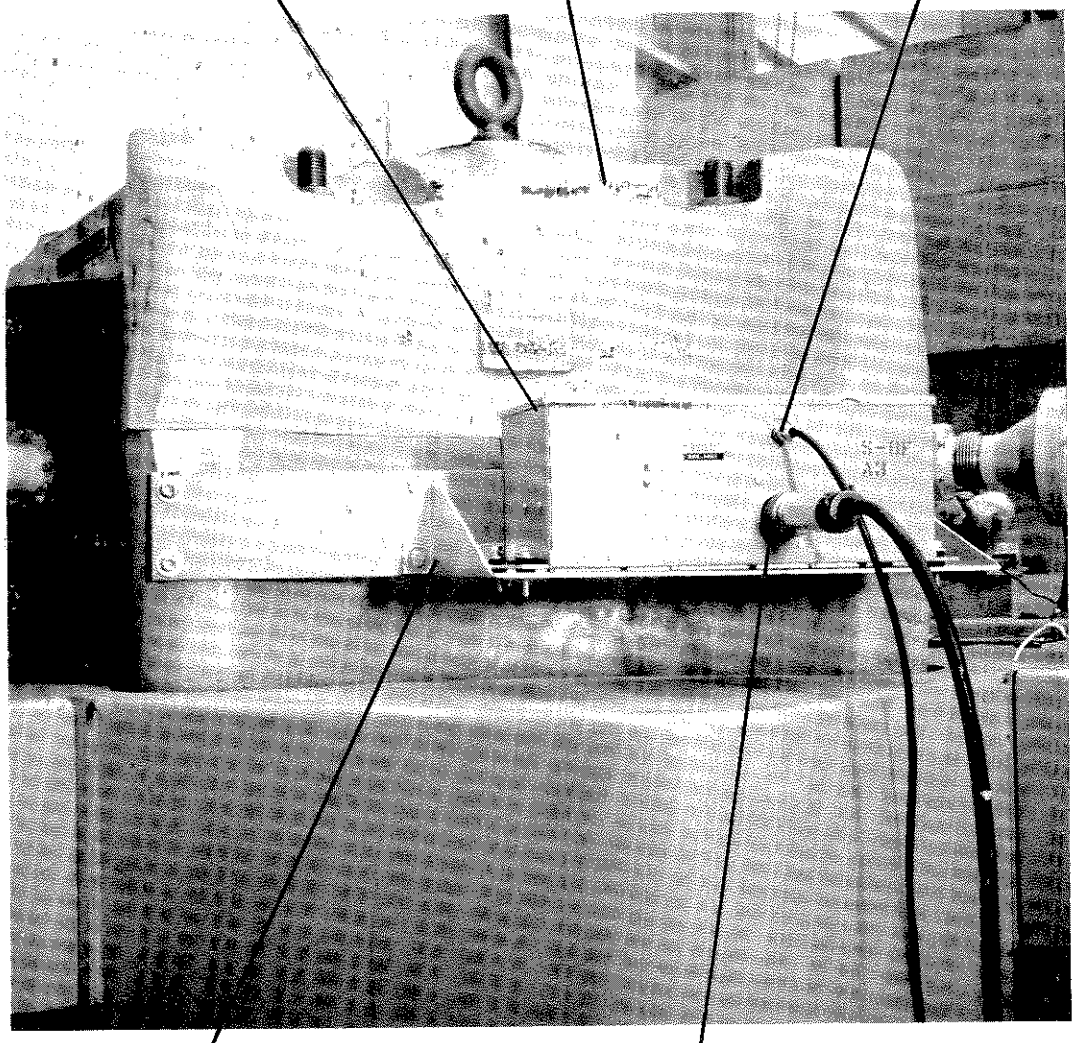


FIGURE 3. TYPICAL INSTALLATION — NMR OSCILLATOR

SECTION II -- INSTALLATION

1. GENERAL

The display-and-control unit is equipped with chassis slides intended for installation in a 20-inch-deep cabinet such as the Emcor series FR-24A through FR-28A. These slides should be mounted in accordance with the manufacturer's (Chassis-Trak, Inc.) drawing C-300-B-20.

2. INSPECTION

The equipment should be thoroughly inspected immediately upon receipt. If the equipment is damaged in any way, notify the carrier and the HVEC Service Department.

3. INSTALLATION PROCEDURE (Refer to Figure 3, page 4 .)

a. Insert the probe into the magnet as far as possible.

> NOTE: When positioning the probe within the magnet, keep in mind that the center of the sensing coil is located one-half of an inch from the end of the probe, and that it is important that the magnetic field be perpendicular to the large face of the probe.

b. Install the multi-conductor interconnecting cable between connector J-01 of the oscillator unit and connector J-01 of the display-and-control unit.

> NOTE: Keep the oscillator unit insulated from ground. If the oscillator unit is grounded, the CRT image will become distorted and it will be difficult to obtain a good resonance display.

c. Install the coaxial cable between connector J-02 of the oscillator unit and the INPUT connector of the frequency counter.

d. Connect the frequency counter and display-and-control unit to a 105-125V, 50-60 cps power source.

e. Energize the magnet and the NMR Fluxmeter system.

f. Move the probe around between the pole faces of the magnet until a point is located which provides the greatest amount of ringing and the greatest amplitude. (Refer to the waveforms shown in Figure 1.)

> NOTE: Since the magnetic field is least uniform at the highest flux density, the probe should be positioned with the magnet current at its maximum value.

g. Set the FIELD LOCKED/MANUALLY TUNED switch to the MANUALLY TUNED position. Locate the resonance and center it on the screen. Reset the FIELD LOCKED/MANUALLY TUNED switch to the FIELD LOCKED position. If the display does not lock to the center of the screen, reverse the field sweep phase, using the POLARITY REV. switch located inside the display-and-control unit (refer to Figure 4, page 10) and relocate and lock the resonance display on the screen. If the display still fails to lock, increase the sweep width and repeat this entire step until the correct position of the POLARITY REV. switch has been determined.

h. Reset the FIELD LOCKED/MANUALLY TUNED switch to the MANUALLY TUNED position. Rotate the TUNING control in a clockwise direction and observe that the display on the screen moves from left to right. If the display does not move from left to right, reverse the connections to the horizontal deflection plates at terminal board TB-09. (Refer to Figure 4, page 10.)

i. After the probe has been positioned within the magnet so as to provide optimum operational results, the oscillator unit may be permanently mounted.

(1) Mount the oscillator through the four grommets contained in the heavier of the two cover panels. These two panels are interchangeable but it is preferable to retain the heavier one on the side nearest the small connector, thus allowing tube replacement without removing the oscillator from its mount.

(2) When mounting the oscillator, place the plastic spacers (provided) beneath the grommets.

SECTION III -- OPERATION

1. OPERATION

a. Press the power switch. After a few minutes a horizontal line will appear on the oscilloscope face.

b. Set the HORIZONTAL SWEEP switch to 60.

c. Set the magnet power supply to a value close to the required flux density of the magnet.

d. Set the TUNING RANGE switch to the flux range corresponding to the magnet setting.

e. Set the FIELD SWEEP control to the optimum position. This optimum setting will be near 15 for the upper three ranges of the fluxmeter and near 5 for the lower three ranges.

> NOTE: Experience will show the optimum sweep widths for the various bands. Generally lower flux densities require narrower sweep widths.

f. Set the FIELD LOCKED/MANUALLY TUNED switch to the MANUALLY TUNED position.

g. Set the VERTICAL GAIN control for approximately 1/16-inch of "grass" on the face of the oscilloscope.

h. Turn the TUNING control slowly from one extreme to the other until resonance is observed.

i. After the display is centered on the oscilloscope, set the FIELD LOCKED/MANUALLY TUNED switch to the FIELD LOCKED position. Set the HORIZONTAL SWEEP control to 120 and adjust the BALANCE control until the two displays coincide. The fluxmeter will now follow changes in the magnetic field, provided that they are not made too abruptly.

2. FREQUENCY DETERMINATION

a. An approximate determination of the NMR oscillator frequency may be made by connecting a signal generator (e.g., Measurements Corporation Model 80 or a generator capable of supplying 0.1 volt) to the counter output jack J-02 on the oscillator and tuning for a resonance display on the CRT.

b. More accurate frequency measurements may be gained by the use of a frequency counter. The counter must have a sensitivity of 0.1 volt. A complete listing of the NMR oscillator frequencies and their corresponding magnetic flux densities is given in HVI-1088, Reference No. 1, addended.

NOTES: Before taking a frequency measurement, make the two CRT images coincide by adjusting the magnet current or the NMR oscillator.

The most accurate frequency determination is obtained when the HORIZONTAL SWEEP control is in the 120 position.

SECTION IV -- MAINTENANCE

1. GENERAL

The following tubes may be used as emergency substitutes in the oscillator:

ORIGINAL EQUIPMENT	EMERGENCY SUBSTITUTE
7788	7737 (Amperex) or 6688
5751	12AX7
6922	*12AU7 or *5963
*These tube types will not operate in the 9-19 kG range.	

2. ADJUSTMENTS

a. THE DISPLAY AND CONTROL UNIT

Adjustments for this unit are shown in Figure 4, page 10.

b. THE OSCILLATOR

Located within the oscillator unit is a rectilinear potentiometer (R-06). This potentiometer controls the gain of the direct-coupled feed-back amplifier in the oscillator amplitude regulating circuit. Normal servicing should not require adjustment of this control and it is not advisable to adjust it until the diode and electron tubes are checked and the unit is inspected for dirt or mechanical damage. If adjustment appears necessary:

(1) Connect a VTVM (100 V dc range) to pin 1 of V-01.

(2) Set the TUNING RANGE KILOGAUSS control on the display-and-control unit to the 9.0-19.0 kG range.

(3) Turn the TUNING control clockwise. The voltage indicated on the VTVM should reach a low of 7.5 volts somewhere in the band, not necessarily at the extremes.

(4) At the low voltage point in the band, shunt the coil L-06 with a 50-ohm resistor. The voltage indicated on the VTVM should rise to approximately 75 volts. If these low-point voltages are either too high or too low, adjust R-06.

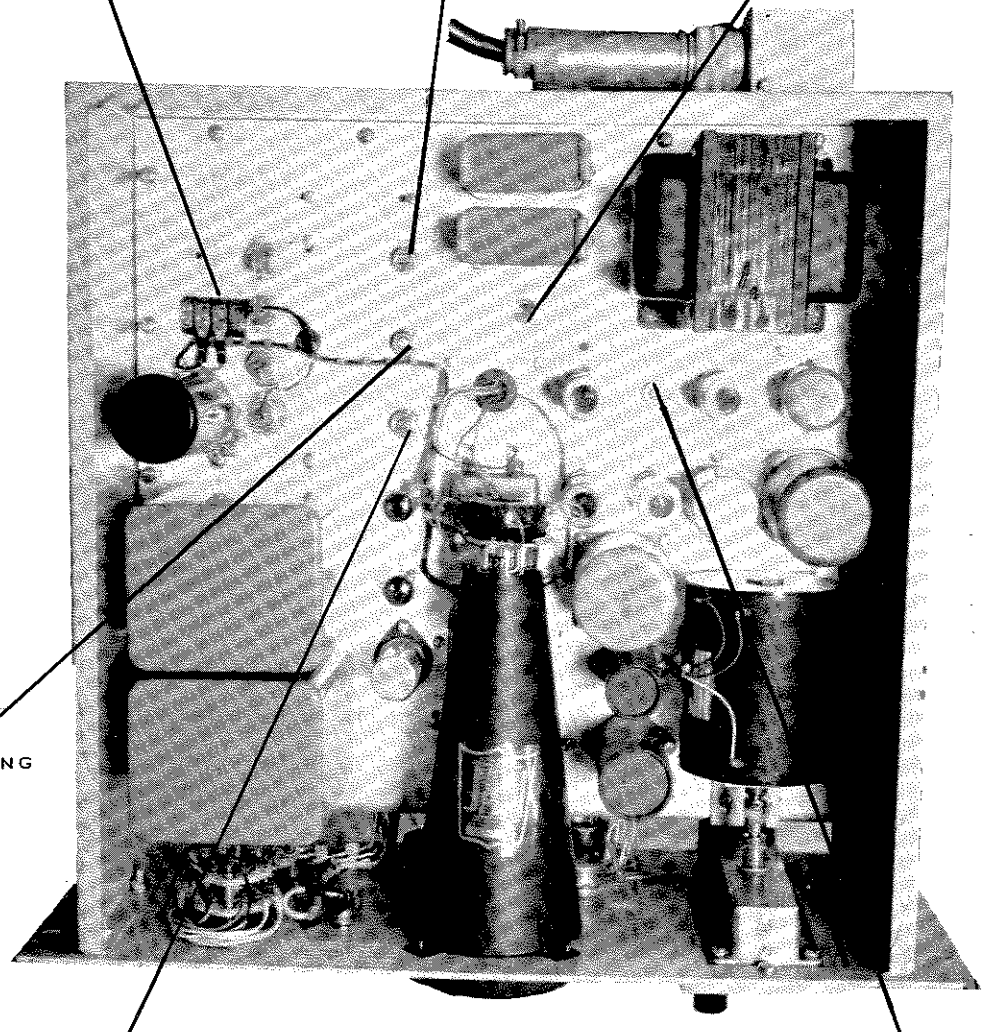


FIGURE 4. DISPLAY AND CONTROL UNIT ADJUSTMENTS

TABLE 1. VOLTAGE AND RESISTANCE CHART

TYPICAL VOLTAGE AND RESISTANCE MEASUREMENTS ON THE DISPLAY AND CONTROL UNIT

ELECTRON TUBE DESIGNATION NUMBER	PIN NUMBER	VOLTAGE*	RESISTANCE**
V-01	1		∞
	2		800 K
	3		800 K
	4		600 K
	5		∞
	6		0
	7		2M
	8		0
	9		0
	10		3 M
	11		∞
	12		∞
V-02	1	+84	1.1 M
	2	0	3.5 K
	3	+1.1	22 K
	4	3 V ac	0
	5	3 V ac	0
	6	+71	1 M
	7	0	0 to 1 M
	8	0	10 K
	9	3 V ac	0
V-03	1	+33	1 M
	2	0	1 M
	3	+1.5	10 K
	4	3 V ac	0
	5	3 V ac	0
	6	+33	1 M
	7	0	1 M
	8	+1.5	10 K
	9	3 V ac	∞
V-04	1	275 V ac	350
	2	-2.3	69 K
	3	+4.2	196
	4	3 V ac	0
	5	3 V ac	0
	6	+4.2	196
	7	-2.8	69 K
	8	3 V ac	0
	9	275 V ac	350
V-05	1	275 V ac	350
	2	-2.3	69 K
	3	+4.2	196
	4	3 V ac	0
	5	3 V ac	0
	6	+4.2	196
	7	-2.8	69 K
	8	3 V ac	0
	9	275 V ac	350
V-06	1	- 150	2 M
	2	- 150 V dc	8 K
	3	- 150 V dc	8 K
	4	- 150 V dc	8 K
	5	+ 40 V dc	85 K
	6	+ 130 V dc	8K to 38 K (2)
	7	- 145 V dc	10.7 K
V-07	1	0	200 K
	2	0	0
	3	3 V ac	0
	4	3 V ac	0
	5	+ 50 V dc	100 K
	6	+ 140 V dc	35 K
	7	+ 3.8 V dc	2.7 K

TYPICAL VOLTAGE AND RESISTANCE MEASUREMENTS ON THE OSCILLATOR AND PROBE UNIT

ELECTRON TUBE DESIGNATION NUMBER	PIN NUMBER	VOLTAGE*	RESISTANCE**
V-01	1	(1)	10K to∞ (2)
	2	+ 16 to - 7	200K-400K
	3	0	0
	4	0	0
	5	+ 6.0	3
	6	(3)	70 K
	7	- .25 to - .3	27K
	8	0	0
	9	0	0
V-02	1	+ 1.8	300
	2	0	27 K
	3	+ 1.8	300
	4	+ 29	15
	5	+ 23	13
	6	+ 115	45 K
	7	+ 105	19.5 K
	8	0	0
	9	+ 115	40 K
V-03	1	+ .96	47
	2	- .02	51 K
	3	+ .96	47
	4	+ 17	9.5
	5	+ 23	12.5
	6	+ 86	45 K
	7	+ 57	21 K
	8	0	0
	9	+ 86	45 K
V-04	1	100	115 K
	2	0	470 K
	3	+ 1.1	2.2 K
	4	+ 11.5	6
	5	+ 11.5	6.5
	6	+ 150	17 K
	7	0	470 K
	8	+ 1.6	2.2 K
	9	+ 17	9.5
V-05	1	+ 110	115 K
	2	0	470 K
	3	+ 1.1	2.2 K
	4	+ 6	3.5
	5	+ 6	3.5
	6	+65	120 K
	7	0 to - 1.4	39 K (4)
	8	+ .2 to 1.6	1 K
	9	+ 11.5	6.5

DISPLAY AND CONTROL UNIT 37 PIN CONNECTOR RESISTANCE MEASUREMENTS**

Pin Number	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z
Resistance	13K	0	12K	12K	12K	13K	8K	6K	16.5	∞	∞	∞	∞	∞	∞	9K	5K	0	450 K to ∞	∞	∞	0

Pin Number	a	b	c	d	e	f	g	h	i	j	k	m	n	p	q
Resistance	∞	0	∞	∞	∞	∞	∞	∞	∞	0	0	16.5	0	0	0

OSCILLATOR AND PROBE UNIT 37 PIN CONNECTOR RESISTANCE MEASUREMENTS**

Pin Number	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z
Resistance	0	0	15	15	15	0	750K	15K	∞	∞	0	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	0

Pin Number	a	b	c	d	e	f	g	h	i	j	k	m	n	p	q
Resistance	1.2K	∞	∞	∞	∞	∞	0	∞	∞	∞	∞	∞	∞	0	0

*All voltage measurements are with respect to ground, all units of the system connected, and the VERNIER control in the extreme clockwise position.

**All resistance measurements are ohms to ground and were taken with all units of the system (including the probe) disconnected. All front panel controls should be in the extreme clockwise position. The FIELD LOCKED/MANUALLY TUNED switch on the display and control unit should be in the MANUALLY TUNED position.

(1) On the three high flux density bands this value should be between 7.5 and 75 volts. On the three low flux density bands this value should be between 7.5 and 100 volts.

(2) Lower value obtained before electrolytic capacitors were formed.

(3) On the three high flux density bands this value should be between 1.2 and 11 volts. On the three low flux density bands this value should be between 0.8 and 8.4 volts.

(4) Positive side of the meter grounded.