HEWLETT hp PACKARD

CURRENT PROBE
MODEL 1110A

OPERATING NOTE/NOVEMBER 1974

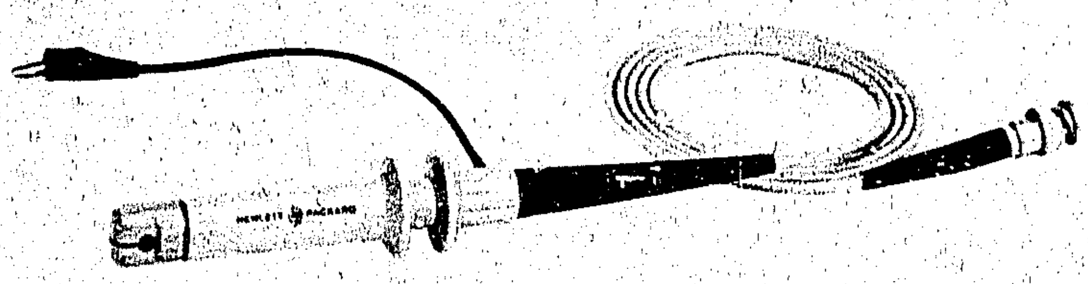

Figure 1. Model 1110A Current Probe

SECTION I
GENERAL INFORMATION

1. INTRODUCTION.

2. The Hewlett-Packard Model 1110A Current Probe is a clip-on probe which produces a voltage output proportional to the current flowing through the probe jaws. It is designed to be used with an oscilloscope or AC voltmeter over the 1700 cps to 50 megacycle range. It may be used to measure fast current pulses or high frequency alternating current in any application where the probe can be clipped over a current-carrying conductor. Typical applications include: measuring base or collector current waveforms in a switching transistor, leakage currents in ground leads, or plate current in a class C RF amplifier.

3. INSTRUMENTS.

4. Table 2 lists the hp instruments with which the Model 1110A may be used. The frequency range shown in the table is limited by the instrument bandwidth. The probe bandwidth is shown in Table 1. To use the Model 10100B Termination, connect the probe to the termination and then the termination to the instrument. If the instrument has a binding post input, use a BNC-to-binding post adapter such as the hp Model 1011A.

5. AMPLIFIER.

6. The hp Model 1111A Current Amplifier is designed specifically for use with the Model 1110A. The amplifier extends the probe's usefulness to 50 cps and provides calibrated control of sensitivity.

7. OPTION C06.

8. Model 1110A, Option C06 is a standard Model 1110A in which the 5-foot probe cable has been replaced

Table 1. Specifications

SENSITIVITY: Without 100-ohm termination: 1 mv/ma With 100-ohm termination: 0.5 mv/ma
ACCURACY: ±3%
BANDWIDTH: Lower -3 db point Without 100-ohm termination: 1700 cps With 100-ohm termination: 850 cps Upper -3 db point With 4 pf capacitive load: greater than 45 Mc With 30 pf capacitive load: 35 Mc
RISE TIME: With 4 pf capacitive load: 7 nsec With 30 pf capacitive load: 9 nsec
INSERTION IMPEDANCE: Approximately 0.01 ohm shunted by 1 μh; capacitance to ground less than 3 pf.
MAXIMUM DC CURRENT: 0.5 ampere
MAXIMUM AC CURRENT: 15 amperes p-p above 4 kc; decreasing below 4 kc at 3.8 amps/kc rate. 30 amperes p-p with 100-ohm termination
DIMENSIONS: Probe aperture 5/32 in. diameter, 5 ft cable

01110-90903

with a 6-foot probe cable. Refer to Table 4. In all other respects, Option C06 is electrically identical to the standard Model 1110A.

SECTION II

OPERATION

9. GENERAL OPERATION.

10. The operation of the probe consists of three basic steps:

a. Connect the probe to the voltmeter or oscilloscope input.

Table 2. ⊕ Instruments Used with Model 1110A

Instrument	Instrument/ Probe Bandwidth
Model 120B Oscilloscope	850Hz* to 450kHz
Model 122A Oscilloscope	850Hz* to 450kHz
Model 130C Oscilloscope	850Hz* to 500kHz
Model 132A Oscilloscope	850Hz* to 500kHz
Model 140A Oscilloscope	850Hz* to 20MHz
Model 141A Oscilloscope	850Hz* to 20MHz
Model 175A Oscilloscope	850Hz* to 35MHz
Model 180A Oscilloscope	850Hz* to 35MHz
Model 181A Oscilloscope	850Hz* to 35MHz
Model 310 Wave Analyzer	1kHz* to 1.5MHz
Model 400 Series VTVM	750Hz* to 4MHz
Model 403 Series AC VTVM	750Hz* to 2MHz
Model 411 RF Millovoltmeter	500Hz* to 45MHz

* Using 10100B Termination

b. Clip the probe around the current-carrying wire by squeezing the flanges together to open the jaws and releasing the flanges slowly to close the jaws around the wire. Make sure that the jaws are completely closed and not clamping the wire. Seat the probe jaws by pushing forward on the front flange.

c. Observe the indication on the oscilloscope or voltmeter. The output conversion factor is 1 mv = 1 ma.

11. Termination. The Model 1110A has a lower -3 db frequency of 1700 cps when the output of the probe is unterminated. The low frequency limit may be extended by terminating the probe output with the ⊕ Model 10100B Feed-Through Termination. The use of the termination lowers the sensitivity of the probe to 0.5 mv/ma.

12. Conventional Current Flow. The arrow on the outer sleeve indicates the direction of conventional current (ac component) which produces a positive output voltage from the probe. Thus there is a sense of polarity when observing current waveforms on an oscilloscope, and the polarity may be reversed by removing the probe from the wire, rotating the probe 180°, and clipping it around the wire again.

13. Increasing Sensitivity. The sensitivity of the probe may be increased by looping the wire through the probe two or more times. The increase in sensitivity is determined by the number of loops; i.e. two loops = twice sensitivity. However, this increase in sensitivity is accompanied by an increase in series loading effect due to the probe, which increases as the square of the number of loops. Also, the looped wire itself adds inductance and shunt capacitance which may be significant at high frequencies.

14. Summing Currents. The probe may be clipped around conductors carrying different currents as well as around loops of the same conductor. In either case the instantaneous output of the probe is the algebraic sum of the instantaneous currents through the probe. This feature makes it possible to bring a circuit such as a push-pull amplifier into balance by clipping the probe around two wires in which the currents are 180° out of phase as they pass through the probe, and adjusting the circuit for minimum output from the probe.

15. High Frequency Effects. At high frequencies, the shunt capacitance of the probe may introduce error into the measurement. When current flows in one direction (with the arrow), the current from the shunt capacitance flows through the probe electrostatic shield and is measured by the probe. If current flows in the other direction (against the arrow) it is shunted to ground immediately and is not measured by the probe. When making measurements in high impedance circuits at high frequencies, the effect of shunt capacitance must be taken into account.

16. Effects of External Fields. The Model 1110A is magnetically shielded to minimize the effects of external magnetic fields. However, strong fields near power transformers, electric motors, or instruments with strong fields may cause an undesired output from the probe. To check for such fields, hold the probe with jaws closed in the region in which you intend to make the measurement. If the probe output is excessive compared to the expected measurement, make the measurement at some other point along the wire farther from the source of the field, or orient the probe head for least output.

17. Peak Current. The peak current which the probe will accept is determined by both probe head saturation and heating at high frequencies. Figure 2 shows a plot of maximum current vs frequency.

18. Maximum DC Current. The effect of DC current in the circuit being measured is to decrease the head inductance, and raise the low frequency -3 db point. For performance within the probe's specifications, the DC current must be limited to less than 0.5 amps.

19. High Frequency Response. The upper -3 db frequency is 45 megacycles when the probe is working into an open circuit. The bandwidth is decreased to 35 Mc when the shunt capacitance is increased from 4 pf to 30 pf.

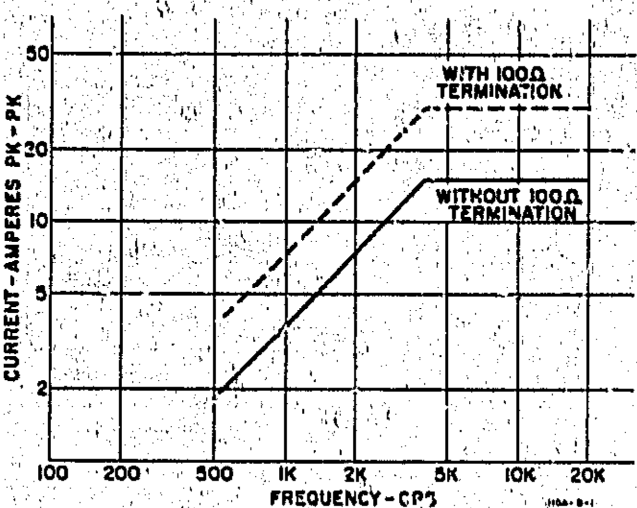

Figure 2. Maximum AC Current

SECTION III

PRINCIPLES OF OPERATION

20. The probe head of the Model 1110A is the secondary of a transformer with a ferrite core. This core is made in two parts, which can be split to clip the probe around a current-carrying conductor. The current-carrying conductor acts as a single-turn primary. The primary current (current in the circuit to be measured) induces a proportional current in the secondary: 1 milliampere for 100 milliamperes in the primary. The secondary current produces a voltage drop across a 100 ohm load resistance. The voltage developed is in the ratio of 1 millivolt per milliampere of primary current.

SECTION IV

MAINTENANCE

21. INTRODUCTION.

22. This section contains information for checking the performance of the Model 1110A, together with procedures for disassembly and repair.

23. PERFORMANCE CHECK.

24. The performance check indicated may be used as a routine maintenance procedure or as an incoming inspection to verify the performance of the instrument. Procedures for the performance check are contained in paragraphs 25, 27, and 30. The instruments required are listed in Table 3. If the recommended equipment is not available, equipment with similar characteristics may be substituted.

25. ACCURACY.

26. The following procedure is used to check the accuracy of the current/voltage conversion factor. Set up the test equipment as indicated in Figure 4.

a. Set the output of the Voltmeter Calibrator to 0.01 volts rms.

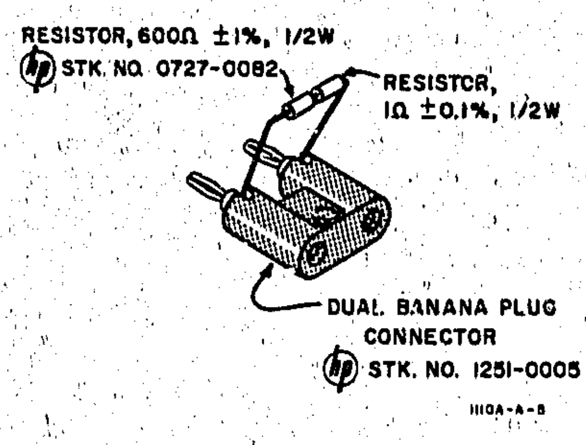

Figure 3. 600 Ohm Load.

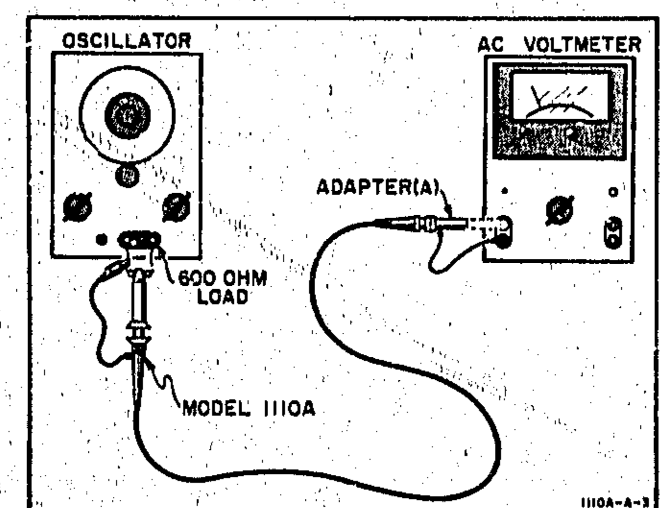

Figure 4. Accuracy and Low-Frequency Limit Test Setup

b. Set the AC Voltmeter to 0.01 volts full scale and connect to the Voltmeter Calibrator output.

c. Determine the error in the AC Voltmeter reading.

d. Connect the AC Voltmeter across the 1 ohm resistor on the 600 Ohm Load (ref. Figure 3).

e. Adjust the output of the Oscillator for a reading of exactly 0.01 volts at 100 MHz (taking into account the voltmeter error measured in step c above).

f. Disconnect the AC Voltmeter from the 1 ohm resistor. Connect the output of the Model 1110A to the voltmeter, and clip the Model 1110A around the 600 ohm resistor.

g. The reading of the AC Voltmeter should be between 0.0097 and 0.0103 volts, correcting the reading for the voltmeter error measured in step c.

27. BANDWIDTH.

28. Low Frequency Limit. Set up test equipment for this test as indicated in Figure 5.

a. Set the Oscillator frequency to 10 kc.

Table 3. Required Test Equipment

Inst. Type	Required Characteristics	Measurement	Ref Para	Recommended Instrument
Voltmeter Calibrator	Output: 0.01V rms Accuracy: ±0.25%	Accuracy	26	ⓗⓟ Model 738AR
Oscillator	Freq: 1 kc to 100 kc Output: 0 - 6V rms constant with frequency	Accuracy Low Freq. Limit	26 28	ⓗⓟ Model 200CD Wide Range Oscillator
AC Voltmeter	Bandwidth: 1.7 kc to 100 kc Range: .01 - 10 volts full scale Accuracy: ±1%	Accuracy	26	ⓗⓟ Model 400H Vacuum Tube Voltmeter
Adapter (A)	BNC female to Banana Plug	Accuracy Low Freq. Limit	26 28	ⓗⓟ Model 10111A
600 Ohm Load		Accuracy Low Freq. Limit	26	To be constructed (Ref. Figure 3.)
Signal Generator	Freq: 1 Mc to 45 Mc Output: 3 volts rms into 50 ohms constant with frequency	High Freq. Limit	29	ⓗⓟ Model 606A
RF Voltmeter	Bandwidth: 1 Mc - 45 Mc Range: .01 V Full Scale	High Freq. Limit	29	ⓗⓟ Model 411A RF Millivoltmeter
50 Ohm Load		High Freq. Limit Rise Time	29 30	To be constructed (Ref. Figure 10.)
Adapter (B)	BNC female to BNC female	High Freq. Limit Rise Time	29 30	ⓗⓟ Stock No. 1250-0080
Oscilloscope	Bandwidth: 350 Mc Rise Time: <1 nsec Sensitivity: 3 mv/cm, high impedance input Sync Pulse: 1.5V into 50 ohms, Rise Time < 2 nsec	Rise Time	30	ⓗⓟ Model 185B with ⓗⓟ Model 187B

b. Set the AC Voltmeter to the 0.01 volt range, and adjust the output of the Oscillator for a reading of 0 db on the AC Voltmeter.

c. Change the Oscillator frequency to 1700 cps.

d. The reading of the AC Voltmeter should be greater than -3 db.

29. High Frequency Limit. Set up test equipment for this measurement as indicated in Figure 5.

a. Set the RF Voltmeter range to 0.01 volt.

b. Set the Signal Generator frequency to 1 Mc.

c. Adjust the Signal Generator output for a reading of 0 db on the RF Voltmeter.

d. Set the Signal Generator frequency to 45 Mc.

e. The reading of the RF Voltmeter should be greater than -3 db.

30. RISE TIME.

31. Set up the test equipment as shown in Figure 6.

a. Obtain a presentation of the pulse on the oscilloscope.

b. Observe the 10% to 90% rise time of the pulse.

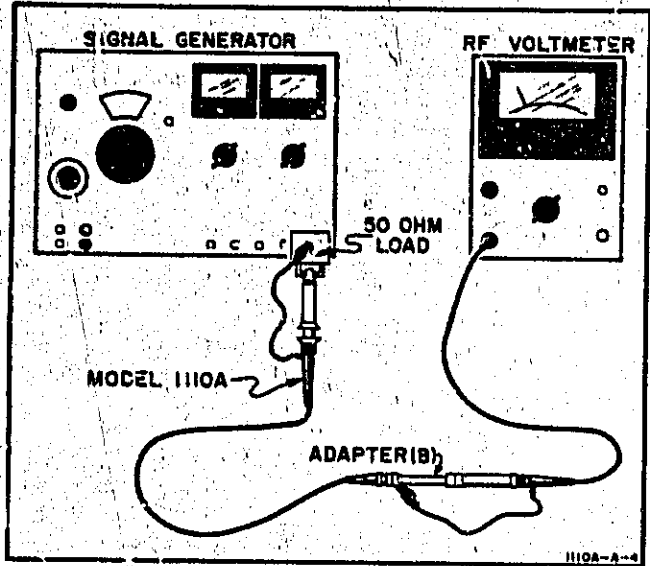

Figure 5. High Frequency Limit Test Setup

c. The rise time should be 7 nanoseconds or less.

d. Disconnect the test equipment.

32. PERIODIC MAINTENANCE.

33. The Model 1110A is built of durable materials, and will withstand hard use. The periodic maintenance required is cleaning. This is accomplished by using the small brush supplied with the probe. All foreign material must be removed from the mating surfaces of the pole pieces. Any accumulation of dirt, grit, or other material will result in the surfaces mating imperfectly, resulting in a deterioration of low frequency response.

34. TROUBLESHOOTING.

35. The following procedure outlines probable causes of trouble with the Model 1110A. Resistances of the windings, as measured from the ground side of the probe, are shown on the schematic, Figure 7.

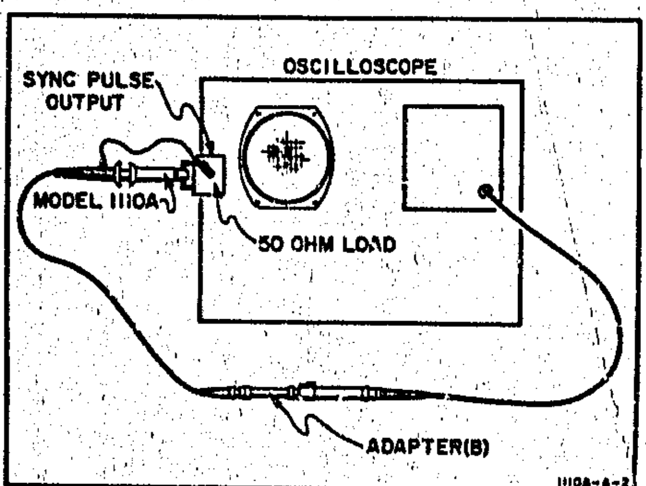

Figure 6. Rise Time Test Setup

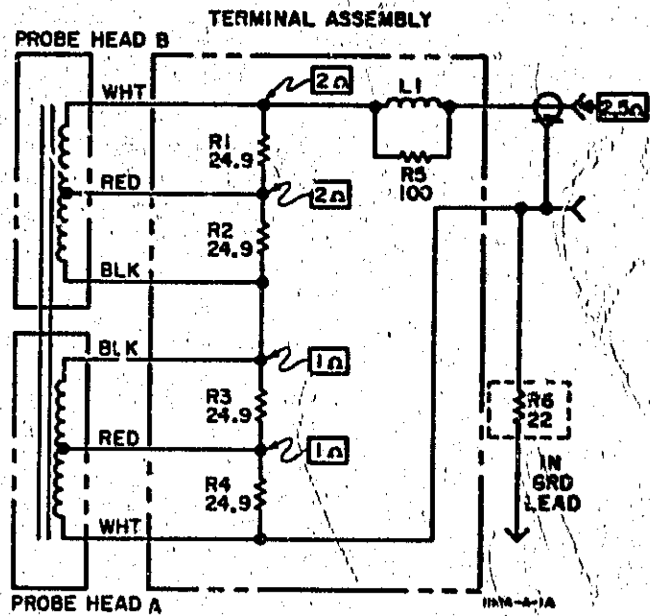

Figure 7. Probe Schematic

a. Low Frequency Response.

(1) Dirt on pole piece mating faces.

(2) Chipped or cracked pole piece.

(3) High resistance connection in cable or terminal assembly.

b. High Frequency Response.

(1) Resistors R1-R4 defective.

(2) Ground lead defective.

c. Pulse Response (excessive reflections): R5-L1 defective.

d. Gain (current/voltage conversion): Resistors R1-R4 defective.

36. REPAIR.

37. If a defective component is suspected, the probe must be disassembled. Refer to Figure 8 for an exploded view of the probe. To gain access to the interior:

a. Mark the jaws and the outer sleeve so that the original orientation will be preserved upon reassembly.

b. Unscrew the front section (front flange) from the center section, holding both parts of the front section together, so that the internal spring does not cause them to fly apart.

c. Remove the coil spring, and slide the jaw assembly out of the outer sleeve.

d. Unscrew the center section from the cable assembly.

e. Drive the roll pin out of the terminal section shield with a 1/16 in. drift punch.

f. Slide the terminal board and jaw assembly out of the shield.

Table 4. Replaceable Parts, Model 1110A Current Probe

Reference Figure 8	Description	ⓗ Stock No.
1	Cable Assembly	01110-61601
1	Cable Assembly for Option C06	01110-61602
2	Ground Lead (includes R6)	456A-21A-10
3	Lockwasher	2190-0012
4	Center Section	5040-0426
5	Coil Spring	1460-0059
6	Outer Sleeve	01110-42301
7	Probe Jaw Assy	See sublist below
Reference Figure 9		
7a	Shield	5020-0430
7b	Roll Pin	1480-0074
7c	Resistor, 24.9 ohms (R1-R4)	0721-0291
7d	Coil Assy (includes L1 and R5)	01110-86001
7e	Bushing	5020-0429
7f	Probe Jaw and Terminal Assy	01110-62101
Miscellaneous	Brush-Head Cleaning	8520-0017

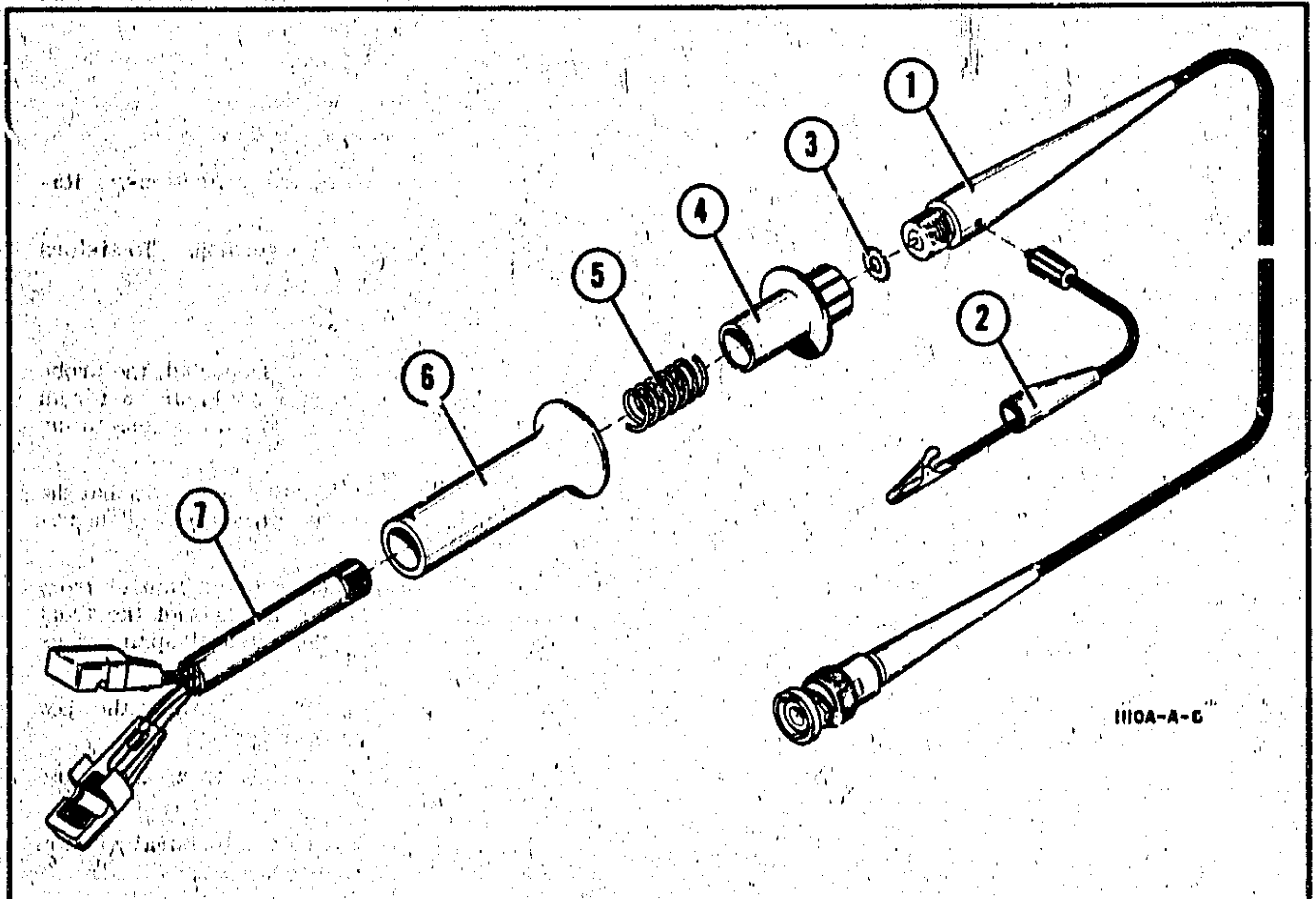

Figure 8. Model 1110A Current Probe, Exploded View

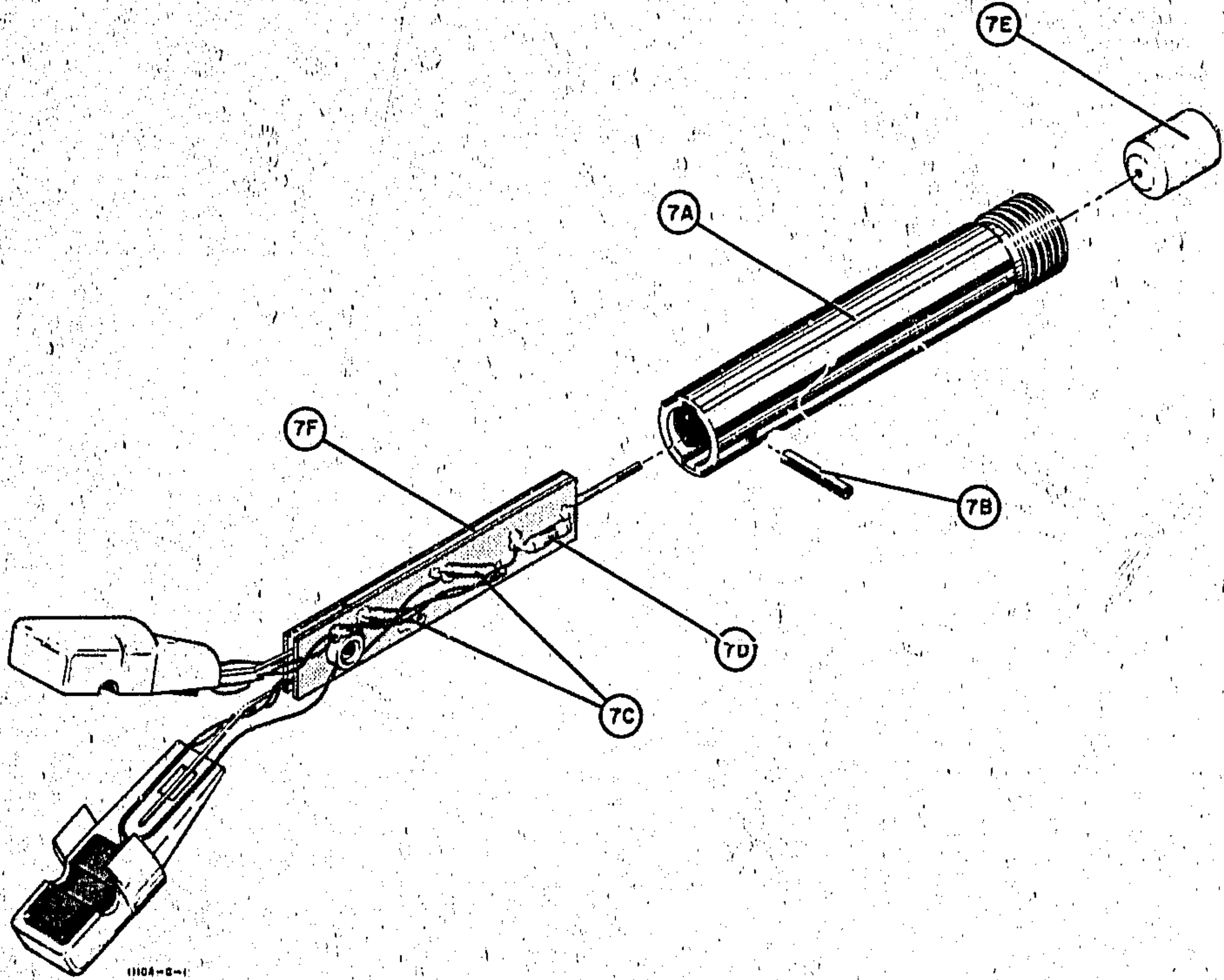

Figure 9. Jaw Assembly Exploded View

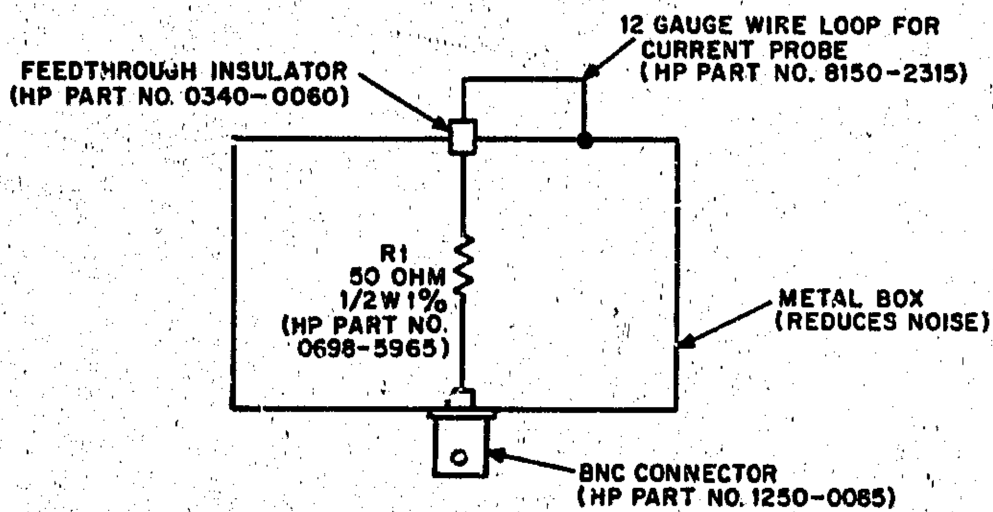

Figure 10. Load, 50-ohm