



# 3529A MAGNETOMETER PROBE

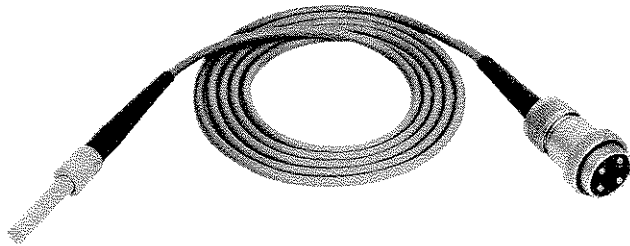


Figure 1. Model 3529A Magnetometer Probe

## SECTION I GENERAL INFORMATION

### 1. INTRODUCTION.

2. The Model 3529A Magnetometer Probe is an accessory which converts the Model 428A or Model 428B into a magnetometer. It is valuable in any

application where a magnetic field exists and an accurate determination must be made of either its direction or its magnitude. Both accurate and compact (the probe tip is only 1/4 in. in diameter), it is useful in a wide range of applications, such as measuring the leakage field of transformers, etc.

### 3. DESCRIPTION.

4. The accuracy of the Model 3529A is better than  $\pm 3\% \pm 0.1$  milligauss. Its bandwidth is from dc (non-varying fields) to 80 cps, allowing it to be used in the measurement of ac fields associated with power-line frequencies.

5. The conversion factor of the Model 3529A is 1 gauss = 1 ampere, that is, the reading from the Model 428A/B in amperes is directly equal to the measured field strength in gauss. The component of the field sensed is the component which is parallel to the cylindrical axis of the probe, allowing the user to eliminate the effects of extraneous fields (such as that of the earth, approximately 500 milligauss) by orienting the probe.

Table 1. Specifications

<b>ACCURACY:</b>	
Probe calibrated to specific instrument:	$\pm 3\%$ of full scale from $0^{\circ}\text{C}$ to $+55^{\circ}\text{C}$
Probe not calibrated to specific instrument:	$\pm 5\%$ of full scale from $0^{\circ}\text{C}$ to $+55^{\circ}\text{C}$
<b>RANGE</b>	
With 428A:	0.3 milligauss to 1 gauss; six ranges from 3 milligauss to 1 gauss, full scale, in 3, 10, 30... sequence
With 428B:	0.1 milligauss to 10 gauss; nine ranges from 1 milligauss to 10 gauss, full scale, in 1, 3, 10... sequence
<b>CONVERSION FACTOR:</b>	1 milligauss/milliamper (1 Gauss/amp)
<b>OPERATING TEMPERATURE RANGE:</b>	$-20^{\circ}\text{C}$ to $+55^{\circ}\text{C}$
<b>COMBINED NOISE AND SHORT-TERM DRIFT:</b>	Typically less than $\pm 0.1$ milligauss, peak
<b>OUTPUT FREQUENCY RANGE, MODEL 428B EQUIPPED WITH MODEL 3529A:</b>	DC to 80 cps (3 db point)
<b>STORAGE RANGE:</b>	$-40^{\circ}\text{C}$ to $65^{\circ}\text{C}$
<b>DIMENSIONS:</b>	3-11/16 in. by 7/16 in. diameter, maximum; cable: 7 feet long



6. CALIBRATION.

7. CHECK THE STRENGTH OF THE EARTH'S MAGNETIC FIELD AS SOON AS YOU RECEIVE THIS INSTRUMENT. USE THIS READING AS A REFERENCE FOR FUTURE CALIBRATION. To measure the earth's field in your locality proceed as follows:

a. The location for taking the reading is important and should be selected with care, taking the following into consideration:

- (1) Since the reading is to be the reference for instrument calibration, choose a place that will always be accessible.
- (2) Since the presence of strong ac fields will affect the reading, choose a location free of power-line pickup.
- (3) Since the presence of magnetic materials also will affect the reading, choose a location which either is free of magnetic material such as steel workbenches and beams or is one in which such material will not be added, taken away, or moved around.

b. Plug Model 3529A into Model 428A/B, and turn Model 428 ON, and allow 15 minutes to warm-up.

c. Turn Model 428 OFF for 30 seconds, and then mechanically zero-set meter (see Section IV for details).

d. Before any measurements are taken, the electrical ZERO adjustment must be centered. Turn red ZERO VERNIER control knob fully clockwise and mechanically center the large black ZERO control knob. This action will set the instrument zero to within  $\pm 3$  milligauss of zero field. As the earth's field is approximately 500 milligauss, less than 1% error will be introduced. If care is taken when mechanically setting the ZERO control, repeatable readings within 0.5 milligauss should be obtained. For greater ease in returning to this setting make a mark on the knob and on the panel adjacent to the knob with a lead pencil.

e. Point tip of probe toward the south and up (toward the south and down in Southern Hemisphere). Extend probe at full cable length from instrument to reduce disturbance from any fields around instrument. Carefully orient probe for maximum reading. (See paragraphs 9 and 10.)

f. Record the value of the maximum reading. This is the value to use as a reference for future calibration. The earth's magnetic field does vary slightly but not enough to be detectable on the 1 AMP range. When recalibrating the instrument be sure to take the measurement at the same location, and be sure that there has been no change in the magnetic environment (i.e., no new steel objects, etc). Any ac fields in the vicinity when making this measurement should not exceed 0.1 gauss peak.

## SECTION II

## OPERATION

8. INTRODUCTION.

9. The Model 3529A measures the component of the magnetic field which is parallel to the axis of the probe. When the meter reads up-scale the tip of the probe points toward a north magnetic pole (opposite to the direction of the magnetic flux). To measure the earth's magnetic field start with the tip of the probe pointed up (down in the Southern Hemisphere) and toward the south (note that the south geographical is a north magnetic pole).

10. A true reading of the ambient value of the earth's magnetic field will be obtained only when all ferromagnetic materials (magnetized or not) are kept well away from the probe head. If the probe is held by a fixture be sure all of the materials of the fixture are non-magnetic and clamp the handle, not the probe-tip. When measurements must be taken in a building with a steel framework keep as far away from steel beams and steel-reinforced walls or floors as possible.

11. MEASURING STEADY MAGNETIC FIELDS.

12. The earth's magnetic field is usually a problem when endeavoring to make an accurate measurement of steady magnetic fields. If the field to be measured can be turned off, the probe may then be oriented to give a zero reading on the meter. When the field to be measured is turned on the probe will indicate the component of the field in the direction of the probe. If this is the direction in which it is desired to measure, or if merely maximizing the field is desired, this procedure is satisfactory. However, if the field must be measured in some other direction, other techniques must be used (see following paragraphs).

13. The earth's magnetic field can be cancelled out at the point of measurement by building a pair of Helmholtz coils around the probe. Orient the coil axis parallel to the earth's field and run current through the Helmholtz coils in the proper direction and magnitude to zero the meter. Then insert the field to be measured and measure in the normal way. The reading of the meter in this case will be only the desired field.

14. If the field to be measured cannot be turned off, other techniques must be used. If the device generating the field can be oriented, set the device to a position where you can get maximum reading. Record the reading and then rotate the device about an axis on a line between the object and the probe. Rotate for minimum reading on the meter, and record this reading. The component of the field from the device in the direction of the probe axis is one-half of the difference between the maximum and minimum readings. The external field of a magnet may be measured by this method.

## 15. MEASUREMENTS OF ALTERNATING FIELDS.

16. Measurements of alternating fields can be performed only by measuring the output of the front-panel OUTPUT jack with an ac voltmeter or an oscilloscope since the meter on the instrument reads only the steady-state value of the magnetic field. The OUTPUT jack is a dc coupled output that gives one volt for a full-scale reading of the field as selected by the RANGE switch.

### CAUTION

The signal resulting from the steady-state value of the magnetic field plus the peak value of the ac field must not overdrive the amplifiers in the instrument. To check the steady field condition, observe the meter; if the needle is offscale the amplifier may be overdriven. To check the ac pick-up, connect an oscilloscope to the front panel OUTPUT jack and observe the waveform for clipping. If either condition is observed, the amplifier is saturating and the instrument must be switched to a higher range to give a true reading. Because of the magnitude of the earth's field, generally ac measurements must be made on the 1 AMP or greater range.

## SECTION III

### PRINCIPLES OF OPERATION

#### 17. DESCRIPTION.

18. The Model 3529A is a flux-gate type magnetometer which operates in the same manner as the standard probe used with the Model 428A/B. Refer to Section III of the Operating and Service Manual for the Model 428A/B for a discussion of the flux-gate principle.

## SECTION IV

### MAINTENANCE

#### 19. INTRODUCTION.

20. INSTRUMENT. Maintenance of the Model 428A/B milliammeter is the same whether the probe used is the Current Probe Assembly (428A-21A) or the Model 3529A Magnetometer Probe. Maintenance of the Model 428A/B is discussed in the Model 428A and 428B Operating and Service Manuals. Where differences between the Current Probe Assembly and the Model 3529A make it necessary to modify the troubleshooting techniques given in the manual, such modification is discussed below under troubleshooting.

21. PROBE. The Model 3529A is a simple device, consisting of two drive coils, wound around forms containing core material, and an output coil wound around both drive coils. In general, probably the only troubleshooting technique that will be required is the ohmmeter check described in paragraph 27.

#### 22. MECHANICAL ZERO-SET.

23. When the meter is properly zero-set the pointer rests over the zero calibration mark on the meter scale when the instrument is (1) at normal operating temperature, (2) in its normal operating position, and (3) turned off. Zero-set as follows to obtain best accuracy and mechanical stability:

a. Allow instrument to operate for at least 20 minutes; this allows meter movement to reach normal operating temperature.

b. Turn instrument OFF and allow 30 seconds for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.

d. Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If pointer over-shoots zero, repeat steps c and d.

e. When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counterclockwise. This is enough to free adjustment screw from the meter suspension. If pointer moves during the step you must repeat steps c through e.

#### 24. TROUBLESHOOTING.

25. If you have another Model 3529A Magnetometer Probe or another type of probe such as the 428A-21A Current Probe Assembly or the large aperture Model 3529A probe, isolate the trouble to either the instrument proper or to the probe, by substitution. If the trouble is in the instrument follow the troubleshooting procedure given in paragraph 29. If the trouble appears to be in the probe see the next paragraph.

#### 26. PROBE.

27. If the trouble appears to be in the probe, disconnect the probe from the Model 428A/B, and measure the resistance across each of the two windings. Only a few ohms should be measured across either winding 1-2 or winding 3-4 (terminal numbers appear adjacent to the pins, on the face of the probe connector). There should be no conductivity between winding 1-2 and winding 3-4.

a. If an examination of the connector indicates the connector is defective, note how the wires are connected, and then replace the connector. This connector is identical to the one used on the Model 428A/B.

b. If the wires inside the probe or cable are defective, probably the entire assembly will have to be repaced as the inside of the probe is filled with silastic compound to protect the leads from mechanical damage.

#### 28. MILLIAMMETER.

29. In general, instrument troubleshooting and maintenance techniques are the same whether the probe used in the 428A-21A current probe or the Model 3529A magnetometer probe. However, wherever the

technique requires current through the probe, procedures given in the Model 428A/B manuals will require some modification. Such modifications are discussed in the following paragraphs.

30. CALIBRATION. Instead of the accuracy check procedures given in the manuals (Model 428A, par. 4-6A, and/or step 23, table 4-2; Model 428B, par. 5-39, and/or step 24, table 5-2), check instrument calibration by re-measuring the earth's magnetic field strength, and comparing the reading obtained with the reference reading made as instructed in paragraph 6. If the readings are not the same, follow the adjustment procedure given in the instrument manual.

31. SIGNAL SOURCE. Some of the techniques described in the paragraphs listed below require that there be an input signal. A suitable ac input may be obtained by placing the magnetometer probe near a power-supply transformer. With such an input, the following procedures can be used.

a. Troubleshooting. Waveforms can be used as describe in

- (1) Model 428A, par. 4-8A
- (2) Model 428B, par. 5-29, 5-30

b. Adjustments.

- (1) Model 428A, table 4-2, steps 9 through 13
- (2) Model 428B, table 5-2, steps 8 through 12

32. LOOP GAIN CHECK. To measure the gain of the amplifier, proceed as follows:

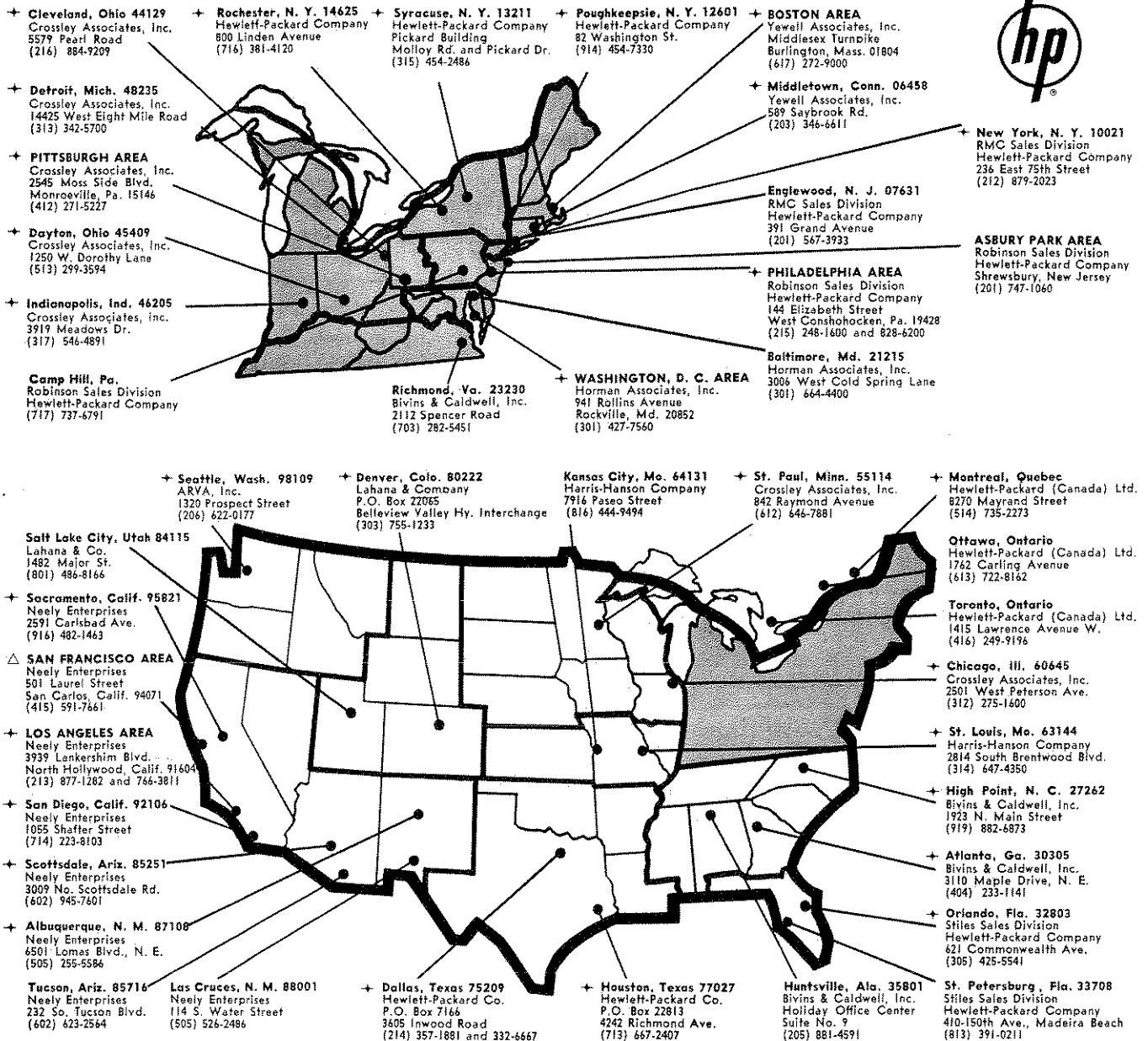
a. Model 428B. See step 18, table 5-2.

- (1) Obtain a signal as follows: wind a 5- to 50-turn coil around the magnetometer probe head, and couple the coil to an oscillator which furnishes signals in the 20 cps to 8--cps range, such as the  $\Phi$  Model 200CD. Set the audio oscillator for 20 cps.
- (2) Proceed as described in step 18 of table 5-2 except for setting the 0 db point on 20 cps (instead of 50).

b. Model 428A. Since the Model 428A does not have an ac output, the procedure is somewhat more complicated than that specified for the Model 428B; measuring the true gain of the amplifier involves disconnecting the feedback loop. Proceed as follows:

- (1) Follow the instructions given in step 14, table 4-2, of the Model 428A manual through zero-setting the meter.
- (2) Wind a 5- to 10-turn coil around the magnetometer probe head.
- (3) Feed enough direct current of the proper polarity through the coil to give a 3 ma. reading on the Model 428A meter. Then turn off this current until step 5.
- (4) Disconnect the jumper across the Test Disconnect terminals on terminal board 428A-75A (board nearest front panel); this jumper will be found across the terminals nearest the front panel. Removing the jumper disconnects the feedback loop.
- (5) Turn instrument on, and rezero. Turn on same current as applied in step 3; meter should now read approximately 60 to 90 ma. If meter reads less, amplifier may have deteriorated. Proceed as described in step 14, table 4-2.

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