TECHNICAL MANUAL

Model: surveyor 2000™
Portable Survey Meter

Manual Part No. 1016907

BICRON®

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BICRON

ELECTRONIC PRODUCTS
STANDARD WARRANTY

Bicron Electronic Products Instruments and options are warranted against defects in materials and workmanship for a period of one year from the date of shipment, unless otherwise agreed upon by Bicron and the customer.

Bicron's obligation with regard to such products shall be limited to repair or replacement, FOB Bicron factory or authorized repair station, at Bicron's option.

The calibration (when applicable) for each instrument is warranted to be within its specified accuracy at the time of shipment. If this initial calibration is determined to be in error, the instrument will be recalibrated at no charge, provided it is returned as described above.

EXCLUSION OF WARRANTY

The aforesaid warranty does not cover life-end failure of components and will be voided if repair has been attempted by other than Bicron's authorized personnel. In no event shall Bicron be liable for consequential or special damages, transportation, installation, adjustment, work done by customer or other expenses which may arise in connection with such defective product or parts.

There are no warranties, express or implied, including without limitation any implied warranty of merchantibility or fitness, which extend beyond the description of the face hereof. This express warranty excludes coverage of and does not provide relief for incidental or consequential damages of any kind or nature, including, but not limited to loss of use, loss of sales or inconvenience. The exclusive remedy of the purchaser is limited to repair, recalibration, or replacement of the instrument at Bicron's option.

This warranty specifically excludes the following items which are covered by their original manufacturers' warranties: photomultiplier tubes, GM and proportional tubes, crystal and other solid-state detectors, and batteries.

BICRON CORPORATION 12345 Kinsman Road, Newbury, Ohio 44065-9677

BICRON CORPORATION
ELECTRONIC PRODUCTS

PROCEDURES and CAUTIONS

The equipment herein described is designed and manufactured in compliance with all applicable safety standards. Nevertheless, certain hazards are inherent in the use of electronic and radiometric equipment.

Adequate warnings are included in the manual and on the product itself to cover hazards that may be encountered in normal use and servicing of this equipment. No other procedures are warranted by Bicron.

It shall be the owner's or user's responsibility to see to it that the procedures herein are meticulously followed, and especially that the warning and cautionary notes are heeded.

Failure on the part of the user in any way to follow the prescribed procedures shall absolve Bicron and its agents from any resulting liability.

This instrument is intended solely for the detection and measurement of ionizing radiation. It should be used only by persons who have been trained in the proper interpretation of its readings and the appropriate safety procedures to be followed in the presence of radiation.

All instructions and warnings contained in this manual or on the instrument must be read before use and must be strictly followed. Failure to follow these instructions and warnings may result in inaccurate readings and/or user hazard.

Indicated battery and other operational tests must be performed prior to each use to assure that the instrument is functioning properly.

*****CAUTION*****

FAILURE TO CONDUCT PERIODIC PERFORMANCE TESTS IN ACCORDANCE WITH ANSI N323-1978, PARAGRAPHS 4.6 and 5.4, AND TO KEEP RECORDS THEREOF IN ACCORDANCE WITH PARAGRAPH 4.5 OF THE SAME STANDARD, COULD RESULT IN ERRONEOUS READING OF POTENTIAL DANGER. ANSI N323-1978 BECOMES, BY THIS REFERENCE, A PART OF THIS OPERATING PROCEDURE.

INSPECTION

Instruments should be examined and tested as soon as received. Claims for transportation damages, if any, should be filed at once with the delivery carrier.

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1.0 GENERAL DESCRIPTION

The Bicron surveyor 2000 is a portable survey meter which utilizes an internal GM detector or an appropriate, external (+900V) GM probe for the detection and measurement of ionizing radiation.

The unit features a recessed meter movement, single on-off range control switch, switch-selectable response time, energy compensated internal GM tube (0-2000 mR/h range only), MHV probe connector, probe holder, dead time compensation and anti-saturation circuitry.

1.1. SPECIFICATIONS

RADIATION DETECTED: Alpha (depending on probe used), beta, gamma with external probe; gamma and X-ray with internal detector.
DETECTOR: GM tube, internal; choice of GM probes external.
RANGE: Linear ranges of 0-.2, 0-2, 0-20, 0-200 mR/h (external probes only), 0-2000 mR/h (internal detector only); 0-240; 2-2400; 0-24,000; 0-240,000 cpm.
HIGH VOLTAGE: Electronically stabilized, factory set at 900 V.
HV TEST: Exclusive self test to verify detector HV power supply.
CONNECTOR: MHV
ACCURACY: Within 15% of reading for ^{137}Cs between 20% and 100% of full scale when calibrated in mR/h with a specific probe.
ENERGY RESPONSE: ±20% from 40keV to 1.2Mev(internal detector).
WARMUP TIME: None
SATURATION: Typically >1000 R/h on all ranges with exclusive anti-saturation circuit for internal detector and most GM probes; 75 R/h for pancake GM probes.
RESPONSE TIME: Switch-selectable, optimized for each range. 0-90% of final reading as follows:

	TIME	
RANGE	FAST	SLOW
X0.1	6 sec.	25 sec.
X1	2 sec.	6 sec.
X10	1 sec.	3 sec.
X100	<1 sec.	1 sec.
X1000	<1 sec.	1 sec.

TEMPERATURE: Operational from -40° to +60°C.
HUMIDITY: 5% change in reading from 10-95% RH.
CONTROL: Eight-position rotary switch - off, bat., HV, X1000, X100, X10, X1, X0.1; rotary response time switch.
BATTERY COMPLEMENT: Single 9-volt (MN1604 or equal). The additional battery holder may be used as storage of spare or parallel-wired.
BATTERY LIFE: > 100 hours or > 200 hours with parallel option.
DISPLAY: Ruggedized, recessed, high-torque 1mA meter with 3.35 inch (8.51cm) scale marked 0-2 mR/h, 0-2400 cpm, 'Bat. ok', 'HV ok'. Meter protected by impact-resistant Lexan polycarbonate window.
GEOTROPISM: Within ±2% of full scale.
SHOCK: 100g per lightweight machine of MIL-STD 202C, method 202B.
VIBRATION: 5g in each of three mutually orthogonal axes at one or more frequencies from 10-33Hz.
CONSTRUCTION: Splash-proof, shock proof, two-piece all-metal case. Scratch-resistant laminated control panel and Bicron Kleen-Krome® trim on case top, durable black polyurethane painted handle and case bottom, stainless steel probe holder.

1.1 SPECIFICATIONS (Cont'd)

AUDIO OPTION: When specified,a built-in speaker, with panel mounted on-off switch, provides audible "click" for each detector pulse. With the speaker off, an audible alarm sounds (if desired) when meter is >full scale on any range.
SIZE: 4.25 X 8 X 6.8" including handle and probe clip (10.8 X 20.3 X 17.3 cm).
WEIGHT: 2.2 lbs. (1 kg), excluding probe.

2.0 BATTERY INSTALLATION

BATTERY TYPE: 9-volt Mallory MN1604 or equivalent.
PROCEDURE:
1. Turn instrument off.
2. Open pull catches at ends of case and separate case bottom from top.
3. Install battery in appropriate clip on bottom circuit board (clip for spare battery is so marked), observing proper polarity.
4. Replace bottom, orienting rubber pad under battery; close catches.

PARALLEL-WIRED OPTION: Instruments with this option have both battery clips wired into the circuit. Installing a second battery thus provides approximately twice the operational hours of one battery. Only one battery is needed to power the instrument, however.

2.1 BATTERY TEST *****SAFETY PRACTICE*****

Turn control switch to the "bat." position; a meter reading within the "bat. OK" range should be observed.
This test allows monitoring of the condition of the battery.

2.2 HIGH VOLTAGE TEST *****SAFETY PRACTICE*****

Turn control switch to the "HV" position; a meter reading within the "HV OK" range should be observed.
This test allows monitoring of the high voltage to the detector.

2.3 RADIATION MEASUREMENTS

1. When using an external GM probe, select the appropriate response time (section 2.4) and measurement range (using the X0.1, X1, X10 or X100 range only). Read only the cpm scale unless the unit has been calibrated in mR/h with a particular SWGM (side-wall GM) or EWGM (end window GM) probe.
2. When using the internal detector, select the appropriate response time and turn the control switch to the X1000 range. Read the mR/h scale only. The detector is mounted near the front of the case, centered vertically and slightly to the right of center horizontally. Position instrument so that radiation is incident on the front of case.

*****CAUTION*****

An external source of ionizing radiation of the type the count rate meter and the GM probe selected were designed to measure must be used to determine proper operation of this instrument.

2.4 SELECTABLE RESPONSE TIME

In addition to the built in circuitry which optimizes response time for each range, response time can be controlled by the switch marked "response" Slow or fast response time can be selected.

2.5 AUDIO OPTION

If instrument is equipped with this option:

1. An internal speaker will produce an audible click for each detector pulse. This speaker is controlled by a panel mounted on-off switch labeled "audio".
2. An audible alarm will sound when the meter is approximately 30%, or more, above full scale on any range. This over-range alarm can be defeated by turning off an internal on-off switch located on the main circuit board.
3. The over-range alarm will function only when the panel mounted "audio" control is in the off position, and the internal switch is on. When the speaker control is in the on postion, the over-range alarm is defeated.

3.0 CIRCUIT DESCRIPTION

The electronic circuitry in the Bicron surveyor 2000 is contained on three interconnected printed circuit boards.

Modern solid-state integrated circuitry is used throughout. The major components are:

1. High-voltage power supply. A feedback-regulated, electronically stabilized supply for the GM tube potential. Additional circuitry provides HV readout on the meter scale.
2. Count-rate meter. A linear charge pump ratemeter converts the GM tube pulses to an exposure rate reading on the calibrated meter scale. The circuitry includes a unique dead-time compensation technique to provide nearly linear response over the full range, an anti-saturation circuit which forces the meter beyond full scale in high radiation fields, automatic time constant selection, and temperature compensation.
3. Optional audio circuitry for individual pulse counting and over-range alarm.

3.1 GM TUBE (PROBES)

The GM tube consists of a thin cylindrical shell which is the cathode, a fine wire anode suspended along the longitudinal axis of the shell, and an inert gas into which a small amount of a halogen gas is inserted to act as a quenching agent.

A potential of approximately 900 volts is maintained between the two electrodes with the anode always positive. This voltage is slightly less than that required to produce a discharge in the gas. When a nuclear particle or ray of sufficient energy enters the GM tube, it ionizes a molecule of the inert gas. Because of the high voltage maintained between the electrodes, the positive ions are attracted to the cathode and the electrons are attracted to the anode. In their movement toward the electrodes, these charged particles trigger the ionization of additional gas molecules, resulting in an avalanche of ions flowing between the electrodes. The gas discharge thus created is similar to the glow of a neon lamp. The tube conducts as long as the gas is in the ionized state.

The small amount of halogen gas in the gas mixture quenches the flow of ions, suppressing further electron avalanches until another nuclear particle or ray enters the tube. This flowing and quenching results in a rapid pulse or

3.1 GM TUBE (PROBES) (cont'd)

surge of current in the external circuit. The number of pulses per minute is approximately proportional to the radiation exposure rate. The meter, suitably connected to the tube, indicates the exposure rate or counts per minute (depending on probe used) on a calibrated scale.

4.0 CALIBRATION

A. STANDARD (mR/h)

1. The instrument is normally factory calibrated with ^{137}Cs gamma rays for the internal detector and when furnished with a specific model SWGM (side-wall GM) or EWGM (end-window GM) probe. Recalibration is required (a) after servicing, (b) if the GM detector or probe is replaced, and (c) at regular intervals specified by the appropriate regulatory agencies.
2. The SWGM (with shield closed) or EWGM probe is placed in a known radiation field with the axis of the probe perpendicular to the beam. The front of the case is placed perpendicular to the beam when calibrating the internal detector.
3. Individual calibration controls are provided for each range, and should be used to adjust the meter reading to correspond to the known exposure rate. The locations of these controls are indicated on the main circuit board.
4. External probes are calibrated on the X0.1, X1, X10 and X100 scales only. The internal detector is calibrated on the X1000 scale only.

Note:
Do not disturb the settings of any controls except those marked X0.1, X1, X10 and X100 (X1000 with internal detector only).

Calibration procedures should follow those specified by the appropriate regulatory agencies.

B. OPTIONAL (CPM)

Electronic calibration (counts per minute) is the only type that can be done when external probes other than a specific SWGM or EWGM are supplied, or when the instrument is not supplied with a given probe.

To Perform an Electronic Calibration, the unit is connected to a variable frequency pulse generator, which is then set at the frequencies needed to produce 80% and 20% of full scale meter readings (cpm) for each range. Calibration controls are set for 80% of full scale readings, and linearity is checked by going to the 20% readings.

C. Detailed calibration procedures are part of the Q.C. Acceptance Procedure found elsewhere in this manual.

BICRON QC ACCEPTANCE PROCEDURE NUMBER 1016937

MODEL: surveyor 2000™

1. Perform visual inspection of finished product.

2. Remove all 9V batteries and connect a 9.30V ± .05V power source across the main battery terminals on the battery board. Perform the following calibrations:

   a. Turn the control switch to "off". Mechanically zero the meter via the rear zero adjustment screw on the meter barrel.

   b. Turn the control switch to "X0.1". Check the +5V supply at pin 1 of U6 (ICL 7663). The reading should be 5VDC ± 10%.

   c. Leave the control switch set at "X0.1" and connect a voltmeter between pins 1 (ground) and 15 of the 24 pin connector. Adjust R31 (50 Kohm zero pot) until the voltmeter reads 1 mVDC + 4/-1.

   d. Turn the control switch to "X100" and connect a high voltage measuring device with an impedance ≥ 1000 megohms to the probe connector center pin. Adjust the high voltage supply via R52 (50 Kohm pot) to + 900 VDC ± 3%.

   e. Rotate the control switch through all 8 positions. HV should be detected at the probe connector in "X100", "X10", "X1" and "X0.1" only.

   f. Connect the HV measuring device across the internal GM tube and rotate the control switch through all 8 positions. HV should be detected in "bat.", "HV" and "X1000" only.

   g. Turn the control switch to "HV" and adjust R34 (500 ohm span pot) until the meter reads in the center of the "HV ok" checkband.

   h. Perform a CPM calibration (unless the instrument is to be supplied with a specific SWGM or EWGM probe):

      1) Turn the control switch to "X100" and connect a variable frequency pulse generator to test point 2 (pin 5 of the 24 pin connector).

      2) Adjust the frequency to the value required to calibrate the unit at 80% of full scale on the meter (see Table T-1).

      3) Adjust R28 (50 Kohm X100 calibration pot) until the meter reads 80% of full scale.

      4) Readjust the frequency to the value required to calibrate the unit at 20% of full scale (see Table T-1).

      5) Note the meter readings from steps 3) and 4) on a certificate of calibration.

6) Repeat steps 2), 3), 4) and 5) for the X10 range (using R26, the 500 Kohm X10 calibration pot), the X1 range (using R24, the 5 megohm calibration pot), and the X0.1 range (using R22, the 2 megohm X0.1 calibration pot).

TABLE T-1

Range	Pulse Generator Output (Hz)	Simulated cpm	Acceptable Meter Reading (cpm)
X100(80%)	1896.0	192,000	163,200 - 220,800
X100(20%)	683.0	48,000	40,800 - 55,200
X10 (80%)	300.0	19,200	16,320 - 22,080
X10 (20%)	78.5	4,800	4,800 - 5,520
X1 (80%)	31.8	1,920	1,632 - 2,208
X1 (20%)	8.0	480	408 - 552
X0.1(80%)	3.2	192	163.2 - 220.8
X0.1(20%)	.8	48	40.8 - 55.2

Note: The values in this table may not correspond to those for other Bicron or competitive models.

i. If specified to be supplied with an SWGM or EWGM probe, perform an isotopic calibration:

1) Connect the GM probe to the probe connector via a cable.

2) Place the probe in a known ^{137}Cs radiation field in the proper fixed geometry.

3) Calibrate each range (except X1000) at 80% and 20% of full scale using the values in Table T-2 and the same calibration pots as those listed for a CPM calibration.

4) Note the meter readings from Step 3 on a Certificate of Calibration.

j. The "X1000" range (internal detector) must always be isotopically calibrated.

1) Position the unit so that the internal GM tube is in the proper fixed geometry within a known ^{137}Cs radiation field.

2) Turn the control switch to "X1000" and calibrate at 80% and 20% of full scale, using the values in Table T2 and R30 (the 5 Kohm X1000 calibration pot).

3) Note the meter readings from Step 2 on a Certificate of Calibration.

TABLE T-2

Range	Field Strength (mR/h)	Acceptable Meter Reading (mR/h)
X1000 (80%)	1600.0	1360 - 1840
X1000 (20%)	400.0	340 - 460
X100 (80%)	160.0	136 - 184
X100 (20%)	40.0	34 - 46
X10 (80%)	16.0	13.6 - 17.4
X10 (20%)	4.0	3.4 - 4.6
X1 (80%)	1.6	1.36 - 1.74
X1 (20%)	.4	.34 - .46
X0.1 (80%)	.16	.136 - .184
X0.1 (20%)	.04	.034 - .046

k. Mark all trimpot bodies in such a way as to show the general position of the adjustment screws after calibration.

3. Test "response" operation:

   a. Connect a variable frequency pulse generator to test point 2 (pin 5 of the 24 pin connector) and turn the response switch to "fast" and the control switch to "X1000".

   b. Vary the frequency of the pulse generator and switch between "fast" and "slow", checking the operation.

   c. Do the same at "X100", "X10", "X1" and "X0.1".

   d. Leave the pulse generator connected if the unit is equipped with the audio option.

4. Test the audio, if so equipped:

   a. Turn the audio switch to "on" and check to see that the audio functions properly on all five ranges, using the pulse generator. Also, check that the audio remains silent when the selector switch is on "bat." and "HV".

   b. Turn the audio switch to "off" and the alarm on/off switch mounted on the main PC board to "on". Drive the meter well beyond full scale with the pulse generator and observe that a continuous tone is heard. Do this on all five ranges.

   c. Disconnect the pulse generator.

5. Test anti-saturation circuit operation as follows:

   a. Turn the control switch to "X100" and connect a 1000 megohm resistor across the probe connector (from + 900V to ground). The meter should peg beyond full scale.

b. Replace the 1000 megohm resistor with a 2000 megohm resistor. The meter should remain at zero.

c. Remove the 2000 megohm resistor.

6. Perform the following test if a CPM calibration was done:

a. Leave the control switch on "X100" and turn the audio switch on.

b. Connect a suitable GM probe to the instrument.

c. Place a small check source near the probe and switch to "X100", "X10", "X1", and "X0.1" in turn. A meter reading should be obtained for each range.

7. Remove all test equipment from the unit. Turn the control switch to "off" and install a new + 9V alkaline battery (MN-1604 or equivalent) in the appropriate battery clip (either clip if the unit has the parallel-wired battery option).

8. Complete, date and sign a Certificate of Calibration.

SPARE PARTS LIST
BICRON surveyor 2000 AHS

SCHEMATIC SYMBOL	DESCRIPTION				PART NO
	Main PC Board Assembly				1016017
C1,C11,C26	Capacitor,	0.1 uF,	Film		9211041
C2,C22,C23	Capacitor,	.001 uF,	1 kV cer.		9201021
C3	Capacitor,	.001 uF,	Film		9211021
C4,C24	Capacitor,	33 uF,	10 V tan.		9233361
C5,C7,C27	Capacitor,	.01 uF,	Film		9211031
C6	Capacitor,	.0033 uF,	Film		9213321
C8	Capacitor,	200 pF,	N750 cer.		9202011
C9,C21	Capacitor,	.22 uF,	Film		9212241
C10,C17,C25,C28	Capacitor,	.047 uF,	Film		9214731
C12	Capacitor,	.47 uF,	Film		9214741
C13,C15,C18	Capacitor,	1.0 uF,	10 V tan.		9231051
C14	Capacitor,	2.2 uF,	10 V tan.		9232251
C19,C20	Capacitor,	.01 uF,	1 kV cer.		9201031
D1-D6,D9-D17,D22	Diode,	1N4148			9600002
D7,D8	Rectifier,	2 kV PIV			9600001
Q1,Q3	Transistor,	2N4126			9610002
Q2,Q4	Transistor,	2N4124			9610001
R1,R6,R15,R17	Resistor,	10k,	1/4w,	5%	8510024
R2	Resistor,	200 ohm,	1/4w,	5%	8120004
R3	Resistor,	27k,	1/4w,	5%	8127024
R4	Resistor,	1.3k,	1/4w,	5%	8113014
R5,R7,R9,R61	Resistor,	4.7k,	1/4w,	5%	8147014
R8,R18,R41,R51	Resistor,	470k,	1/4w,	5%	8147034
R10,R53	Resistor,	200k,	1/4w,	1%	8520034
R11,R33	Resistor,	82.5k,	1/4w,	1%	8582524
R12,R13,R16,R20	Resistor,	100k,	1/4w,	5%	8110034
R14,R57	Resistor,	274k,	1/4w,	1%	8527434
R19,R37,R40,R42,R43, R44,R45,R54,R58, R59	Resistor,	1 meg,	1/4w,	5%	8110044
R21,R47	Resistor,	499k,	1/4w,	1%	8549934
R22	Trimpot,	2 meg			9392051
R24	Trimpot,	5 meg			9395051
R26	Trimpot,	500k			9395041
R28,R36,R52	Trimpot,	50k			9395031
R29,R32	Resistor,	4.99k,	1/4w,	1%	8549914
R30	Trimpot,	5k			9395021
R34	Trimpot,	500 ohm,			9395011
R35	Resistor,	249 ohm,	1/4w,	1%	8524904
R38	Resistor,	1 meg,	1/4w,	1%	8510044
R39	Resistor,	11k,	1/4w,	1%	8511024
R46	Resistor,	1000 meg,		1%	8810071
R48	Resistor,	33.2k,	1/4w,	1%	8533224
R49	Resistor,	390 ohm,	1/4w,	5%	8139004

R50	Resistor,	2.7k,	1/4w, 5%	8127014
R55	Resistor,	100k,	1/4w, 1%	8510034
R56	Resistor,	23.7k,	1/4w, 1%	8523724
R63	Resistor,	3.3 meg,	1/4w, 5%	8133041
RN1	Res. Network,	7 x 220k		8822031
SW3	Switch,	Slide,	SPST	9560001
U1	Int. Ckt.,	MC3302PDS		9640002
U2	Int. Ckt.,	MC14538BCPDS		9650004
U3	Int. Ckt.,	MC14093BCPDS		9650001
U4,U5	Int. Ckt.,	CA3160BEX		9640001
U6	Int. Ckt.,	ICL7663CPA		9640003
U7,U8	Int. Ckt.,	CD4016BEX		9650002
V1	GM Tube Ass'y,	Energy-compensated		9730010
XFMR	Transformer,	M8149		9500001
	Connector,	24-pin		9780001

Switch PC Board Assembly 1016027

R31	Resistor,	681 ohm,	1/4w, 1%	8568104
SW1	Switch,	Rotary,	8 pos.	9560005
SW2, SW4	Switch,	Rotary,	2 pos.	9560002
	Header,	24-pin		9780002
	Sounder,			9720001

Header PC Board Assembly 1016030

C29	Capacitor,	.001 uF,	Film	9211022
Q5	Transistor,	2N4124		9610001
R65	Resistor,	10k,	1/4w, 5%	8110024

Battery PC Board Assembly 9420001

Case Top Assembly 1016147

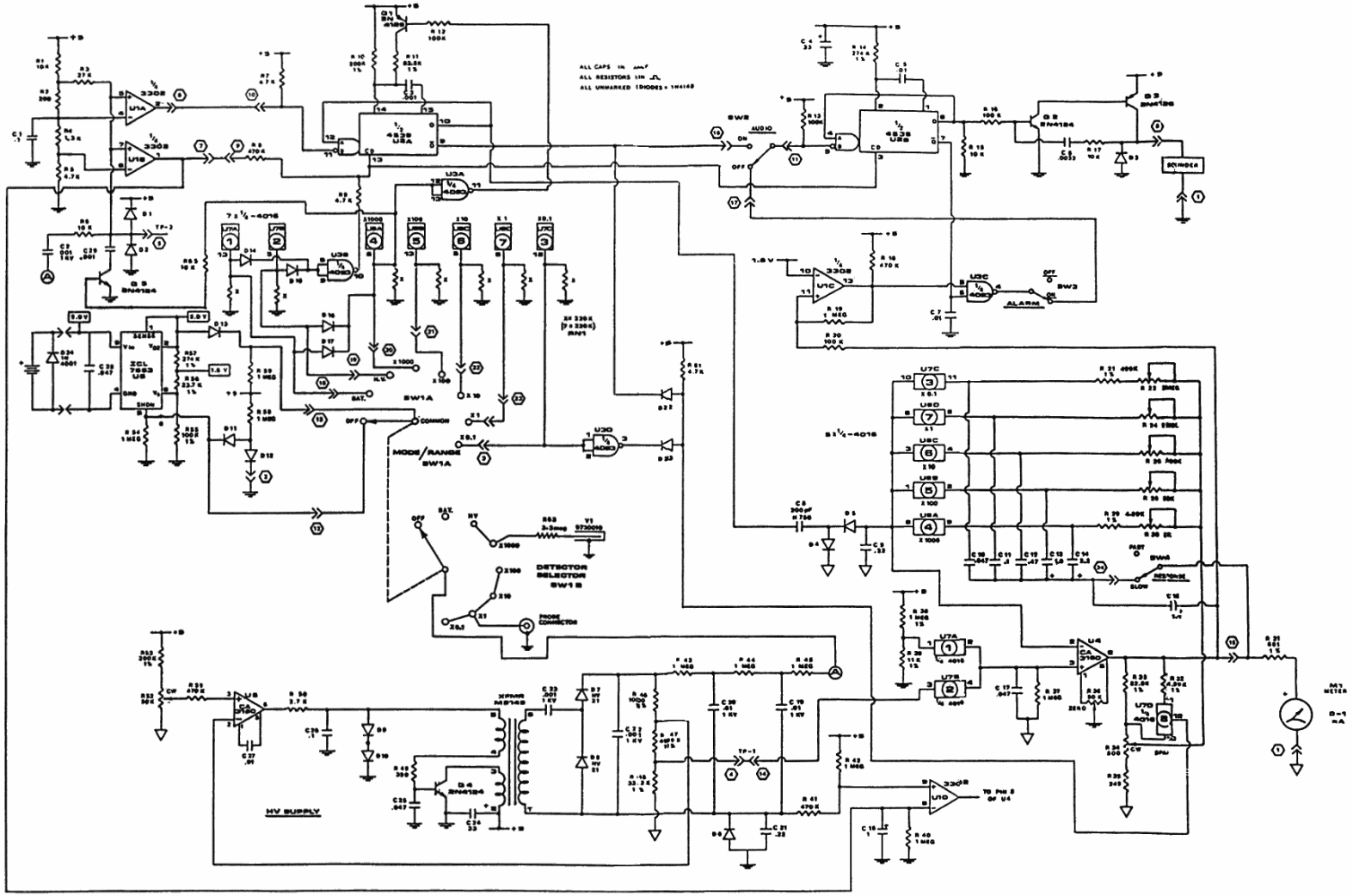
Handle	9710002
Meter	9400016
Meter Window	9400011
Meter Support Bracket	9850002
MHV Connector	9782001
Probe Clip	9460004

	Case Bottom Assembly	1016050

	Miscellaneous	
BT1	Battery, 9V alkaline, MN1604	9750001
	Cable, Probe, MHV-MHV, 36"	9801001
	Knob, Function	9770003
	Knob, Audio and Response	9770001
	Manual, Operator's	1016907
	Spare Parts List	1016917
	Schematic Circuit Diagram	1016927

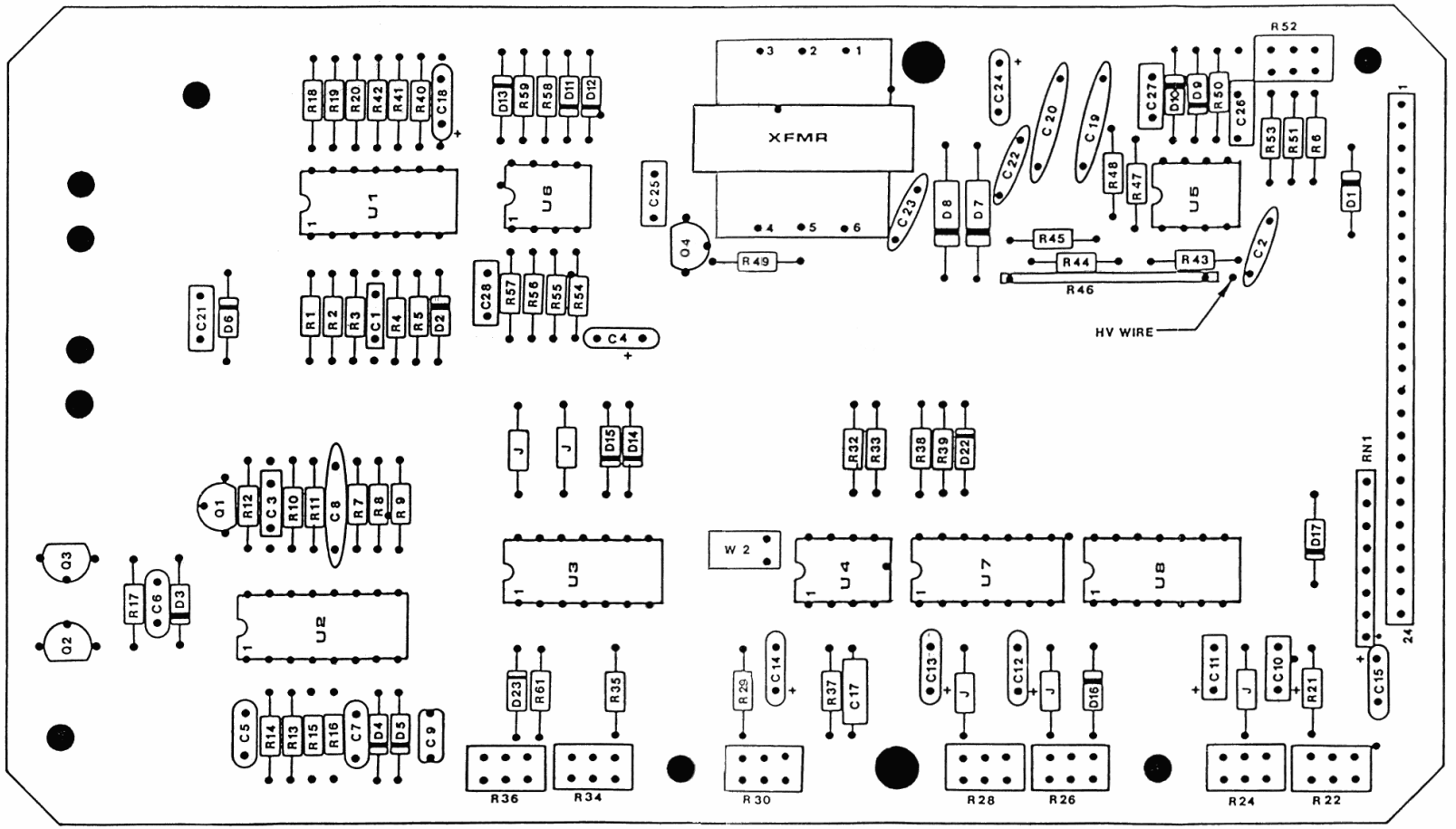
Part No. 1016917

Issue:	Date:
Original	08/08/84
Rev A	10/31/84



TOLERANCES UNLESS OTHERWISE SPECIFIED	SCALE: NONE	BICRON CORPORATION NEWBURY, OHIO U.S.A.
FRAC. ± .XX ± .XXX ± ANGLES ± MICRO FIN.	DRAWN 7-5-84 J.C.	
	CHECKED	DATE
	DO NOT SCALE PRINT	SCHEMATIC CIRCUIT DIAGRAM
	IN SI SYST.	SURVEYOR 2000 AHS
		DRWG. NO. D1016927 REV. A

REV.	DATE	DESCRIPTION	BY



SURVEYOR 2000 AHS
COMPONENT SIDE