NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

February 5, 2000

ADDENDUM TO SYSTEMS GROUP CHAIRMAN FACTUAL REPORT, FUEL QUANTITY INDICATORS

A. ACCIDENT : DCA96MA070

Location : East Moriches, New York

Date : July 17, 1996

Time : 2031 Eastern Daylight Time

Airplane : Boeing 747-131, N93119
Operated as Trans World Airlines (TWA) Flight 800

B. SYSTEMS SUB-GROUP

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C. SUMMARY

On July 17, 1996, at 2031 EDT, a Boeing 747-131, N93119, crashed into the Atlantic Ocean, about 8 miles south of East Moriches, New York, after taking off from John F. Kennedy International Airport (JFK). All 230 people aboard were killed. The airplane was being operated as a Code of Federal Regulations (CFR) Part 121 flight to Charles De Gaulle International Airport (CDG) at Paris, France, as Trans World Airlines (TWA) Flight 800.

A Systems Group met on August 19, 1998, to examine fuel quantity indicators (indicators) from the reserve fuel tanks of the accident airplane (tanks 1R and 4R). The group again met on January 11, 1999, to examine the gross weight/total fuel weight indicator (totalizer) from the TWA flight 800 wreckage.[1] The electrical connector from the CWT indicator was also examined during the meeting of January 11.

The Safety Board worked with the Boeing Engineering Quality Analysis Laboratory to examine two B-747 fuel quantity indicators on October 28, 1998. The inoperative indicators were not from the accident airplane and had been provided by an airline after maintenance personnel noted that the parts had an acrid burned smell.

The Systems Group obtained documents pertaining to the FQIS and indicator failure history and failure modes and the records included the number of spare part (transformer) shipments made by Honeywell and a transformer manufacturer. The search for documents about fuel quantity indication system (FQIS) problems also found Boeing Document (D3-11796-1), dated July 31, 1980, and titled KC-135 FUEL QUANTITY INDICATING SYSTEM FAILURE ANALYSIS. The report stated that a KC-135 aircraft experienced a ground fire in the aft body [fuel] tank, that a possible ignition source was

[1] The flight engineer station instrument is described in the Trans World Airlines 747 OPERATIONS MANUAL as the GROSS WEIGHT/TOTAL FUEL WEIGHT INDICATOR. An illustration in the manual shows the indicator with GROSS WT as an upper digital display and TOTAL FUEL WINDOW as the lower display. The group referred to the instrument by the reference "totalizer indicator" that Honeywell provided in the FUEL QUANTITY INDICATING SYSTEM MAINTENANCE DATA document (or as "totalizer").

believed to be associated with the fuel quantity probe, and that the manufacturer of the KC-135 FQIS had been Honeywell. An Air Force engineering assignment tasked Boeing Military Airplane Company (BMAC) to perform the failure analysis.

D. DETAILS OF THE INVESTIGATION

COMPONENT EXAMINATIONS

RESERVE INDICATORS

The group examined two reserve fuel quantity indicators at the Honeywell laboratory in Minneapolis, Minnesota. The data plates on the indicators had the following markings:

#1 Left Reserve Fuel Quantity Indicator

SPEC NO.	:	60B92010-1
MFR PART NO.	:	JG603C4RG1006AA01
SERIAL NO.	:	Q-150
TWA PART NO.	:	34127
SERIAL NO.	:	Q-150

#4 Right Reserve Fuel Quantity Indicator

SPEC NO.	:	60B92010-1
MFR PART NO.	:	JG603C4
SERIAL NO.	:	A-19
TWA PART NO.	:	Not Readable
SERIAL NO.	:	A-19

Both Reserve Fuel quantity indicators exhibited signs of corrosion and the indicator faces were missing. The electrical connector from indicator A-19 was pulled out of the case and the interior was exposed. The case of indicator Q-150 was split at the mechanical section. The indicator cases were cut off and the circuit boards inside were found bent and cracked. Both indicator circuit boards were removed and cleaned.

The circuit boards in indicator A-19 were put into an operable indicator and the indicator worked properly during the bench test, except the indicator could not be calibrated. Capacitors C6 and C7 were noted to be missing from the bridge card during the bench check and a review of the photographs showed that C6 and C7 were missing when the indicator was disassembled. Evidence of impact damage was found in the area. The missing components were in the control circuit and the group agreed that the calibration problem was due to the missing components.

The schematic (C13386AA02) provided by Honeywell for the examination shows that connector pin 11 provides an airframe ground through capacitors C6 and C7. The Honeywell representative noted that without this ground the capacitance circuit would create a low indication and that operation would be affected. The bench test indicated a zero value of 188 picofarads (pf[2]) and full value of 362 pf, with a calibration error of 30 pf. The group agreed that indicator A-19 appeared to have been able to function prior to the accident. The circuit boards were then removed from the sample indicator.

The amplifier circuit board from Indicator Q-150 had impact damage to the C5 capacitor and Q4 transistor and both damaged components were found in the case. Both components were replaced and the circuit boards were soldered into the sample indicator used to test the components from indicator A-19. The unit could not be calibrated during bench tests; with the zero fuel indication at 185 pf and full indication at 413 pf. The calibration errors were 32 pf at zero and 51 pf at full. The group agreed that indicator Q-150 appeared to have been able to function prior to the accident and then removed the circuit boards from the sample indicator.

TEAR-DOWN OF GROSS WEIGHT/TOTAL FUEL WEIGHT INDICATOR (totalizer)

The totalizer was received without extensive distortion of the case, the glass missing from the case, and a puncture in the top surface. At the face of the indicator, the GROSS WT display on the face of the indicator was between 587.0 and 588.0. The TOTAL FUEL display digits were between 169.0 and 170.0. When touched with a finger, the digits would slightly rattle, but did not change values. The set knob was bent downward and away from case center. The front bezel was loose and hanging from the knob.

The group found hand-written black ink spelling "TWA#34134" and orange ink-stamps spelling "MFD (illegible)9." and "MAY 196(illegible)." The accident instrument had an outline of adhesive in the same area and shape as the data plate found on a sample instrument. Markings were found imprinted into the case and were in the same orientation as those on the sample, but the markings on the sample were not imprinted into the case metal. The markings were:

[2] A measurement of electrical capacitance.

For the sample instrument fields:

STOCK NO. SPEC NO.
MFR PART NO. SERIES SERIAL NO.
[NOMENCLATURE]

For the accident instrument markings:

60B92010-5
JG613C1 5 A-8
INDICATOR, FUEL QUANTITY AND GROSS WEIGHT

The upper two case screws located above the totalizer connector were found with space beneath the screw-heads and with visible thread. The forward (as installed) screw has a safety wire tab and gap of .06 inches. The aft screw has a .04 inch gap and is slightly tilted. Three of the case screws, including the two with visible thread, were loose.

The electrical connector of the indicator was received mated with the airplane side of the connector and slightly less than a foot of airplane wiring. The airplane wires were found to have the following pin orientation:

CONNECTOR PIN #	WIRE NUMBER	DIAM (in.) w/ INSULATION	COPPER DIAM. w/ NO INSULATION
1	W186-Q608	.053	
2	W186-Q638	.052	
3	W186-Q623	.052	
4	(Plugged)		
5	W186-L914	.052	
6	W186-L913	.053	
7	W186-Q753	.042	.030
8	W186-Q743	.052	
9	W186-Q613	.050	.038
10	W186-Q618	.052	.038
11	W186-Q628	.052	
12	W186-Q633	.052	

The aircraft wire insulation measured about .007 inches thick and after stripping the wire ends, the wires were taped to a paper next to the associated pin numbers. All external wires were marked W42A/1/1/20, except for W186-Q753, which was marked W42A/1/1/22. The resistance between pairs of wires was checked with a Fluke 77 Multimeter (measurements attached).

The connector was opened without difficulty and two pins from the indicator remained with the red rubber grommet of the connector. The pins were from location numbers 9 and 12, that the electrical schematic provided by Honeywell shows for tanks one and four, respectively. Small bits of material fell from the opened connector area and under 10X magnification the material contained both gray, black, and red particles. The red particles were approximately the same shade as a o-ring found inside of the connector.

A break-out connector was attached to the instrument and the continuity across most of the instrument pins were checked with the Fluke 77. Those values that were beyond the capability of the Fluke 77 multimeter were measured with a Multimeter of (maximum) 2.8 giga-ohm capability (Hewlett-Packard Model 3457A, found with the Fluke 77 to have an output of 1.45 volts at 11 megohms). In each of the electrical measurements, the lowest resistance found to CWT pin 3 was .85 mega-ohms, in separate measurements to both the transformer and to pin 4. The CMM circuit diagram shows resistors between pin 3 and the case ground of (maximum) 739,000 ohms, although the Honeywell Overhaul Manual (October 1, 1982) indicates that the resistance between pin 3 and ground should be approximately 439,000 ohms maximum.

The case was cut open and the gear from the rebalance potentiometer (pot A1 R1) fell out of the case. The servo motor was loose, rusty, hanging by the wires, and the shaft would not rotate under light finger pressure. The case contained dried adhesive around the calibration resistor screw port. The rebalance pot (A1 R1) was found loose and hanging by the wires with the aft portion of the case separated and skewed. The transformer was found loose, with the mounting bracket broken at the forward edge of the core. The gray and brown wires were separated from the transformer body. A white/black wire was found loose behind the transformer, but a mating attachment point was not visible.

Although found electrically open (not in contact), the soldered internal side of connector pins 3 (CWT) and 11 (from tank 3) appeared to be touching and paper could not be slipped between the contacts. Slowly increasing voltage from a controllable source resulted in current flow (limited to .5 milliamperes) at a reading that was between the 250 and 300 volt graduations. The test was repeated three times. Post-test inspection found that the crack between the solder connections had opened slightly, but the crack was still less than half the width of a wire of .011 inch diameter.

The Honeywell Component Maintenance Manual (CMM) shows that the printed circuit card nearest to the external electrical connector was card A-2 and that it contains eight adjustable (variable) trim resistors. The circuit card was found slightly warped around the hole for the wire bundle, but generally intact. The A-2 card has 4 colors of trim resistors with 1968 and 1986 date codes. (Component manufacturer BOURNES provided the date codes.) The following observations were made for components on the card:

The R1 trim resistor was brown.

The R5 trim resistor was green, marked:
10025148-144 [IRC Company part number (p/n)]
6837 [date code]

The R9 BOURNES trim resistor was blue and marked with the following markings:
RJ22CW104
MADE IN MEXICO

8626M [date code]

The R12 trim resistor was black and marked:
10025148-147

The R14 trim resistor was black and marked:
M175PCT204A
200K
CTS 2968.

The R16 resistor was black and marked:
M175PCT204A
200K
CTS 2968.

The R18 trim resistor was black and marked:
M175PCT504A
500K
CTS6838.

The CMM indicated that the R20 and R21 resistors were installed in series in with connector pin 3, attached by airplane wiring to the center wing fuel tank compensator LO-Z. The R20 resistor was green and marked "6837."

The A-3 printed circuit card was found tilted with the (as installed in the aircraft) forward side displaced about 1/2 inch toward the connector. The circuit card was more extensively damaged than the A-2 card. The following was found on this card:

The CR4 was found lifted at one end and separated from the card at the C1 end.

The C1 capacitor was found marked:
CK06CW 103K
200V
E8133 [date code]

The C2, C3, and C7 capacitors were not flush with the circuit card. The C2 and C7 capacitors were in a warped area of the circuit card and the area of the C3 capacitor was flat.

The C4 capacitor visually appeared cracked at the inboard lead.

The R2 resistor was found broken.

The R5 resistor was found cracked.

The R10 (RN55C1402F) resistor was loose at one end (area of damaged circuit card) and separated from the card.

The Q4 transistor was found rusty and rust was on the surrounding components.

EXAMINATION OF CWT INDICATOR CONNECTOR

After examination of the totalizer found the near-contact of solder at pins 3 and 11 (previous section), the connector from the CWT indicator was examined. The solder connections for the internal wires were found to have been had been previously removed by melting the solder for disassembly.

On the green encapsulated surface of the connector, an iridescent sheen was found between the center pin and pins 2, 3, and 4. The Maintenance Data Operations and Flight Data Manual (page 7, fig 2) shows the center connection to be from the shielded HI-Z. The figure shows pin 2 attach to the tank unit LO-Z wire (then to the refuel door switch and the aircraft press-to-test switch), pin 3 connect to the COMP LO-Z, and pin 4 connect to the 5V ground and aircraft frame. When electrically tested with a high resistance multimeter (HP Model 3457A), between all pin combinations, the readings were all greater than the measuring range of the meter (min. 2.8 giga-ohms). (Note: The Multimeter was checked with a Fluke 77 of 11.1 mega-ohm resistance and found to have an output of 1.13 volts.)

The CWT indicator wire harness (<12 inches of W186 wire bundle) was received with the airplane side of the connector. The assembly was electrically tested for continuity between all pin combinations with the high resistance multimeter (HP Model 3457A) and all measurements were greater than the measuring range (min. 2.8 giga-ohms).

TRANSFORMER FAILURES

The Safety Board worked with the Boeing Engineering Quality Analysis Laboratory (ref. EQA Report 1858T) to examine two B-747 fuel quantity indicators on October 28, 1998. The indicators had been provided by an airline after maintenance personnel noted an acrid burned smell. The examination found that the connector on each indicator had been improperly inserted into the worn connector of a ground test set during maintenance. Reference to an electrical schematic (C13386AA02) provided by the Honeywell representative revealed that the improper assembly had applied 115 volt (AC) power to circuits designed for less than 28 volts. The examination found that one indicator had a short circuit between the 115 volt (AC) primary transformer winding and the winding leading to the pin that connected to a fuel tank wire. Portions of the yellow tape on the windings of the transformer were dark brown to black in color. The Honeywell schematic shows a limiting resistor between the transformer and connector pin.

Following tear-down of the indicators, the indicator tear-down records for transformers from the accident airplane were re-examined. For the indicators that were recovered and examined, the records did not reveal short circuits and none had the darkened areas on the yellow tape that had been found in the Boeing EQA examinations of the two failed transformers.

DOCUMENT SEARCH RESULTS

TRANSFORMERS

Manufacturer and operator documents pertaining to the FQIS and the indicators were obtained for an examination of FQIS failure history and failure modes. A November 19, 1998, letter from Schott Corporation, one manufacturer of transformers, stated that "short circuits between windings are a known failure mode for transformers of any origin. Typically, drawing excessive current from one or more secondary windings causes field failures of this nature."

The records from Honeywell and Schott show that 237 new transformers had been sent to airlines during the 1992 to 1998 period. Honeywell Service Bulletin JG603-28-01 provides instructions for the modification of a JG603C4 indicator into a JG603C80 indicator and that the modification requires replacement of the transformer. Honeywell wrote that "the quantity of 69 dash 106 transformers in 1992 is most likely associated with performing this modification."

CIRCUIT PROTECTION

The schematic provided by Honeywell shows a limiting resistor between the transformer and connector pin. Boeing and Honeywell did not have design records that specified the values (ohms) to be used for resistors that prevent introduction of energy into fuel tanks through the FQIS. The TWA wire diagram 31-35-33 (SGT 2, PAGE 1) shows that between the airborne integrated data system (AIDS) and splice SM65, which attaches wires that lead to the CWT, also is a limiting resistor (R468). Boeing described the sizing of the resistor value for an AIDS resistor in a letter of January 29, 1999.

Boeing Specification 60B92010 contains the following numbered paragraphs:

3.1.11.2 The energy supplied to the tank and compensator units shall not exceed .02 millijoules.

3.1.11.3 The current in the tank and compensator unit leads shall not exceed .010 amperes under any one of the following conditions:

a) Normal operation with any desired bridge circuit adjustment.

b) Failure of any component in the current limiting circuit.

c) Shorting of any or any combination of tank and compensator units and any capacitor in the bridge circuit.

3.1.11.4 The current in the tank and compensator unit leads shall not exceed .150 amperes under any combination of (b) and (c) above.

KC-135 FUEL QUANTITY INDICATING SYSTEM FAILURE ANALYSIS

A search for documents about fuel quantity indication system (FQIS) problems revealed Boeing Document (D3-11796-1), dated July 31, 1980, and titled KC-135 FUEL QUANTITY INDICATING SYSTEM FAILURE ANALYSIS. The report stated that a KC-135 aircraft experienced a ground fire in the aft body [fuel] tank, that a possible ignition source was believed to be associated with the fuel quantity probe, and that the manufacturer of the KC-135 FQIS had been Honeywell. The KC-135 report includes a complete circuit diagram and a diagram that shows the portion that Boeing studied. The studied portion includes (in order) a transformer, variable resistor, limiting resistor, (connector pin not shown), connected outside of the indicator to a fuel probe with a ground fault.[3] An Air Force engineering assignment tasked Boeing Military Airplane Company (BMAC) to perform the KC-135 failure analysis and the Boeing report is attached.

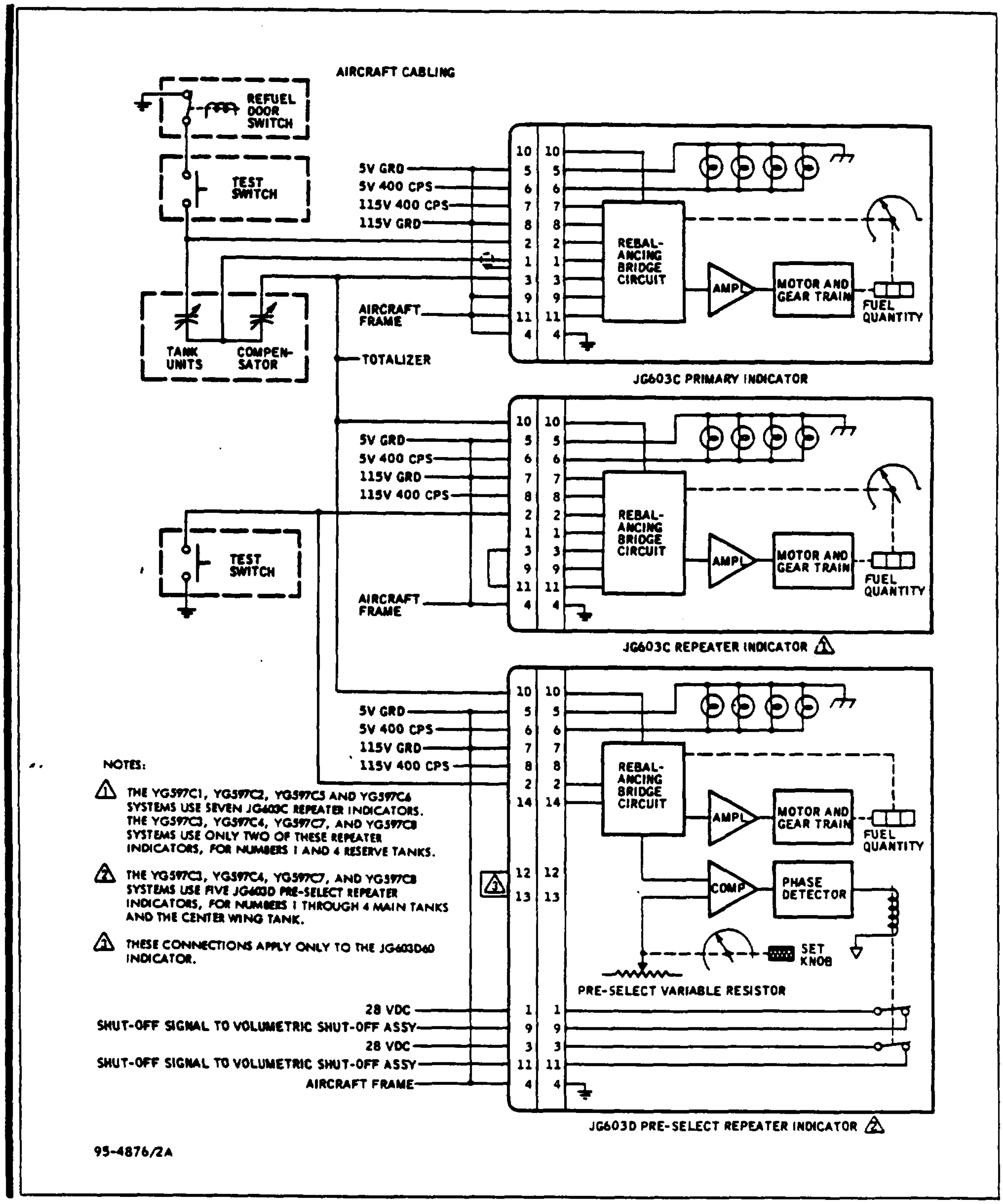
Robert L. Swaim
Robert L. Swaim
TWA800 Systems Group Chairman
2/7/00

[3] The Component Maintenance Manual (CMM) for Boeing 747 fuel gages shows the same items in the same order (without the ground fault).

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

Attached Documents pertaining to
Transformers and Circuit Protection

FUEL QUANTITY INDICATING SYSTEM



Fuel Quantity Indicating Subsystem

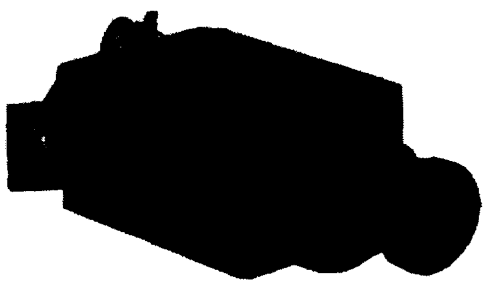
Figure 2

Aircraft Circuit Breakers

2TC | 3TC | 6TC | 9TC | 2TC49 | 6752-12 | 6752-1xx | 6752-3xx
20TC | 7235 & 7236 | 7270 & 7271 | 7274 | 7277 | 10RC | 3SB
Aircraft Circuit Breaker Overview Page

2TC Series

Single Phase, Ambient Compensated



Features

- Miniature Size
- Light Weight
- Trip Free
- MIL-C-5809 Qualified
- Current Ratings (1 to 25 Amps)
- Coordinated Ratings
- High Vibration Resistance
- High Interrupting Capacity

Overview

Klixon® single-phase TC devices are the smallest, lightest, high performance aircraft circuit breakers available today. They represent the "state-of-the-art" for protection of today's aerospace power systems. Their lightweight and small size make them especially well suited for aircraft, avionics and electronic systems.

The Klixon® trademark has set the standard for aerospace circuit breakers. For a small, lightweight configuration, the TC series offers the endurance and reliability required by exacting military specifications, and are available in standard current ratings from 1 through 35 amperes.

Coordination

The single phase 2TC and 3TC, and three phase 6TC and 9TC breaker ratings are coordinated so any rating will trip before another circuit breaker twice it's rating in the event of a fault of up to 600 amps let through current. This results in improved overall equipment performance, since only the smallest faulted circuit is interrupted, while larger circuits remain operational.

Ambient Temperature Compensation

The 2TC serves as an ambient compensated circuit breaker permits system designers to specify smaller gauge wire where the circuit breaker and wiring are exposed to different ambient temperatures. They are especially suited for application where ambient temperature exceeds the 160°F (71°C) maximum of non-ambient compensated thermal circuit breakers. The 2TC series may be applied where operating temperatures are as high as 250°F (121°C), with no derating of the circuit breaker. This eliminates the need for cooling air and allows substantial weight, space and cost savings.

Options

- Longer Pushbuttons
- Metric Mounting Thread
- Dust Boot [1]
- Auxiliary Switch
- Terminal Barriers
- Terminal Hardware

[1] Part number 14500-1 fits 15/32 bushing
Part number 14500-5 fits 7/16 bushing

Qualifications

MS3320 2TC2
MS3320L 2TC27
MS3320V 2TC63
European Standards
All US Aircraft OEM's
Most European Aircraft OEMs
SAE Industry Standards

Calibration: 1-25 Amps (Typical*)

Temp °C	Min. Ult. Trip	Max. Ult. Trip	Trip Time - Seconds		
			200%	500%	1000%
+25	115%	138%	4 - 16	.4 - 4.6	.10 - .40
-54	115%	165%	7 - 35	.6 - 3.0	.15 - .70
+121	85%	145%	2 - 13	.25 - 1.0	.06 - .25

*The above calibration chart is representative of a standard commercial device. TI offers specific variants with similar performance dependant on military or customer specifications.

Performance

Vibration*.................10 G minimum, 50-500 Hz
Mechanical Shock.....50 G
Acceleration..............10 G
Weight...................... 24 grams
*Other vibration levels available

Interrupting Capacity

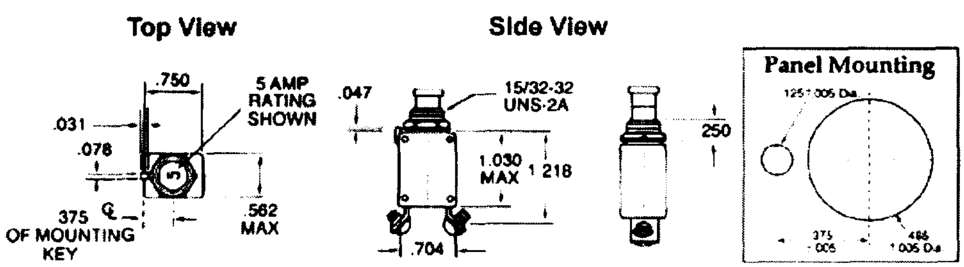
1-20 amps	6000 amps at 28 VDC
25 amps	1625 amps at 28 VDC
3-15 amps	2500 amps at 120 VAC, 400 Hz
20 amps	2000 amps at 120 VAC, 400 Hz
25 amps	1800 amps at 120 VAC, 400 Hz

Endurance

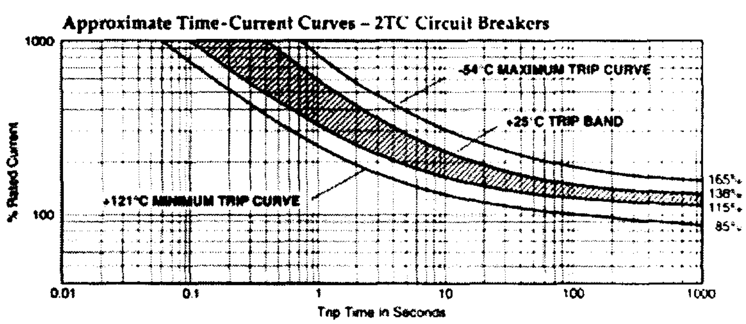
2500 cycles	120 VAC. 400 Hz, Inductive
5000 cycles	120 VAC. 400 Hz, Resistive
2500 cycles	30 VDC, Inductive
5000 cycles	30 VDC, Resistive
10,000 cycles	Mechanical, No Load

Amp Rating	Voltage Drop (max)*
1	1.10
2	0.70
2½	0.50
3	0.40
4	0.45
5	0.35
7½	0.30
10	0.28
15	0.25
20	0.25
25	0.20

*Maximum voltage drop at nominal rated current.



Nominal dimensions provided for reference purposes.



Pricing Information Request Form

TW (13) Set function switch to A/C + PROBE SIM and observe that indicator
TW reading reads full weight listed in figure 505 within ±1%. If
TW indicator is not within limits check compensator condition and
TW circuit integrity. Ref-Fuel Quantity Compensator - Adjustment/Test
TW 28-41-02.
TW (14) Open AC REFUEL GAGES and FUEL QUANTITY REFUEL circuit breakers on
TW P6 panel. Disconnect test equipment. Replace covers on indicators
TW and install indicators. Close circuit breaker.
TW (15) Repeat steps (1) thru (14) for all fuel tank indicators as required
TW on P4 and P42 panels.
TW (16) Remove electrical power if no longer required (Ref 24-22-00).

7. <u>System Test - Fuel Quantity Indicating</u>

TW A. Equipment and Materials
TW (1) Field Calibration Unit MD-2A, R&R 90069 or equivalent
TW (2) Test Cables:
TW (a) EQ449-50 - Inboard and Center Tanks
TW (b) EQ449-3 - Outboard Main Tanks
TW (c) EQ449-2 - Reserve Tanks 1 and 4
TW (d) EQ449-70 - Reserve Tanks 2 and 3

B. Test Fuel Quantity Indicating System Insulation Resistance
(1) Remove the AIDS Flight Deck Acquisition Unit #2 (AMM 31-35-02/401).
(2) Defuel and purge applicable fuel tank (Ref 28-26-00 MP, 28-11-00 MP).
(3) Remove applicable fuel quantity indicator; disconnect electrical plug.
(4) Remove total fuel quantity indicator; disconnect electrical plug.
(5) Remove volumetric shutoff control unit at E3-1 rack.
(6) Open refueling control panel access door.
(7) Remove applicable fueling quantity indicator and disconnect electrical plug.
TW (8) Using field calibration unit, measure insulation resistance values
TW at fuel quantity indicator electrical plug at P4 panel. Connect the MD-2 with appropriate test cable.

<u>NOTE</u>: Let the test unit stabilize for 10 seconds before you record each reading.

(a) Insulation resistance value of tank unit between HI Z and LO Z should not be less than 50 megohms.
(b) Insulation resistance value of fuel quantity compensator between HI Z and LO Z should not be less than 500 megohms.
(c) Insulation resistance values between HI Z and LO Z and SHIELD should not be less than 1 megohm.

(9) Connect electrical plug to fuel quantity indicator and install indicator.
(10) Connect electrical plug to total fuel quantity indicator and install indicator.
(11) Install volumetric shutoff control unit at E3-1 rack.
(12) Connect electrical plug to fueling quantity indicator and install indicator.

MIL-T-4687B(ASG)
NOTICE -1
9 OCTOBER 1967

MILITARY SPECIFICATION

TESTER, CAPACITOR-TYPE, FUEL-QUANTITY-GAGE TANK UNIT, TYPE MD-2A

Specification MIL-T-4687B(ASG), dated 16 January 1957, is hereby cancelled. There is no superseding document.

Custodians:
Navy - AS
Air Force - 82

Preparing activity:
Air Force - 82

Project No. 6625-F299

U.S. GOVERNMENT PRINTING OFFICE: 1967-301-113/2030

FSC 6625

MIL-T-4687B(ASG)
AMENDMENT-3
4 JUNE 1958
Superseding
Amendment -2
31 January 1958

MILITARY SPECIFICATION

TESTER, CAPACITOR-TYPE, FUEL-QUANTITY-GAGE TANK UNIT, TYPE MD-2A

This amendment forms a part of Military Specification MIL-T-4687B(ASG), 16 January 1957, and has been approved by the Department of the Air Force and by the Navy Bureau of Aeronautics.

Page 2, paragraph 2.1:

(a) Under "STANDARDS" add the following:

"Military

MS3101	Connectors, Electric, Receptacles, Cable Connecting
MS3102	Connectors, Electric, Receptacles, Box Mounting
MS3106	Connectors, Electric, Plugs, Straight
MS3108	Connectors, Electric, Plugs, Angle 90°"

(b) Under "DRAWINGS" delete the following:

"Air Force-Navy Aeronautical Standard Drawings

AN3102	Connectors - Electrical, Receptacles, Box Mounting
AN3108	Connectors - Electrical, Plugs, Angle 90°"

Page 3, paragraph 3.4.1, lines 3, 7, and 8: Delete "ciruity" and substitute "circuitry".

Page 4, paragraph 3.4.5.1 Case material, line 1, delete "including the control panel".

Page 4, paragraph 3.4.5.2 Case finish, line 2, delete "including the panel" and "black".

Page 7, FIGURE 3: Panel: Delete, and substitute new Figure 3.

Page 8, paragraph 3.4.5.6 Lid, line 2, immediately after "lid support" insert "of corrosion resistant stainless steel"; line 5, delete "leads" and substitute "cable". Delete the entire fourth sentence.

Page 8, paragraph 3.4.5.7 Latches, lines 1 and 2, delete "with hooks on the case and latches on the lid"; line 3, delete "hooks and".

Page 8, paragraph 3.4.5.9 Panel: At the end of the paragraph add the following sentence: "The outside surface of the panel shall be finished in black."

Page 10, paragraph 3.4.7.3 Cover glass: At the end of the paragraph add the following sentence: "This requirement applies to both indicators shown on figure 4."

1543

H 6625

MIL-T-4687B(ASO)
Amendment -3

Page 11, Table I, delete and substitute:

TABLE I

Dial markings

Markings	Height or length inch ±0.010	Width of line or graduation inch ±0.005	Material or finish
Main dial			
Numerals	0.180	0.031	Durable dull black
Capacity uuf	0.156	0.031	Durable dull black
Major graduations	0.250	0.031	Durable dull black
Background of dial	---	---	Durable dull white
Subdial			
Numerals	0.100	0.015	Durable dull black
Major graduations	0.094	0.010	Durable dull black
Minor graduations	0.063	0.010	Durable dull black
Circle diameter	0.906	0.015	Durable dull black
Background of dial	---	---	Durable dull white

Page 11, paragraph 3.4.8.1 Capacitance section, line 6, delete "three" and substitute "four"; line 7, delete "two" and substitute "three".

Page 12, paragraph 3.4.8.5 Standard electronic parts: The change incorporated in the preceding amendment is deleted by this amendment.

Page 12, paragraph 3.4.8.6 Electron tubes: At the end of the paragraph add the following sentence: "Upon approval by the procuring activity, transistors may be employed in the circuits in lieu of vacuum tubes whenever practicable."

Page 12, paragraph 3.4.8.7 Reference capacitors, line 6, change "capacitor" to "capacitors".

Page 14, paragraph 3.4.8.8.4 Control knob, line 3, delete "to the switch" and substitute "of the switch".

Page 14, paragraph 3.4.11 Input power cable: Delete and substitute:

"3.4.11 Input power cable.- A rubber-jacketed, flexible cable incorporating two insulated, size 20 AWG (0.0320), stranded copper conductors shall be provided along with the adapters described below for facilitating the connection of the tester to the 115V, 400-cps, single-phase, power source. The over-all length of the power cable shall be 20 feet ±6 inches. One end of the power cable shall be provided with an adapter conforming to Part No. AN3057-4A and an associated 90 degree angle connector plug conforming to Part No. MS3108E-10SL-3s. The other end of the power cable shall be provided with an adapter conforming to Part No. AN3057-4A and an associated straight connector plug conforming to Part No. MS3106-10SL-3P. Two adapter cables having an over-all length of 12 ±1 inches shall also be provided. Flexible cable of the same type specified for the power cable shall be provided for the adapter cables. One of the adapter cables shall be provided with an adapter conforming to Part No. AN3057-4A and a cable connecting receptacle conforming to Part No. MS3101-10SL-3s on one end and on the other end the jacket shall be removed from the cable for a length of 6 ±1/2 inch, and each conductor shall be provided with an electrical cable clip, Mueller Electric Company, Part No. 45, or equal. Each clip shall be provided with a flexible insulator protective sleeve. At the point where the electrical conductors protrude from the jacket, suitable means shall be provided for sealing and reinforcing the cable. The other adapter cable shall be provided on one end with an adapter conforming to Part No. AN3057-4A and a cable connecting receptacle conforming to Part No. MS3101-10SL-3s and the other end shall terminate with a Type MS91185 connector plug conforming to Specification MIL-C-3767."

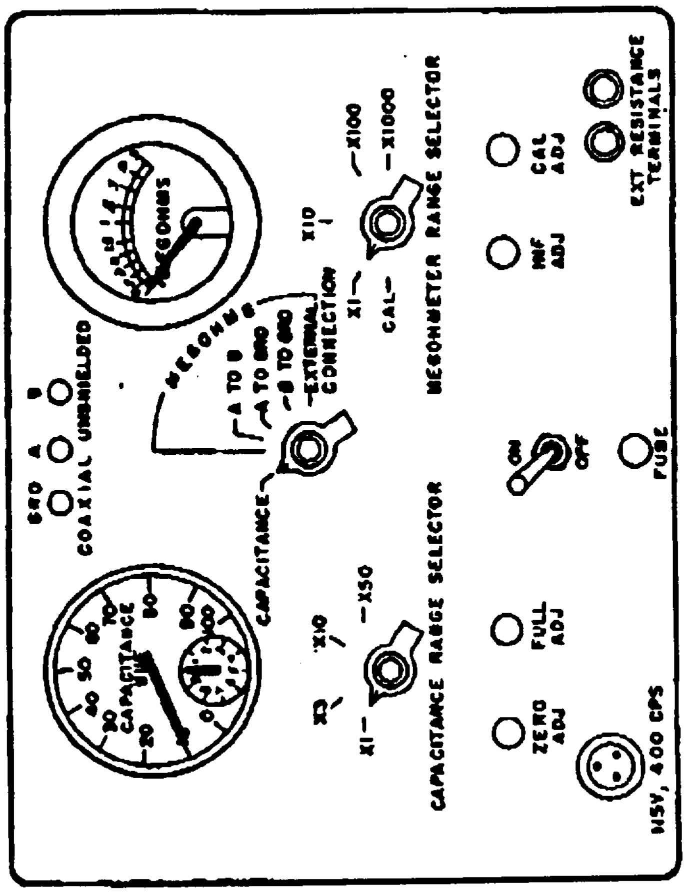


FIGURE 3. Panel

MIL-T-4687B(ASO)
Amendment -3

Page 17, add the following new paragraph:

"3.12.1 Caution placard.- A placard shall be permanently attached to the inside surface of the transit case lid denoting that the tester shall be connected to a 115-volt, 400-cycle, single-phase power source. The placard shall be so designed and located as to be readily conspicuous."

Page 20, paragraph 4.5.2 Operation at room temperature: Delete the last sentence.

Page 21, paragraph 4.5.2.1 Immediately after the last sentence insert: "The same measurement shall be repeated with the resistance standard electrically connected across receptacle A and ground, receptacle B and ground, and across the external resistance binding posts."

Page 21, paragraph 4.5.2.2, subparagraph "(c)", line 4, delete "un-".

Custodians:
Navy - Bureau of Aeronautics
Air Force

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MIL-T-4687B(ASG)
16 JANUARY 1957
Superseding
MIL-T-4687A(ASG)
10 March 1955

MILITARY SPECIFICATION

TESTER, CAPACITOR-TYPE, FUEL-QUANTITY-GAGE TANK UNIT, TYPE MD-2A

This specification has been approved by the Department of the Air Force and by the Navy Bureau of Aeronautics.

1. SCOPE

1.1 This specification covers one type of tank unit tester, designated Type MD-2A. The MD-2 type tank unit tester is inactive for new design.

2. APPLICABLE DOCUMENTS

2.1 The following specifications, standards, drawings, and publications, of the issue in effect on date of invitation for bids, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Federal

QQ-A-318	Aluminum Alloy 52S; Plate and Sheet
QQ-S-571	Solder; Soft (Tin, Tin-Lead, and Lead-Silver)

Military

MIL-C-17	Cables, Radio Frequency; Coaxial, Dual Coaxial, Twin Conductor, and Twin Lead
MIL-W-76	Wire and Cable, Hook-Up, Electrical, Insulated
MIL-T-945	Test-Equipment, for Use with Electronic Equipment; General Specification
MIL-S-4456	Shock, Variable Duration, Method and Apparatus for
MIL-E-4682	Electron Tubes, Choice and Application of
MIL-C-5015	Connectors, Electric, "AN" Type
MIL-D-5028	Drawings and Data Lists: Preparation of Manufacturers' (for Production Aeronautical and Associated Equipment)
MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for
MIL-C-5541	Chemical Films for Aluminum and Aluminum Alloys
MIL-P-5633	Packaging and Packing of Aircraft Material in Steel Shipping Containers
MIL-S-6872	Soldering Process, General Specification for
MIL-S-7742	Screw Threads, Standard, Aeronautical

[illegible] Comp., Dayton, Ohio
4/60 500

MIL-G-7817	Gage, Fuel Quantity, Capacitor Type, Uncompensated, General Specification for
MIL-G-7818	Gage, Fuel Quantity, Capacitor Type, Compensated, General Specification for
MIL-A-8625	Anodic-Coatings, for Aluminum and Aluminum Alloys
MIL-G-8798	Gage System, Fuel-Quantity, Capacitor-Type, Nonvacuum Tube, Integrally Lighted, General Specification for
MIL-M-10304	Meters, Electrical Indicating, Panel Type, Ruggedized
MIL-G-26988	Gage Liquid Quantity, Capacitor Type, Transistorized, General Specification for

STANDARDS

Federal

FED. STD. NO. 595	Colors

Military

MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U. S. Military Property
MS28042	Clamp, Mounting, Aircraft Instruments
MS33516	Case - Standard Dimensions for 3-1/4 Inch Size Instrument
MS33586	Metals, Definition of Dissimilar

DRAWINGS

Air Force-Navy Aeronautical Standard Drawings

AN3057	Adapter, Electrical Accessory to Cable
AN3102	Connectors - Electrical, Receptacles, Box Mounting
AN3108	Connectors - Electrical, Plugs, Angle 90°
AN10404	Pointers - Standard Design of Aircraft Instrument

U. S. Navy

NAL9050	Cap and Chain Assembly CW-123A/U

PUBLICATIONS

Air Force-Navy Aeronautical Bulletins

No. 143	Specifications and Standards; Use of
No. 405	Storage Life - Aeronautical Articles

U. S. Air Force Specification Bulletin

No. 729	Codes for Aircraft Finishing Schemes

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Qualification.- The testers furnished under this specification shall be a product which has been tested and has passed the Qualification tests specified herein.

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3.2 Component parts.- The tester shall consist of a single integral unit incorporating a transit case, instrument case, capacitance measuring circuity of the a-c rebalancing bridge type, d-c electrical-resistance measuring circuity, switches, wiring, and accessories.

3.3 Materials.- Materials shall conform to applicable specifications, as specified. When materials are used which are not specifically designated, they shall be entirely suitable for the purpose. The use of lightweight materials and weight-saving designs is a major consideration, and their use shall be investigated to the greatest possible extent.

3.3.1 Metals.- Metals shall be of the corrosion-resistant type, unless suitably protected to resist corrosion during storage and normal service use.

3.3.1.1 Dissimilar metals.- Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined by Standard MS33586.

3.3.2 Nonmagnetic materials.- Nonmagnetic materials shall be used for all parts, except where magnetic materials are essential.

3.3.3 Fungus-proof materials.- Materials which are not nutrients for fungi shall be used to the greatest extent practicable. Where materials that are nutrients for fungi must be used, such materials shall be treated with a fungicidal agent, as approved by the procuring activity.

3.3.4 Protective treatment.- When materials are used in the construction of the tester that are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage, they shall be protected against such deterioration in a manner that will in no way prevent compliance with the performance requirement of this specification. The use of any protective coating that will crack, chip, or scale with age or extremes of climatic and environmental conditions shall be avoided.

3.3.5 Selection of materials.- Specifications and standards for all materials, parts, and Government certification and approval of processes and equipment, which are not specifically designated herein and which are necessary for the execution of this specification, shall be selected in accordance with ANA Bulletin No. 143, except as provided in the following paragraph.

3.3.5.1 Standard parts.- Standard parts (MS, AN, or JAN) shall be used wherever they are suitable for the purpose, and shall be identified on the drawing by their part numbers. Commercial utility parts such as screws, bolts, nuts, cotter pins, etc, may be used, provided they possess suitable properties and are replaceable by the standard parts (MS, AN, or JAN) without alteration, and provided the corresponding standards numbers are referenced in the parts list and, if practicable, on the contractor's drawings. In the event there is no suitable corresponding standard part in effect on date of invitation for bids, commercial parts may be used provided they conform to all requirements of this specification.

3.4 Design and construction.-

3.4.1 The tester shall be designed to provide two measurement sections, one of which shall be capable of measuring and indicating electrostatic capacitance, and the other shall be capable of measuring and indicating electrical insulation resistance. The circuity design incorporated in the tester shall be suitable for accomplishing the above mentioned measurements on fuel-quantity gage-tank units of the capacitor type conforming to Specifications MIL-G-7817, MIL-G-7818, MIL-G-8798, and MIL-G-26988. The capacitance measuring circuity shall incorporate an a-c rebalancing-type bridge, a high-gain amplifier, and an associated indicator. The insulation-resistance-measuring circuity shall incorporate an indicator and an associated electronic unit. Both measurement sections shall be designed to operate from a 115V, 400-cps, single-phase, a-c power source. The basic measuring circuit provided for the capacitance measuring section shall be fundamentally in accordance with figure 1. The electronic circuit provided for the resistance measuring circuit shall be entirely suitable for the purpose intended. It shall be designed in such manner that no damage is incurred when the test leads or adapter leads are shorted.

3.4.2 General layout.- The general layout of the tester shall conform substantially to figures 2 and 3. The detailed mechanical and electrical design of the tester shall be accomplished by the contractor subject only to the requirements of this specification, these requirements being detailed only to the extent considered necessary to obtain the desired mechanical and electrical characteristics, performance, and permanence of the same. The design, layout, assembly of the tester, and its component parts shall be such as to facilitate quantity production and ease of maintenance and operation. The design shall be subject to approval by the procuring activity.

3.4.3 Measurement ranges.- The capacitance section shall be capable of measuring the direct capacitance of individual tank units or groups of tank units connected in parallel, the capacitance values of which may vary from approximately 0 to 5,000 uuf. The insulation-resistance section shall be capable of measuring the d-c resistance existing between the electrodes of the tank units, as well as the conductors of the associated interconnecting cables with respect to each other and to ground. The insulation resistance shall be measured and indicated in units of megohms over a range of from approximately 0 to 10,000. A selector switch shall be incorporated to permit measurement of either capacitance or insulation resistance. The capacitance measuring section shall incorporate four measuring ranges and a suitable selector mechanism as shown on figure 3. The resistance measuring section shall incorporate four measuring ranges and a calibration check position and a suitable selector mechanism as shown on figure 3.

3.4.4 The construction of the tester shall be mechanically and electrically sound, suitable for the purpose intended, and shall be such as to give assurance of permanence in the accuracy of indications. The design and construction of the tester shall take into account the extreme conditions of temperature, humidity, vibration, shock, and operational requirements specified herein.

3.4.5 Cases.- A transit case and an instrument case shall be provided as shown on figure 2. The instrument case shall be rigidly secured within the transit case by means of screws or other suitable fastening devices which will permit the instrument case to be removable.

3.4.5.1 Case material.- The transit and instrument cases, including the control panel, shall be made of one-half hard aluminum conforming to Specification QQ-A-318. The minimum thickness of the material shall be 0.081 inch for the transit case, including the lid, and 0.064 inch for the instrument case.

3.4.5.2 Case finish.- The inside and outside surfaces of the transit and instrument cases, including the panel, shall be black anodized in accordance with Specification MIL-A-8625. The inside and outside surfaces of the transit and instrument cases shall be finished in final form in accordance with U. S. Air Force Bulletin No. F29, code No. F29-8, color No. 13538 as specified in Federal Standard No. 595.

3.4.5.3 Dimensions.- The outside dimensions for the transit case shall be in accordance with figure 2.

3.4.5.4 Feet.- The transit case shall be provided with 4 feet in the hinged side of the case and 4 feet on the side opposite the lid. The feet may be dimpled or formed projections of the case.

3.4.5.5 Handle.- The transit case shall incorporate a hinged metal handle as shown on figure 2. The handle shall provide a clearance from the case sufficient to pass a block 1-7/8 by 4-3/8 inches in cross section and having the edges rounded to a 15/16-inch radius. The grip portion of the handle shall be of a nonmetallic material and shaped to fit the hand comfortably.

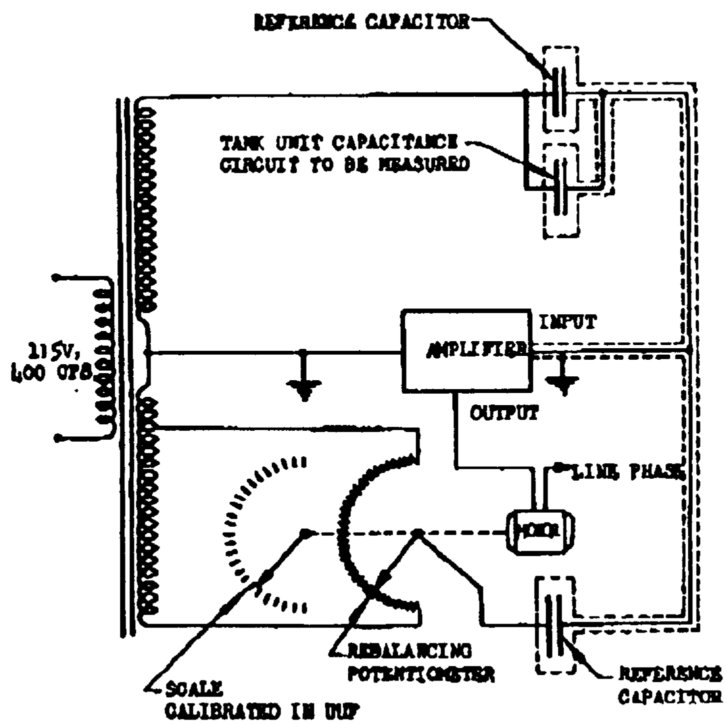
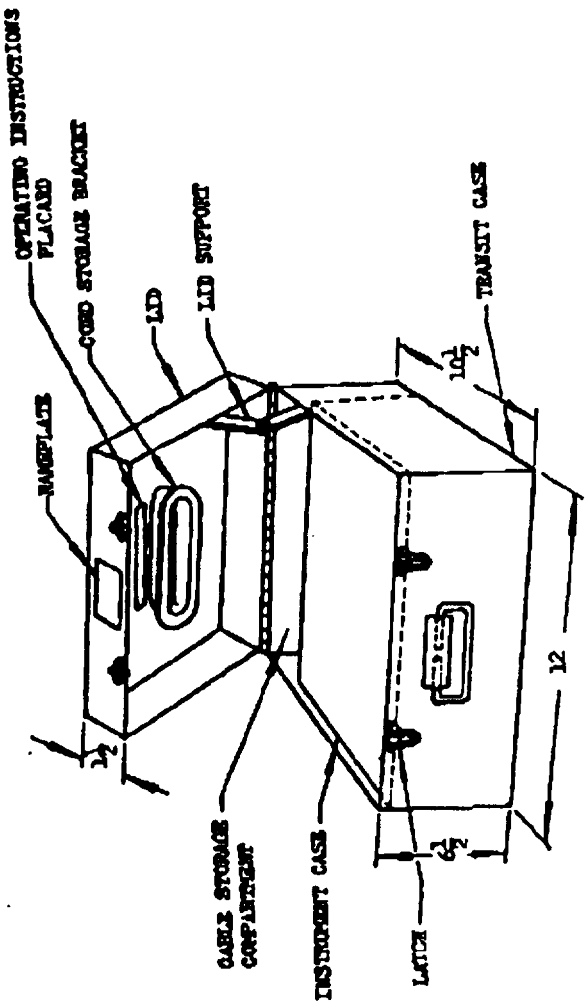


FIGURE 1. Basic capacitance measuring circuit



DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCE: FRACTIONS ±1/16.

FIGURE 2. Case

06-41-15

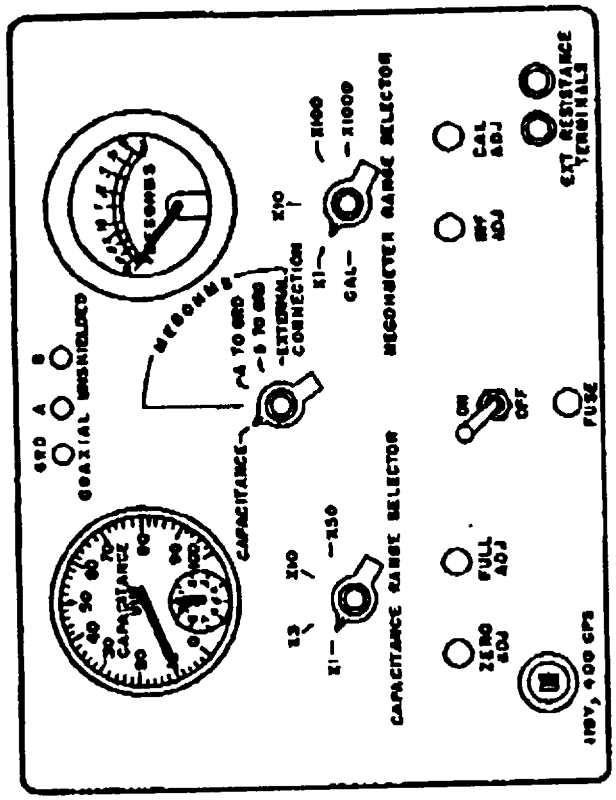


FIGURE 3. Panel

3.4.5.6 Lid.- The transit case shall be provided with a nondetachable lid secured to the case by a hinge of the continuous type. A sturdy lid support shall be fastened to the case and lid for the purpose of relieving hinge strain when the lid is open. A bracket assembly shall be provided on the underneath surface of the lid to permit the winding of the a-c power leads thereon for storage purposes. The bracket assembly shall be of corrosion-resistant stainless steel. Suitable means shall be provided for securing the operating instructions chart on the inside surface of the lid. The lid support shall be mounted in such manner to insure that no damage will result to the stowed cable and adapters.

3.4.5.7 Latches.- Sturdy trunk-type, pulldown latches with hooks on the case and latches on the lid shall be provided for securing the transit case lid as shown on figure 2. The hooks and latches shall be of corrosion-resistant stainless steel.

3.4.5.8 Accessory storage.- A compartment for the storage of all accessories with the exception of the input power cable shall be provided as shown on figure 2. The width of the storage compartment shall be not less than 2.50 inches. The storage compartment shall be free of sharp edges and protrusions.

3.4.5.9 Panel.- The instrument case shall incorporate a panel for mounting the indicators, electronic units, range adjustments, switches, and receptacles. The panel shall be fabricated of aluminum alloy conforming to Specification QQ-A-318, 0.125-inch minimum thickness, or moulded phenolic 0.25-inch minimum thickness. All component parts of the tester, except accessories and shock mounted components, shall be rigidly mounted on the panel to form an assembled unit. The design shall be such that the assembled unit can be readily installed and removed from the instrument case.

3.4.5.9.1 The electronic units shall be shock mounted. The shock mounts employed shall perform satisfactorily regardless of the position of the tester. The design shall also permit the electronic units to be easily and quickly disconnected, removed, and replaced. The capacitance section indicator shall be secured to the panel by an MS28042-2 clamp. The panel layout shall be substantially in accordance with figure 3 and shall be subject to approval by the procuring activity.

3.4.5.10 Moisture pockets.- All pockets, wells, and traps in which water or condensed moisture can collect when the tester is in the normal operating position, shall be eliminated.

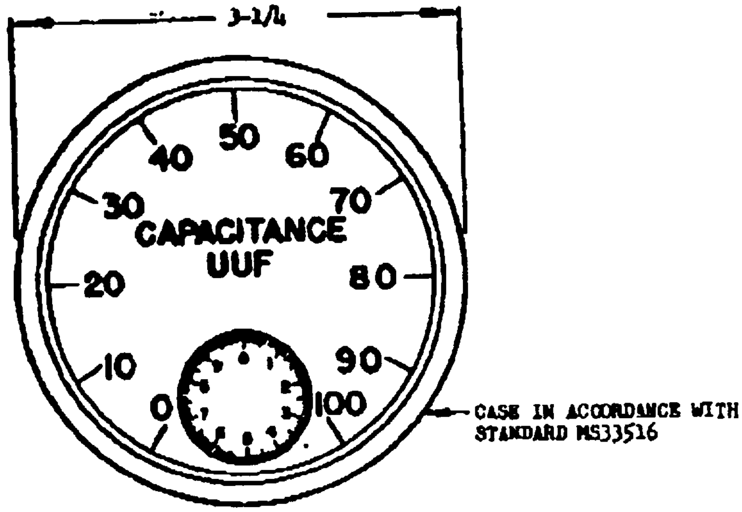
3.4.5.11 Sealing.- The instrument case, panel, control shafts, switches, indicators, and receptacles shall be adequately sealed to meet the requirements specified herein. Gasket materials shall be fungus inert. In general, the following types of material shall be used:

(a) Cellulose acetate
(b) Nylon
(c) Polyvinylchloride
(d) Rubber (natural or synthetic)

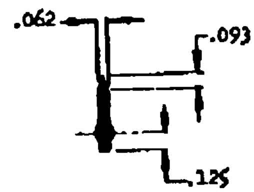
3.4.6 Controls.- All controls provided for the tester shall be readily accessible, suitably arranged, and of such size and construction as to permit convenience and ease of operation under all service conditions by operating personnel. Controls shall rotate freely and smoothly without binding or excessive lost motion. Controls shall be adequately lubricated, where necessary, and such lubricants shall be selected and applied in a manner that the tester will meet the requirements specified herein. Control knobs shall be firmly secured to their respective control shafts by suitable retaining devices.

3.4.7 Indicators.-

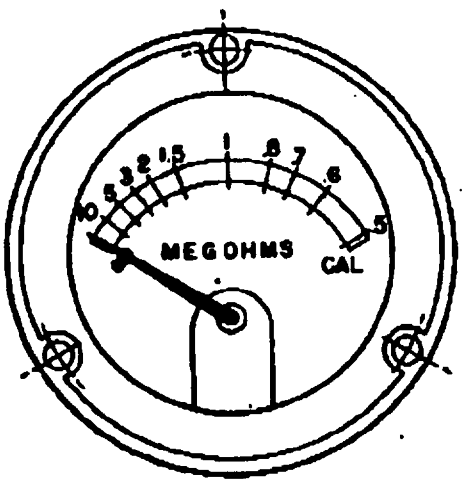
3.4.7.1 The indicator specified for the capacitance-measuring section shall be an electrical receiver, employing a small 2-phase, low-inertia motor, a reduction gear train, and a rebalancing potentiometer assembly. The indicator shall be of the sensitive, subdial-presentation type shown on figure 4.



CAPACITANCE INDICATOR



SUBDIAL POINTER



INSULATION-RESISTANCE INDICATOR

DIMENSIONS IN INCHES. UNLESS OTHERWISE SPECIFIED, TOLERANCES: DECIMALS ±0.005.

FIGURE 4. Indicator

3.4.8.2 Resistance section.- The electronic unit provided for the resistance-measuring circuit shall incorporate a sensitive and stable electron-tube-resistance-measuring circuit. The d-c voltage applied by the circuit across the electrodes and conductors, or both, undergoing test shall not exceed 50 volts. Adjustments as shown on figure 3 shall be provided for properly setting the resistance circuit in order to provide the highest degree of measurement accuracy. Easily detached protective covers incorporating adequate sealing provisions shall be provided on the panel for enclosing respectively the adjustments specified for the capacitance- and resistance-measuring circuits. The design shall not permit removal of the covers from the panel during normal use.

3.4.8.3 Explosion hazard.- The capacitance- and resistance-measuring circuits shall be so designed that the current in the adapter leads shown on figure 5 shall not exceed 0.2 ampere when any combination of circuits are operating under normal conditions and the leads are shorted together, or when the circuits are abnormally operated, e.g., by setting the adjustments to any desired position or by shorting any capacitor or combination of capacitors in the measuring circuits.

3.4.8.4 Input voltage isolation.- Isolation transformers shall be incorporated in the 115-volt, 400-cycle, single-phase input circuit of the tester, in order to eliminate the possibility of operating personnel becoming subjected to dangerous potential because of failure to observe the correct polarity in connecting the input cable of the tester to the power source.

3.4.8.5 Standard electronic parts.- Electronic parts, and the application thereof, shall be in accordance with Specification MIL-T-945.

3.4.8.6 Electron tubes.- Selection of electron tubes shall be in accordance with Specification MIL-E-1682, as applicable.

3.4.8.7 Reference capacitors.- Reference capacitors employed in the capacitance-measuring circuit shall be of the three-terminal type, accurately calibrated, and aged to insure a high degree of stability over extended periods of operation. The capacitors shall be self-contained, i.e., the capacitors shall not be collectively constructed and sealed as a single unit. A trimmer capacitor may be used with each respective reference capacitor to provide a high degree of calibration accuracy, if required. The reference capacitor shall be rated at a minimum of 500V peak across the plates or from either plate to ground. The dissipation factor of the reference capacitors shall not exceed 0.001 at a frequency of 400 cps and at a temperature of 25°C. The reference capacitors shall be adequately sealed and shall be capable of meeting the test requirements specified herein.

3.4.8.8 Switches.- The rotary-type switches shown on figure 3 shall be ruggedly constructed and shall be entirely suitable for the purpose intended. The switches shall incorporate a positive mechanical index locating each contact position. The index mechanism employed shall be designed to prevent the movable element from coming to rest between contact positions.

3.4.8.8.1 Contacts.- The electrical contacts shall be self-cleaning. The material used for the contacts and the processing of the material shall be entirely suitable for the purpose intended.

3.4.8.8.2 Insulation.- The insulation provided for the switches shall be nonporous, ceramic material.

3.4.8.8.3 Stops.- Stops shall be provided to limit the travel of the switches beyond their design ranges and shall be sufficiently rugged to prevent damage to the associated mechanisms.

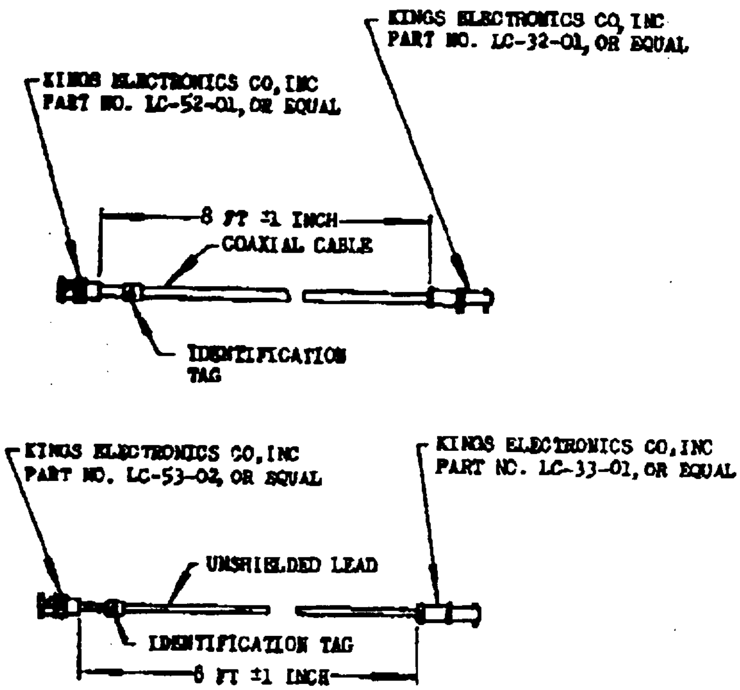


FIGURE 5. Connector cabling

3.4.8.8.4 Control knob.- A one-piece molded phenolic knob, black in color, with a bored, brass insert and bushing for 1/4-inch shaft shall be provided for controlling each rotary switch. The knob shall be firmly secured to the control shaft to the switch by means of a flat or other positive method to prevent slippage. The knob shall incorporate a bar-type extension to facilitate switching operations. The skirt diameter of the knob shall be approximately 0.937 inch. The pointer shall be provided with a white reference marking.

3.4.9 Internal wiring.- All electrical connections within the instrument case shall be suitably supported, in order to alleviate breakage and minimize changes in the measuring circuity caused by strains, jars, vibration, and other conditions incident to shipping, storage, and service. Hook-up wire shall conform to Specification MIL-W-76. Soldering lugs or terminals shall be provided for all points of connection. Before soldering, all wires shall be securely fastened by crimping the wire upon the terminals or lugs.

3.4.10 Electrical connectors.- Unless otherwise approved by the procuring activity, the electrical connectors provided for the capacitance-section indicator shall conform to Specification MIL-C-5015. Lug-type electrical connections shall be provided for the resistance-section indicator. Connector plugs and receptacles required for the adapter leads shall conform to the applicable requirements specified herein. Nonremovable screw-top binding posts of heavy-duty construction, General Radio Company, type 938, or equal, and incorporating suitable insulating materials shall be provided for facilitating external connection of test leads to the insulation-resistance section. Unless otherwise specified by the procuring activity, an electrical connector receptacle conforming to Part No. AN3102E-10SL-3P shall be suitably located on the control panel to permit electrical connection to the input electrical power cable.

3.4.11 Input power cable.- A rubber-jacketed, flexible cable incorporating two insulated, size 20 AWG (0.0320), stranded copper conductors shall be provided as a means for connecting the tester to the 115V, 400-cps, single-phase, power source. The insulation provided for one of the conductors shall be black in color and the other, white in color. On one end of the cable, an adapter conforming to Part No. AN3057-4A and an associated 90-degree-angle connector plug conforming to Part No. AN3108E-10SL-3S, shall be provided. On the other end of the cable, the insulated rubber jacket shall be removed for a distance of 6 ±1/2 inches, and each conductor shall be provided with an electrical cable clip, Mueller Electric Company, Part No. 45, or equal. Each clip shall be provided with a flexible insulator protective sleeve. At the point where the electrical conductors protrude from the rubber jacket, a jacket or other suitable means shall be provided for sealing and reinforcing the cable. The over-all length of the power cable shall be 10 feet ±3 inches.

3.4.12 Connector cabling.- Two detachable cables, including electrical connectors, shall be provided for the tester as shown on figure 5. The connectors provided for one end of the cables shall mate, respectively, with the receptacles provided on the instrument panel. Kings Electronics Company, Inc, receptacles Part No. LC-72-03 and LC-73-03, or equal, shall be provided respectively for the receptacle positions "A" and "B" shown on figure 3. Each receptacle shall be provided with a cap and chain type No. CW-123A/U conforming to Drawing RE449050. The cables shall be equipped with identification tags as shown on figure 5. The material and type of marking employed for the tags shall be capable of satisfactorily withstanding normal service usage and the tests specified in section 4. A binding post shall be provided as shown on figure 3 for grounding the tester.

3.4.12.1 Test leads.- A pair of heavy-duty flexible test leads, equipped with spade- or banana-type terminals on one end and spring clips with protective sleeves on the other end, shall be furnished. The terminals shall satisfactorily mate with the binding posts provided for facilitating the measurement of resistance externally. The color of the insulation provided for the conductors of both test leads shall be black. An additional lead of the same basic design shall be provided for grounding the tester.

3.14.12.2 Adapter leads.- One each of the adapter leads as shown on figure 6 shall be furnished. In addition, one of the adapter leads specified in table II and having the same length as those shown on figure 6, shall be provided.

TABLE II
Adapter leads

Connector required for one end	Type of interconnecting electrical cable required	Connector required for other end	Cable identification letter
Kings Electronics Company, Inc, Part No. LC-53-02, or equal	Unshielded	Kings Electronics Company, Inc, Part No. LC-52-03, or equal	I
Kings Electronics Company, Inc, Part No. LC-53-02, or equal	Unshielded	Kings Electronics Company, Inc, Part No. LC-32-02, or equal	J

3.4.12.3 The coaxial cable specified for the connector cabling and adapter leads shall conform to Specification MIL-C-17, type RG-58C/U. Size No. 20 AWG (0.0320), stranded wire shall be provided for the unshielded leads and shall be insulated with a material which is entirely suitable for the purpose intended. The over-all diameter of the unshielded wire shall be maintained within dimensions of from 0.110 to 0.120 inch.

3.4.13 Soldering.- Soldering shall be in accordance with Specification MIL-S-6872. Solder used for the electrical connections shall be in accordance with Specification QQ-S-571, and of a suitable composition.

3.4.13.1 Soldering flux.- Only rosin, rosin and alcohol, or equivalent plastic rosin mixtures, shall be used as a flux in the assembly of the electrical wiring and connector cables.

3.5 Interchangeability.- All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Changes in manufacturer's part numbers shall be governed by the drawing number requirements of Specification MIL-D-5028.

3.6 Screw threads.- Unless otherwise specified, the threads of all machine screws, 0.060 inch or larger in diameter, shall conform to Specification MIL-S-7742.

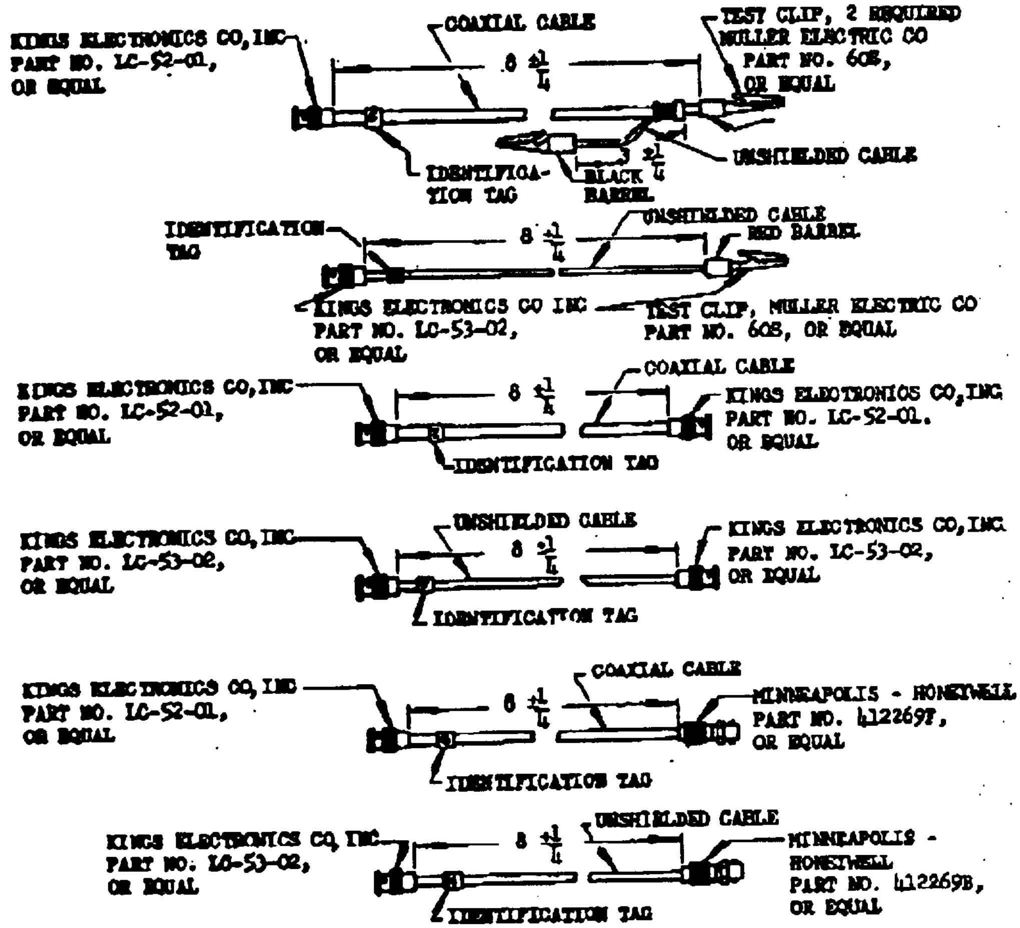
3.7 Weight.- The weight of the tester shall be held to the minimum consistent with high-quality instrument design.

3.8 Finishes and protective coatings.-

3.8.1 Aluminum-alloy parts.- Aluminum-alloy parts shall be covered with an anodic film conforming to Specification MIL-A-8625, except as follows.

3.8.1.1 Dials, small holes, and case inserts need not be anodized.

3.8.1.2 Aluminum alloys which do not anodize satisfactorily shall be coated with a chemical film in accordance with Specification MIL-C-5541.



DIMENSIONS IN INCHES.

FIGURE 6. Adapter leads

3.8.1.3 Where the primary purpose of the treatment is to afford a suitable paint base, chemical treatments in accordance with Specification MIL-C-5541 may be used in lieu of anodizing.

3.8.1.4 When abrasion resistance is a factor, chemical films in accordance with Specification MIL-C-5541 shall not be used in lieu of anodizing.

3.8.2 Bonded aluminum surfaces.- Aluminum surfaces which require bonding shall be provided with means to insure a low-resistance electrical path.

3.9 Performance.- The tester shall be capable of meeting the test requirements specified in section 4.

3.10 Markings.- The text and approximate locations of marking for the instrument panel shall be substantially as shown on figure 3. The markings shall be engraved in the panel and shall be 0.125 ±0.010 inch in height and 0.020 ±0.005 inch in width. The depth of the markings shall be 0.015 ±0.005 inch. Engraved markings shall be filled with enamel or other suitable material, white in color.

3.11 Identification of product.- Equipment, assemblies, and parts shall be marked for identification in accordance with Standard MIL-STD-130.

3.11.1 Use of AN or MIL designations.- AN or MIL designations shall not be applied to a product, except for qualification test samples, nor referred to in correspondence, until notice of approval has been received from the activity responsible for qualification.

3.12 Operating instructions.- Operating instructions shall be attached to the inside surface of the transit case lid as shown on figure 2. The body of the chart shall be white and the markings black. The operating instructions provided shall be capable of satisfactorily withstanding the effects of the tests specified in section 4 and normal service usage. The operating instructions shall include the following:

(a) Procedures to follow in operating the tester.
Note: These data shall include the manner in which the tester should be grounded, connected to the input power source; settings which should be made prior to turning on the tester, settings which should be made after turning on the tester, warm-up time required, and general procedures to follow in measuring capacitance and insulation resistance of fuel gage tank units and associated connector cables. A statement shall be included indicating that the unshielded lead or associated electrode provided for the unmeasured section of compensated tank units shall be grounded when measurements are being made.

(b) Illustration showing the values registered by the capacitance-section indicator when the pointer is maintained at any given fixed position between 40 and 50 on the scale and with the selector switch in positions of X1, X3, X10, and X50.

(c) Illustration showing the values registered by the resistance-section indicator when the pointer is maintained at any fixed position between 1.5 and 2.0 and with the selector switch in positions of X1, X10, X100, and X1000.

3.13 Workmanship.- The tester, including all parts and accessories, shall be constructed and finished in a thoroughly workmanlike manner. Particular attention shall be given to neatness and thoroughness of soldering, wiring, marking of parts and assemblies, welding and brazing, painting, riveting, machine-screw assemblies, and freedom of parts from burrs and sharp edges.

3.13.1 Dimensions.- Dimensions and tolerances not specified, shall be as close as is consistent with the best shop practices. Where dimensions and tolerances may affect the interchangeability, operation, or performance of the tester, they shall be held or limited accordingly.

3.13.2 Screw assemblies.- Assembly screws and bolts shall be tight. The word "tight" means that the screw or bolt cannot be appreciably tightened further, without damage or injury to the screw or bolt or threads.

3.13.3 Cleaning.- The tester shall be thoroughly cleaned of loose, spattered, or excess solder, metal chips, and other foreign material, after final assembly. Burrs and sharp edges, as well as resin flash that may crumble, shall be removed.

4. QUALITY ASSURANCE PROVISIONS

4.1 Classification of tests.- The inspection and testing of the tester shall be classified as follows:

(a) Qualification tests: Qualification tests are those tests performed on samples submitted for approval as qualified products.

(b) Acceptance tests: Acceptance tests are those tests performed on individual lots which have been submitted for acceptance.

4.2 Qualification tests.-

4.2.1 Sampling instructions.- The Qualification test samples shall consist of two testers. Samples shall be identified with the manufacturer's own part number and as required and forwarded to the activity responsible for qualification, designated in the letter of authorization from that activity. (See 6.3.)

4.2.2 Qualification required.- Prior to actual procurement, the product which this specification covers shall pass the Qualification tests specified herein. If this product is later modified in any way, the modified form shall be subjected to and shall pass the same Qualification tests.

4.2.3 Tests.- The Qualification tests shall consist of all the tests of this specification, as described under "Test methods."

4.3 Acceptance tests.- The Acceptance tests shall consist of Individual tests and Sampling tests.

4.3.1 Individual tests.- Each tester shall be subjected to the following tests, as described under "Test methods":

(a)	Examination of product	(4.5.1)
(b)	Operation at room temperature	(4.5.2)
(c)	Sealing	(4.5.3)
(d)	Connector cable and adapter lead	(4.5.4)

4.3.2 Sampling tests.-

4.3.2.1 Sampling plan A tests.- Two testers selected at random from each lot of 100 or less on the contract or order shall be subjected to the following tests, as described under "Test methods":

(a)	Individual tests	(4.3.1)
(b)	Detail examination	(4.5.5)
(c)	Voltage and frequency variation	(4.5.6)
(d)	Low temperature	(4.5.7)
(e)	High temperature	(4.5.8)
(f)	Vibration	(4.5.9)

4.3.2.1.1 Lot.- A lot shall consist of testers manufactured under essentially the same conditions and submitted for acceptance at substantially the same time.

4.3.2.1.2 Rejection and retest.- When one or more items from a lot fail to meet the specification, acceptance of all items in the lot will be withheld until the extent and cause of failure are determined. After corrections have been made, all necessary tests shall be repeated.

4.3.2.1.2.1 Individual tests may continue.- For production reasons, Individual tests may be continued pending the investigation of a Sampling test failure. But final acceptance of the entire lot shall not be made until it is determined that the lot meets all the requirements of the specification.

4.3.2.2 Sampling plan B tests.- Unless otherwise specified, (see 6.2), one tester selected at random from the first 10 items of the contract or order shall be subjected to the following tests, as described under "Test methods":

(a)	Individual tests	(4.3.1)
(b)	Sampling plan A tests	(4.3.2.1)
(c)	Temperature cycling	(4.5.10)
(d)	Shock	(4.5.11)
(e)	Humidity	(4.5.12)
(f)	Cycling test, capacitance section	(4.5.13)

4.3.2.2.1 Rejection and retest.- When one item selected from a production run fails to meet the specification, no items still on hand or later produced shall be accepted until the extent and cause of failure are determined.

4.3.2.2.1.1 Individual tests may continue.- For operational reasons, Individual tests may be continued pending the investigation of a Sampling test failure. But final acceptance of items on hand or later produced shall not be made until it is determined that items meet all the requirements of the specification.

4.3.3 Defects in items already accepted.- The investigation of a test failure could indicate that defects may exist in items already accepted. If so, the contractor shall fully advise the procuring activity of all defects likely to be found and methods of correcting them.

4.4 Test conditions.-

4.4.1 Atmospheric conditions.- Whenever the pressure and temperature existing at the time of the tests are not specified definitely, it is understood that the test is to be made at atmospheric pressure (approximately 29.92 inches Hg) and at room temperature (approximately 25°C) with a relative humidity not exceeding 60 percent. When tests are made with atmospheric pressure, or room temperature differing materially from the above specified values, proper allowance shall be made for the difference from the specified condition.

4.4.2 Position.- Unless otherwise specified, the tester shall be tested in normal operating position.

4.4.3 Capacitance and resistance standards.- The standards specified herein, shall be precision fixed or variable capacitors and resistors, as applicable. The accuracy of the capacitance standards shall be 0.12 percent for capacitance of 50 uuf or more, and 0.1 uuf for capacitances less than 50 uuf. The resistance standards employed may vary from the specific values specified hereinafter by as much as 2 percent. However, the accuracy of the resistance standards employed shall be certified to an accuracy of 0.1 percent. The use of correction charts is permitted. The calibration accuracy of the standards shall be based on Bureau of Standards' certification. The calibration accuracy requirements listed above apply when the standards are maintained at a temperature of 25°C.

4.4.4 Tester adjustment.- Prior to the accomplishment of the tests specified hereinafter, the tester shall be connected to a 115V, 400-cycle, single-phase power source and shall be electrically energized for a period of 5 minutes. Immediately after the warm-up period the capacitance and resistance sections shall be properly adjusted and the adjustment cover secured for the capacitance section. No further changes in the settings of the adjustments for the capacitance section shall be made during the accomplishment of the specified tests. Unless otherwise specified, the resistance section may be readjusted prior to taking readings during the accomplishment of the specified test. Prior to the final setting of the adjustments, it shall be determined that the "zero" adjustment shall permit the main pointer of the capacitance section indicator to be displaced a minimum of 10 degrees counterclockwise from "zero" and a minimum of 10 degrees clockwise from "zero," and that the "full" adjustment shall permit the pointer of the capacitance-section indicator to be displaced a minimum of 10 degrees clockwise from the "100"-scale graduation on the main dial and a minimum of 10 degrees counterclockwise from this mark.

4.5 Test methods.-

4.5.1 Examination of product.- Each tester shall be inspected to determine compliance with the requirements specified herein with respect to materials, workmanship, and marking.

4.5.2 Operation at room temperature.- The calibration accuracy of the tester shall be determined at room temperature by means of the precision capacitance and resistance standards specified in 4.4.3. With the capacitance standard connected to receptacles A and B on the tester by means of suitable electrical cabling, measurements shall be conducted with the capacitance section of the tester when the following capacitance values are introduced. The capacitance values registered by the capacitance-section indicator herein referred to as "reference values" shall not differ respectively from the true capacitance values introduced by the capacitance standard by more than ±0.5 percent of the reading, or ±0.25 percent of the maximum value of each capacitance range, whichever is greater. The values established up scale and down scale shall not differ respectively by more than ±0.15 percent. The same measurement shall be repeated with the resistance standard electrically connected across receptacle A and ground, receptacle B and ground, and across the external resistance binding posts.

10 uuf	400 uuf
20 uuf	600 uuf
40 uuf	800 uuf
60 uuf	1,000 uuf
80 uuf	2,000 uuf
100 uuf	3,000 uuf
180 uuf	4,000 uuf
300 uuf	5,000 uuf

4.5.4 Connector cable and adapter lead.- Each connector cable and adapter lead shall be checked for continuity of wiring. In addition, the d-c resistance of each cable and adapter lead shall be measured with a reliable megohmmeter. The measurements shall be taken between the center conductor and each respective connector shell. The readings established shall be not less than 5,000 megohms.

4.5.5 Detail examination.- The tester shall be critically examined to determine full compliance with regard to physical dimensions, markings, neatness of wiring, soldering, and similar detail requirements.

4.5.6 Voltage and frequency variation.- The tester shall be checked under the combinations of frequency and voltage of the nominal 115V, 400-cps, a-c external power source specified in table III.

TABLE III
Frequency combinations

Conditions	Voltage ±1.0V	Frequency ±5 cps
(1)	115	400
(2)	105	360
(3)	125	440

The change in indications of the capacitance and resistance section of the tester under conditions (2) and (3) from that observed under condition (1) shall not differ by more than 1.0 percent of the reading, or ±0.5 percent of the maximum value of each capacitance range, whichever is greater for the capacitance section, and for the resistance section the readings shall not differ by a resistance value equal to 0.062 inch of scale length at the respective test points. The test shall be conducted at no less than three test points for each measuring section of the tester.

4.5.7 Low temperature.- The testers shall be placed within a test chamber with the internal temperature maintained at -55° ±2°C for a period of 12 hours. At the end of the 12-hour period, the temperature shall be raised to -40° ±2°C for a period of 2 hours. At the end of this period, and while the testers are still at the low temperature, the testers shall be examined and checked to determine that the calibration accuracy does not differ respectively from the "reference values" by more than ±1.0 percent of the reading, or ±0.5 percent of the maximum value of each capacitance range, whichever is greater. For the resistance section, the respective readings shall be noted and shall not differ from the reference values by a resistance value equal to ±0.062 inch of scale length at the respective test points.

4.5.7.1 Calibration measurements at test points corresponding to the "reference values" shall be conducted after the testers have returned to room temperature for a minimum of 12 hours. The calibration accuracy tolerances specified in 4.5.2 shall apply. No change shall be noted which would affect subsequent operations.

4.5.8 High temperature.- The testers shall be placed within a test chamber capable of maintaining an internal temperature of 71° ±2°C for a period of 12 hours. At the end of the 12-hour period, the temperature shall be lowered to 55° ±2°C for a period of 2 hours. At the end of this period, and while the testers are still at the high temperature, they shall be examined and checked to determine that the testers operate satisfactorily and that the calibration accuracy does not differ respectively from the "reference values" by more than ±1.0 percent of the reading, or ±0.5 percent of the maximum value of each capacitance range, whichever is greater. For the resistance section, the respective readings noted shall not differ from the reference values by a resistance value equal to ±0.062 inch of scale length at the respective test points.

4.5.8.1 Calibration measurements at test points corresponding to the "reference values" shall be conducted after the testers have returned to room temperature for a minimum of 12 hours. The calibration accuracy tolerance specified in 4.5.2 shall apply. No damage shall be noted which would affect subsequent operations.

4.5.9 Vibration.- The testers, with the lid closed and secured, shall be mounted on the vibration test stand. The testers shall be vibrated with the frequency varying between 10 and 55 cps at a total excursion of 0.03 ±0.006 inch. The frequency shall be varied uniformly from 10 to 55 cps and returned to 10 cps in approximately 1 minute. The vibration shall be applied in each of the following directions for a period of 1 hour:

(a) Horizontally, parallel to the major horizontal axis of the tester.

(b) Horizontally, at right angles to the major horizontal axis of the tester.

(c) Vertically.

Upon completion of the vibration, the testers shall be inspected to ascertain that no fixed parts have become loose or damaged. The calibration accuracy of the tester shall be checked and shall be within the applicable tolerances specified in 4.5.2.

4.5.10 Temperature cycling.- The tester shall be placed within a test chamber capable of maintaining internal temperatures of -55° ±2°C and 70° ±2°C, respectively, for a period of 2 hours. The tester shall be subjected to a minimum of 5 temperature cycles. Each cycle shall consist of starting at room temperature, lowering and maintaining the temperature at -55° ±2°C for a period of 2 hours, returning to room temperature for a period of 2 hours, raising and maintaining the temperature at 70° ±2°C for a period of 2 hours, and returning to room temperature for a period of 2 hours. Calibration measurements at points corresponding to the "reference values" shall be conducted after the tester has returned to room temperature for approximately 12 hours. The calibration accuracy tolerances specified in 4.5.2 shall apply. No damage shall be noted which would affect subsequent operation.

4.5.11 Shock.- The tester shall be subjected to impact shocks of 25g, each shock impulse having a time duration of 11 ±1 milliseconds in accordance with the test procedure outlined in Specification MIL-S-4456. The shocks shall be applied in the following directions:

(a) Horizontally, parallel to the major horizontal axis (three shocks in each direction for a total of six shocks.)

(b) Horizontally, at right angles to the major horizontal axis (three shocks in each direction for a total of six shocks.)

(c) Vertically, (three shocks in each direction for a total of six shocks.)

Calibration measurements at test points corresponding to the "reference values" shall be conducted after the tester has been subjected to the above shock conditions. The calibration accuracy tolerances specified in 4.5.2 shall apply. No damage shall be noted which would affect subsequent operation.

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4.5.12 Humidity.- The tester shall be subjected to the Humidity test in accordance with Procedure I of Specification MIL-E-5272. The tester shall be mounted in its normal operating position with the lid open and cables and adapters removed. Within 1 hour after the end of the 360-hour period, the calibration accuracy of the tester shall be checked, and the readings established for the capacitance section shall not differ respectively from the "reference values" by more than ±3 percent of the reading, or 1.5 percent of the maximum value of each capacitance range, whichever is greater. For the resistance section, the respective readings shall be noted and shall not differ from the reference values by a resistance value equal to ±0.093 inch of scale length at the respective test points. The external moisture on the panel shall be wiped off with a cloth before testing. The tester shall be visually inspected to determine that no corrosion or other deterioration exists which will affect subsequent operation of the tester.

4.5.13 Cycling test, capacitance section.- The capacitance section of the tester shall be electrically connected to a variable capacitance capable of causing the indicator pointer to transverse the complete scale. During the cycling procedure, the capacitance shall be continuously varied, in order that the indicator pointer moves from "zero" to "end" point and returns to "zero" within 5 ±1 minutes. The total cycling period shall be a minimum of 5,000 cycles and shall be conducted in 12-cycle intervals. After each interval, the tester shall be deenergized electrically a minimum of 10 minutes between cycling intervals. After the cycling tests, the calibration accuracy of the capacitance section shall be checked, and the readings established shall not differ from the "reference values," as applicable, by more than ±1 percent of the reading, or ±0.5 percent of the maximum value of each capacitance range, whichever is greater.

5. PREPARATION FOR DELIVERY

5.1 Application.- The requirements of section 5 apply only to direct purchases by or direct shipments to the Government.

5.2 Packaging and packing.- Each tester shall be packaged and packed for shipment in accordance with Specification MIL-P-5633.

5.3 Marking of shipments.- Interior packages and exterior shipping containers shall be marked in accordance with Standard MIL-STD-129. The identification shall be composed of the following information listed in the order shown:

Stock No. or other identification number as specified in the purchase document*
TESTER, CAPACITOR-TYPE, FUEL-QUANTITY-GAGE TANK UNIT, TYPE MD-2A
Specification MIL-T-4687B
Manufacturer's Part No.

*NOTE: The contractor shall enter the Federal Stock No. specified in the purchase document or as furnished by the procuring activity. When the Federal Stock No. is not provided or available from the procuring activity, leave space therefor and enter the Stock No. or other identification when provided by the procuring activity.

5.3.1 Reinspection date.- The reinspection date markings shall be in accordance with ANA Bulletin No. 405.

6. NOTES

6.1 Intended use.- The Type MD-2A tester covered by this specification is to be used to check the calibration accuracy and electrical insulation qualities of fuel gage tank units of the capacitor type. The tester is designed for field or shop use.

06-37-45

6.2 Ordering data.- Procurement documents should specify the following:

(a) Title, number, and date of this specification.

(b) Whether Sampling plan B tests are to be conducted. (See 4.3.2.2.)

(c) Level of packaging and packing.

6.3 Provisions for qualification.- With respect to products requiring qualification, awards will be made only for such products as have, prior to the bid opening date, been tested and approved for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date.

6.3.1 The attention of suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government, tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Requests for information pertaining to qualification of products covered by this specification should be addressed to the Commander, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, the activity responsible for qualification, with a copy to the Bureau of Aeronautics, Navy Department, Washington 25, D. C.

6.4 Definitions.-

6.4.1 Transit case.- A transit case is a case without a test instrument built in, having a compartment for accessory storage. The transit case is primarily a protective case intended to house the equipment and accessories but is not to be confused with a packing case, and is not intended for initial shipment without additional packing.

6.4.2 Instrument case.- An instrument case is a case protecting the instrument proper and is part of the instrument. Thus, an instrument panel may be part of an instrument case.

6.4.3 Hermetic seal.- A hermetic seal is defined as a perfectly closed and airtight seal made between vitric or metallic materials. A hermetic seal is not intended to include seals accomplished by gaskets.

NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodians:
Navy - Bureau of Aeronautics
Air Force

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November 19, 1998

National Transportation Safety Board
Robert Swaim, AS-40
490 L'Enfant Plaza, E, SW
Washington, DC 20594

Dear Mr. Swaim:

This letter is submitted in response to your letter of November 6, 1998, requesting information on transformer model Honeywell part number 10033398. We have conducted a diligent search of our records and based on those records and our experience, we are able to provide the following responses to your questions.

1. Honeywell drawing 10033398 includes specifications for seven similar transformers, 10033398-101 through 10033398-107. Schott Corporation has previously manufactured all of these except 10033398-103. The quantities and invoice dates for all shipments since 1/1/1990 are shown in Attachment 1. We no longer possess records of our sales history on shipments before that date.

2. Short circuits between windings are a known failure mode for transformers of any origin. Typically, drawing excessive current from one or more secondary windings causes field failures of this nature.

3. Regarding causes of short circuits, the statement following is quoted from Magnetic Circuits and Transformers, M.I.T. Press, Copyright 1943, 15th edition (January, 1965), page 386: "Excessively high insulation temperatures, resulting from serious overloads, cause deterioration of the insulating materials and shorten the life of the transformer." You may find other sources of information available in literature that was not readily available to us.

4. As part of our quality assurance program, all of these parts are tested for excitation current (which would detect any shorts within individual windings) and dielectric strength (which would detect any potential shorts between windings) during the manufacturing process and after completion prior to shipping. According to our record retention policy, we keep test records for five years; however, we were able to locate data on 238 of the 286 parts shipped. Based on the available records, two of the 238 parts (10033398-106) failed for unidentified causes. These two parts were not shipped as they failed testing. There are no records of known failures for shorts or dielectric failures.

We hope this information will be helpful in your investigation.

Yours truly,

Tim Voeller

Tim Voeller
Quality Assurance Manager
Schott Corporation

Attachment 1
Honeywell 10033398 Transformers
Shipments by Schott Corporation

		Qty	Invoice Date	Invoice #
Honeywell P/N: 10033398-101		4	11/12/93	43857
Schott old P/N: 67098750		5	12/2/93	43968
Schott new P/N: 25299		1	12/2/93	43967
Schott P/N assigned 4/11/1985		9	6/30/95	44084
Shipments prior to 1/1/1990 unknown		4	9/21/95	45551
		10	11/15/95	46554
		10	4/11/96	49843
		10	6/27/96	51503
		10	1/17/97	55234
		10	4/3/97	56750
	Total	73		

		Qty	Invoice Date	Invoice #
Honeywell P/N: 10033398-102		10	11/11/92	42127
Schott old P/N: 67136570		16	1/26/93	42462
Schott new P/N: 28557		3	1/28/93	42475
Schott P/N assigned 9/8/1992		6	3/17/93	42691
	Total	35		

		Qty	Invoice Date	Invoice #
Honeywell P/N: 10033398-104		3	4/8/94	44502
Schott old P/N: 67145210		11	8/19/94	40137
Schott new P/N: 24859		1	8/22/94	40156
Schott P/N assigned 2/16/1994		6	9/8/95	45326
	Total	21		

		Qty	Invoice Date	Invoice #
Honeywell P/N: 10033398-105		1	10/18/91	40691
Schott old P/N: 67131520		2	1/6/92	40939
Schott new P/N: 28497	Total	3		
Schott P/N assigned 9/3/91				

		Qty	Invoice Date	Invoice #
Honeywell P/N: 10033398-106		10	11/20/91	40800
Schott old P/N: 67131460		62	5/7/92	41336
Schott new P/N: 28306		49	6/19/92	41503
Schott P/N assigned 8/20/91		29	7/9/93	43254
	Total	150		

		Qty	Invoice Date	Invoice #
Honeywell P/N: 10033398-107		4	1/6/92	40940
Schott old P/N: 67131930	Total	4		
Schott new P/N: 28594				
Schott P/N assigned 11/22/91				

Swaim Bob

From: Taylor, Lou (MN51) [LTaylor@cfsmo.honeywell.com]
Sent: Thursday, December 17, 1998 10:53 AM
To: Swaim Bob
Subject: RE: Updated B-747 Transformer usage

Importance: High

xfmr_2.doc

Bob,
I saved it as a Word 6.0 / Word 95 file this time. Let me know if you have
any trouble with this one.
<<xfmr_2.doc>>
Merry Christmas
Lou

> ----------
> From: Swaim Bob[SMTP:SWAIMBO@NTSB.gov]
> Sent: Thursday, December 17, 1998 8:58 AM
> To: Taylor, Lou (MN51)
> Cc: Speranzo, Neal (MN51); Gille, Robert (MN51); Gilbertson, Shelly
> (MN17)
> Subject: RE: Updated B-747 Transformer usage
>
> Thank you for your message, but the attachment only opened to be 68 pages
> of
> illegible content. Maybe you could resave it as a lower WORD document or
> as
> a RTF.
>
> Thanks
> Bob
>
> -----Original Message-----
> From: Taylor, Lou (MN51) [mailto:LTaylor@cfsmo.honeywell.com]
> Sent: Tuesday, December 15, 1998 3:51 PM
> To: Swaim Bob
> Cc: Speranzo, Neal (MN51); Gille, Robert (MN51); Gilbertson, Shelly
> (MN17)
> Subject: Updated B-747 Transformer usage
> Importance: High
>
>
> Bob,
> Attached is an updated sheet on the transformer usage. The previous
> sheet showed no usage for the -103 transformer, I have since discovered
> there were 33 of these transformers sent out as spares. I have verified
> that we did not order any -103's during this time so we must have been
> shipping from stock on hand. The quantity of -101's is also increased by
> one, we just received an order for one from British Airways.
>
> You will notice a large quantity of -106 transformers. This
> transformer is used when a JG603C4 is modified to a JG603C80. I believe
> the
> vast majority of these transformers were used for mod and not as
> replacements for failed transformers.
>
> I checked where we shipped transformers for the past three years
> (1996 --> 1998). They were all sent in quantities of one or two to
> airlines
> who do repair work or to repair shops.
> <<transformer spares, rev1.doc>>
>
> Lou
>

Table 1: Transformers which have been sent out as spares during 1992 to 1998

Transformer 10033398								
Dash →	-101	-102	-103	-104	-105	-106	-107	
Tank →	CWT, 2, 3	1R, 4R	1, 4	2R, 3R	Body Tank	1R, 4R	Body Tank	
JG603 →	C3, C44, C51, C52	C4, C42	C2, C43	C67, C70	C73, C81	C80	C78	
Year	Quantity of transformers sent out as spares							Total
1992	10	14	4	1	0	69	0	98
1993	13	2	7	5	0	0	0	27
1994	7	1	6	12	0	3	0	29
1995	19	4	5	4	0	0	0	32
1996	14	5	0	0	0	0	0	19
1997	4	3	4	0	0	1	0	12
1998	11	2	7	0	0	0	0	20
Total	78	31	33	22	0	73	0	237

Note: Honeywell Service Bulletin JG603-28-01 provides instructions for modification of a JG603C4 indicator into a JG603C80 indicator. Part of the modification replaces the dash 102 transformer with a dash 106 transformer to adjust the scale from 3,500 pounds to 4,000 pounds. The quantity of 69 dash 106 transformers in 1992 is most likely associated with performing this modification.

Table 2: Transformers are used on Boeing 747 Classic fuel guage

Dash #	JG603	Fuel Tank	Lbs / Kg	Scale
-101	C3	CWT, 2, 3	Lbs	0 → 95,000 Lbs
	C44		Kg	0 → 50,000 Kgs
	C51		Lbs	0 → 150,000 Lbs
	C52		Kg	0 → 60,000 Kgs
-102	C4	1R, 4R	Lbs	0 → 3,500 Lbs
	C42		Kg	0 → 2,000 Kgs
-103	C2	1, 4	Lbs	0 → 35,000 Lbs
	C43		Kg	0 → 20,000 Kgs
-104	C67	2R, 3R	Kg	0 → 3,000 Kgs
	C70		Lbs	0 → 6,000 Lbs
-105	C73	Body Tank	Lbs	0 → 40,000 Lbs
	C81		Lbs	0 → 13,000 Lbs
-106	C80	1R, 4R	Lbs	0 → 4,000 Lbs
-107	C78	Body Tank	Kg	0 → 6,000 Kgs

Table 3: Transformers ordered by Honeywell (all but 25 of the –102's are from Schott)

Transformer 10033398								
Dash →	-101	-102	-103	-104	-105	-106	-107	
Year	Quantity of transformers ordered by Honeywell							Total
1991	0	0	0	0	3	10	4	17
1992	0	60	0	0	0	112	0	172
1993	10	0	0	0	0	30	0	40
1994	0	0	0	15	0	0	0	15
1995	23	0	0	6	0	0	0	29
1996	40	0	0	0	0	0	0	40

1997	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0
Total	73	60	0	21	3	152	4	313

Ronald J. Hinderberger
Director
Air Safety Investigation

Boeing Commercial Airplane Group
P.O. Box 3707 MC 67-PR
Seattle, WA 98124-2207

BOEING

12 January 1999
B-B600-16589-ASI

Mr. R. Swaim, AS-40
National Transportation Safety Board
490 L'Enfant Plaza East, SW
Washington, DC 20594-0003

Subject: Resistor Sizing, TWA 747-100, N93119 Accident off Long Island, NY - 17 July 1996

Reference: Your email dated 1 December 1998

Dear Mr. Swaim:

In your reference email message you questioned what the design requirements were for sizing the resistor in the AIDS Burndy block.

Neither Boeing nor Honeywell could find any design records for sizing the resistor. However, the resistor sizing would have been accomplished with the same safety requirements in mind as the basic FQIS in terms of voltage, current, and energy levels available under failure conditions. It is believed by both Boeing and Honeywell, that Honeywell at least reviewed and approved the resistor size prior to the release of the design.

Although the design records were not found, the fuel system safety requirement implementation can be seen when calculating the fault current resulting from a short of the FQIS/AIDS line to the AIDS power supply of 115Vac. This current is 2.2 milliamps which is well below the 10 milliamps maximum safe fault current allowed on probe wiring.

If you have any questions, please do not hesitate to call.

Very truly yours,

for Ronald J. Hinderberger
Director, Air Safety Investigation
Org. B-B600, M/S 67-PR
Telex 32-9430, STA DIR PURVIS
Phone (425) 237-8525
Fax (425) 237-8188

Enclosures: TWA Wiring diagram, 2 pages

cc: Mr. A. Dickinson, IIC

Ronald J. Hinderberger
Director
Air Safety Investigation

Boeing Commercial Airplane Group
P.O. Box 3707 MC 67-PR
Seattle, WA 98124-2207

BOEING

29 January 1999
B-B600-16589-ASI **R1**

Mr. R. Swaim, AS-40
National Transportation Safety Board
490 L'Enfant Plaza East, SW
Washington, DC 20594-0003

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Although the design records were not found, the fuel system safety requirement implementation can be seen when calculating the fault current resulting from a short of the FQIS/AIDS line to the AIDS power supply of 115Vac. This current is 2.2 milliamps which is well below the 10 milliamps maximum safe fault current allowed on probe wiring.

If you have any questions, please do not hesitate to call.

Very truly yours,

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Telex 32-9430, STA DIR PURVIS
Phone (425) 237-8525
Fax (425) 237-8188

Enclosures: TWA Wiring diagram, 2 pages

cc: Mr. A. Dickinson, IIC

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

Attached Documents from

KC-135 FUEL QUANTITY INDICATING SYSTEM

FAILURE ANALYSIS,

Dated July 31, 1980

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

4 December 1998

OC-ALC/PA
3001 Staff Dr Ste 1AG78A
Tinker AFB OK 73145-3010

National Transportation Safety Board
Attn: R. Swaim, AS-40
490 L'Enfant Plaza, E, SW
Washington DC 20594

Dear Mr. Swain

The Office of Public Affairs has approved your request for release of Boeing Document Number D3-11796-1. The material provided has been reviewed by Mr. David Luke, OC-ALC/LCR, and has been proven to be technically accurate, unclassified, suitable for open publication and does not violate contractor's proprietary rights.

Questions pertaining to this matter can be directed to the undersigned at (405)739-2026.

RHONDA L. LUGO
Security and Policy Review
Office of Public Affairs

THE BOEING COMPANY

FSCM NO. 82918

THIS DOCUMENT IS:

CONTROLLED BY 3-78133 AVIONICS AND ELECTRICAL SYSTEMS

ALL REVISIONS TO THIS DOCUMENT SHALL BE APPROVED BY THE ABOVE ORGANIZATION PRIOR TO RELEASE.

PREPARED UNDER ☒ CONTRACT NO. F34601-79-C-2930
☐ IR&D
☐ OTHER

DOCUMENT NO. D3-11796-1 MODEL KC135

TITLE KC-135 FUEL QUANTITY INDICATING SYSTEM FAILURE ANALYSIS

****

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PREPARED BY	B. Weniger G. May	7813	7-30-80
SUPERVISED BY	B. Keton	7813	7/31/80
APPROVED BY	D. Fitch	7813	7/31/80
	S. Starch	8830	

E4319 Rev. 2/80

TABLE OF CONTENTS

FIGURES

1.0 INTRODUCTION

This report describes a failure analysis on the KC-135 Fuel Quantity Indicating System and is divided into three parts:

- o Analytical Ground Fault Evaluation
- o Discussion of investigation into electro statics
- o Recommendations

1.1 BACKGROUND

A KC-135 aircraft experienced a ground fire in the aft body tank. A possible ignition source was believed to be associated with the fuel quantity probe.

1.2 STUDY REQUIREMENTS

Oklahoma City Air Logistics Center (OCALC) established engineering task No. 80-2A-43 to perform a KC-135 Fuel Quantity Indicating System Failure Analysis.

An engineering assignment was issued by OCALC/MMSRG to task Boeing Military Airplane Company (BMAC) to perform the desired study. The assigned tasks were:

- o Conduct an analytical evaluation of potential failure modes or faults in the Fuel Quantity Compensator Probe and it's circuitry to determine if the potential exists for a .25 millijoule energy level. The study shall include but not limited to the following:

  (1) Fuel probe energy levels under various failure or fault conditions.
  (2) Fuel probe compensator energy levels under various failure or fault conditions.
  (3) Evaluate potential static electricity inter-relationship with probe installations.
  (4) Identify possible candidate fault conditions for subsequent testing and recommend type of tests and test requirements to be conducted if appropriate.

1.2.1 .25 MILLIJOULE ENERGY LEVEL

Figure 1 shows that the spark ignition energy varies with the fuel-air ratio of the mixture and tends to be minimum near the stoichiometric mixture ratio for complete combustion. For paraffinic hydrocarbons, their minimum ignition energy (MIE) is approximately 0.25 MJ at atmospheric pressure and normal temperature. This information is from Pittsburgh Mining and Safety Research Center Bureau of Mines, Report No. 4193, August 1973.

1.3 STUDY ACTIVITY DISCUSSION

For purpose of establishing a baseline, it was decided to use the aft body tank indicating system for analysis.

1.3.1 DISCUSSION OF ANALYTICAL GROUND FAULT EVALUATION

In response to the engineering assignment described in Para. 1.2, BMAC engineering found early in the study, that the original Fuel Quantity Indicator/Power Supply, Honeywell P/N JG131A6, was modified by TCTO No. 5LG-3-20-501 to a new P/N JG131A33. This modification included a transformer change in the power supply section from a 24V (RMS) secondary winding to a transformer with a 38V, RMS, secondary. This change was initiated to allow easier field calibration of the fuel quantity system for the empty level adjustment.

Figure 2 shows the schemetic and wiring diagram for the aft body tank fuel quantity system, including the indicator/power supply. For the purpose of this analysis, we will concern ourselves with the portion of the circuit that has the highest voltage output to the fuel cell. This is the secondary winding of the transformer that has the 2K OHM "Empty" adjustment pot, with a 1K OHM current limiting resistor, out thru pin "N" of the indicator/power supply connector and on to the inner electrode of the probe in the fuel cell.

Figure 3 represents a simplified version of this circuit used for the analysis and shows the 38V transformer tap, 1K OHM current limiting resistor (R_1) and the fuel probe with a potential ground fault (RF) on the electrode. It should be remembered that this is a fault to ground and in-so-much as we are only concerned with hazards in the fuel cell area, we are assuming the ground fault on the active portion of the electrode, wire to the electrode or in the fuel tank connector wiring. Also, we have in Figure 3, set the ground fault at 1KOHM which is the worst case condition due to the fact that maximum power transfer will occur when ground fault resistance (R_F) is equal to the 1K OHM current limiting resistor (R_1). That is to say that maximum power will occur when $R_1 = R_F$. Therefore, applying OHM's law as shown on Figure 3, the total current in the circuit (I_F) can be determined.

$$I_F = \frac{V}{R_1 + R_F}$$

Knowing I_F we can then compute the amount of power (in watts) in the ground fault (R_F) with the following formula.

$$P_{RF} = I_F^2 \times R_F$$

In-so-much-as, 1 watt second is equal to 1 joule (joule is a measurement of energy and is a function of power and time), the amount of energy or joules can be arrived at by multiplying P_{RF} (Power in

Rev. 2 80

ground fault in watts) times time in seconds.

Assuming the worst case condition having the empty adjust pot turned full CW allowing the maximum 38V on the circuit, and a 1K OHM ground fault R_F, using the above formulas we have:

$$I_F = \frac{38V}{1000 + 1000} = .019 \text{ AMP}$$

$$P_{RF} = (.019)^2 \times 1000 = .361 \text{ watts}$$

$$.361 \text{ watts} \times .001 \text{ sec} = .000361 \text{ joule} = \underline{.361 \text{ millijoule}}$$

.001 second is used for simplicity. Thru analysis using peak voltage of this transformer instead of RMS voltage, it has been determined that the minimum time required to develop .25 MJ is actually .000375 second.

This .361 millijoule energy level is above the MIE of .25 MJ allowed in Para. 1.2. A full range of ground fault resistances was computed with the above formulas and plotted on a curve. See figure 4. Also on Figure 4, results of computations using the original 24V transformer (Para. 1.3.1) are plotted reflecting energy levels below the .25MJ level.

1.3.2 GROUND FAULT POSSIBILITIES

Figure 5 shows the fuel probe wiring in the fuel cell. The potential for a ground fault in the probe and it's wiring is present as can be seen in Figure 5. A short from the wire shielding to the inner electrode circuit or between the active and ground grid of the electrode itself, can produce energy levels above .25 MJ.

1.3.3 DISCUSSION OF ELECTRO STATICS

Explosions and fires have occured from time to time during the filling of a wide variety of shapes and sizes of tanks with liquid hydrocarbons. It has been recognized for many years that one source of ignition of such a fire is the discharge of electrostatic charges accumulated in the fuel tank.

Electrostatic charges are generated in fuel flowing thru pipes and hoses and to a much greater extent in fuel flowing thru filters and at high flow rates. Factors affecting electron build-up in fuel are as follows:

(A) Flow rate thru pipe
(B) Pipe material
(C) Filtering
(D) Agitation
(E) Splash filling from top
(F) Bottom filling that creates turbulence

These electron build-up factors can also be greatly aggravated by the following conditions:

(A) Water considerably enhances build-up rate
(B) Insulated fuel tanks restrict discharge
(C) Gas bubbles
(D) Solids settling

The amount and polarity of charge generated depends on the trace polar materials in the fuel and on the pipe or filter thru which the fuel passes.

When fuel carrying static charge is filled into a tank, an electric field can be produced in the vapor space of the tank and much higher electric fields at the ends of any metal protrusions in the vapor space. If the field strengths are sufficient, then electric discharges will occur between the metal protrusion and the fuel surface. Further, electric discharges are more likely to occur if the tank is nonconducting (such as rubber lined tank) than if it is a good conductor or there are grounded conductors in the tank, The flow of hydrocarbon liquids such as JP4 through pipe and hose lines may develop considerable volumetric electrification by the contact difference of potential. Since the resistance of hydrocarbon liquids is very high, the electric charges do not dissipate readily. Discharge rate is much longer, of course, in the case of insulated tanks. Measurements have shown that the generation of electricity in these liquids increases about linearly with the rate of flow. On the average, the rate of flow of the electric charges has been found to be approximately 3×10^{-10} amps per gallon per minute.

Therefore, the control of static build-up during fuel transfer is a major consideration. Some methods for the control of static build-up during fuel transfer are as follows:

(A) Additives that make the fuel more conductive.
(B) Fuel at reduced flow rates.
(C) Anti-static agents coating non-metals.
(D) Active neutralizer system.
(E) Larger pipe diameters after filtering.
(F) Bottom filling.
(G) Ground any conductor in tank.
(H) Keep fuel tanks clean (Water, etc.)

Measurements have also shown that the built-up charges in insulated tanks, accumulate on the surface of the liquid and will be greatly concentrated in the area of any isolated (non-grounded) metallic object.

A cause for fires and explosions, however, may have arisen from a somewhat different condition wherein an insulated conductive member forming a plate of a capacitor, such as a clamp, or metal label isolated by an insulator or glue, becomes charged from electrostatic induction over a period of time. Because of the imperfect high resistance insulation between such materials, electric charges are induced slowly into these partially insulated parts such as by charged fuel. These charges will remain impounded as the result of the high resistance. Therefore, a high voltage can exist between the "Electrified" capacitor and ground which is a potential source of fire hazard. All that is needed to initiate a fire or explosion resulting from such a charged part is the synchronized occurrence of a flammable mixture and a spark of sufficient energy to cause ignition.

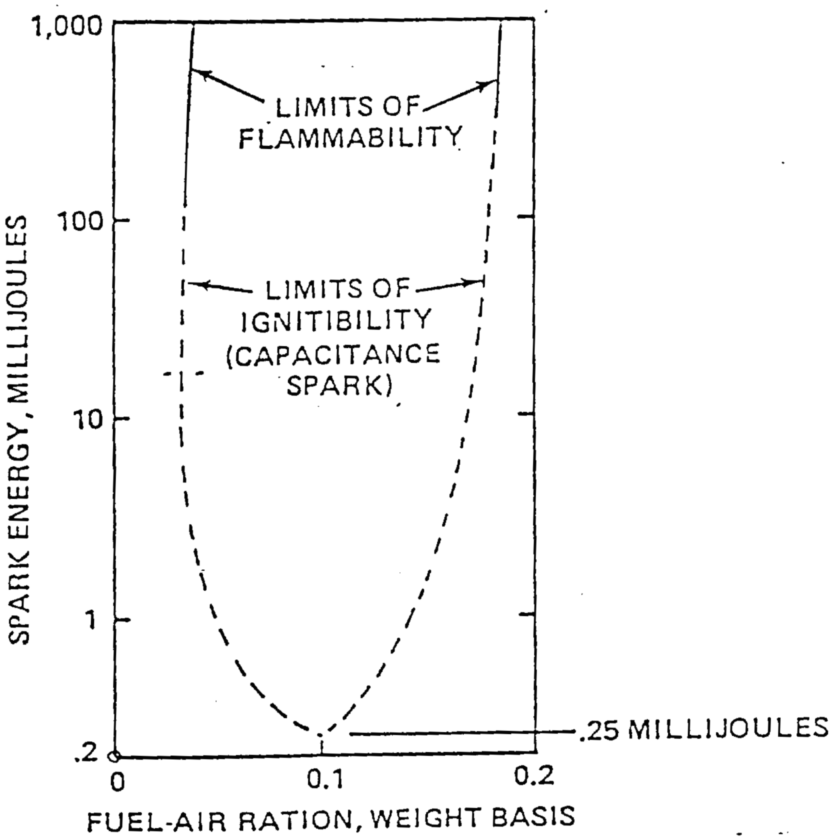
Therefore, in localities where flammable fuel-air mixtures may cause hazardous atmospheres, extra precautions should be taken to insure thorough bonding and grounding of all isolated metal parts.

2.0 SUMMARY

Although the entire fuel quantity system was evaluated, only the worst case, or that part of the circuit most probable to create a hazardous condition, was analyzed in detail. Analysis of the power supply of the indicator has shown that an energy level of .25MJ is available in a ground fault condition. BMAC has learned thru conversation with independent testing labs, that if analysis shows a probable hazardous condition, the suspected circuit should be tested on special spark gap equipment to determine if this condition could create an explosion. Also, in the area of electrostatics, BMAC has learned that hydrocarbon fuels do take on electric charges in fuel transfer. In fact, JP4 is one of the most susceptible liquids for electron build-up and retention of that charge. Electrostatics is a phenomenon and must be dealt with accordingly.

3.0 RECOMMENDATIONS

- o Continue computer fault analysis on the complete fuel quantity indicator system.
- o Conduct laboratory testing using the fuel quantity indicator system on spark gap machinery with fuel vapor to demonstrate conclusively, whether or not the energy level available in the system could be hazardous with a ground fault.
- o Conduct a visual inspection of fuel tanks in an aircraft to define all isolated (non-bonded) metal.
- o Task Boeing to define procedures/methods suitable for a TCTO to implement resulting necessary modifications from the above activities.



SPARK IGNITION ENERGY VS FUEL-AIR RATIO FOR N-BUTANE-AIR MIXTURES AT 1 ATMOSPHERE AND 78°F.

FIGURE 1

LIMITS OF FLAMMABILITY

KC300007-77

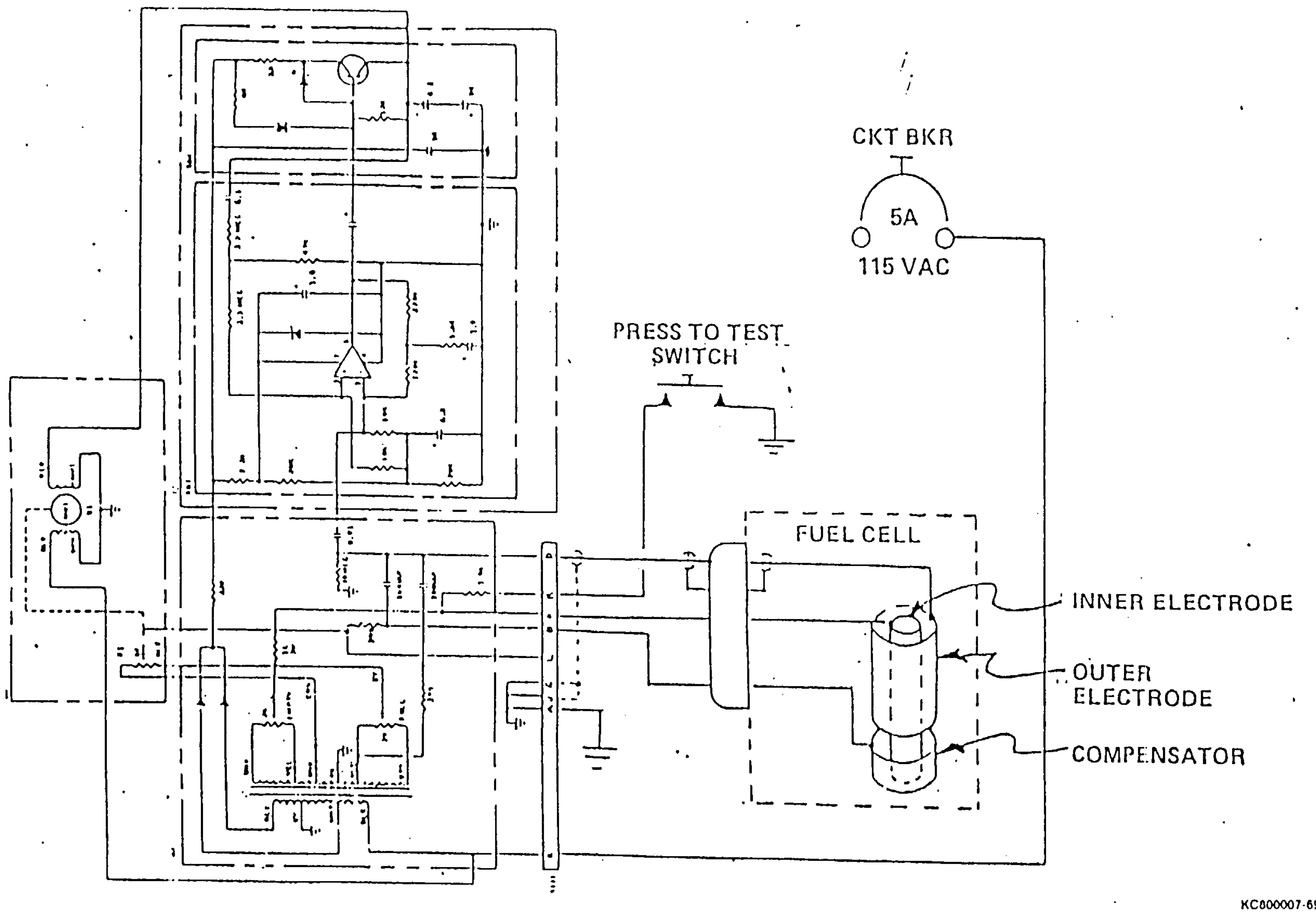
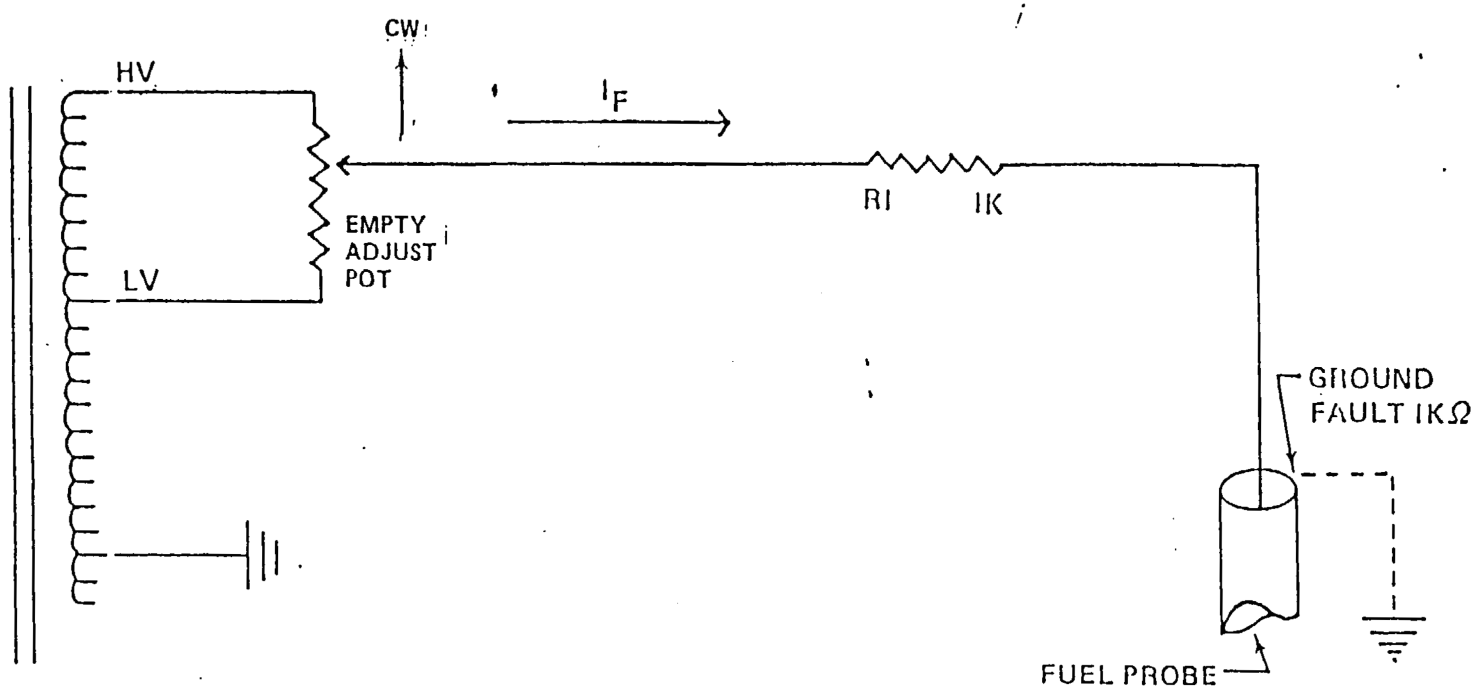


FIGURE 2

FUEL QUANTITY INDICATOR



$$I_F = \frac{V}{R_1 + R_F}$$

$$P_{R_F} = I_F^2 \times R_F$$

$$P_{R_F} \times .001 \text{ SEC.} = \text{JOULES}$$

KC800007-76

FIGURE 3

SIMPLIFIED FAULT CIRCUIT

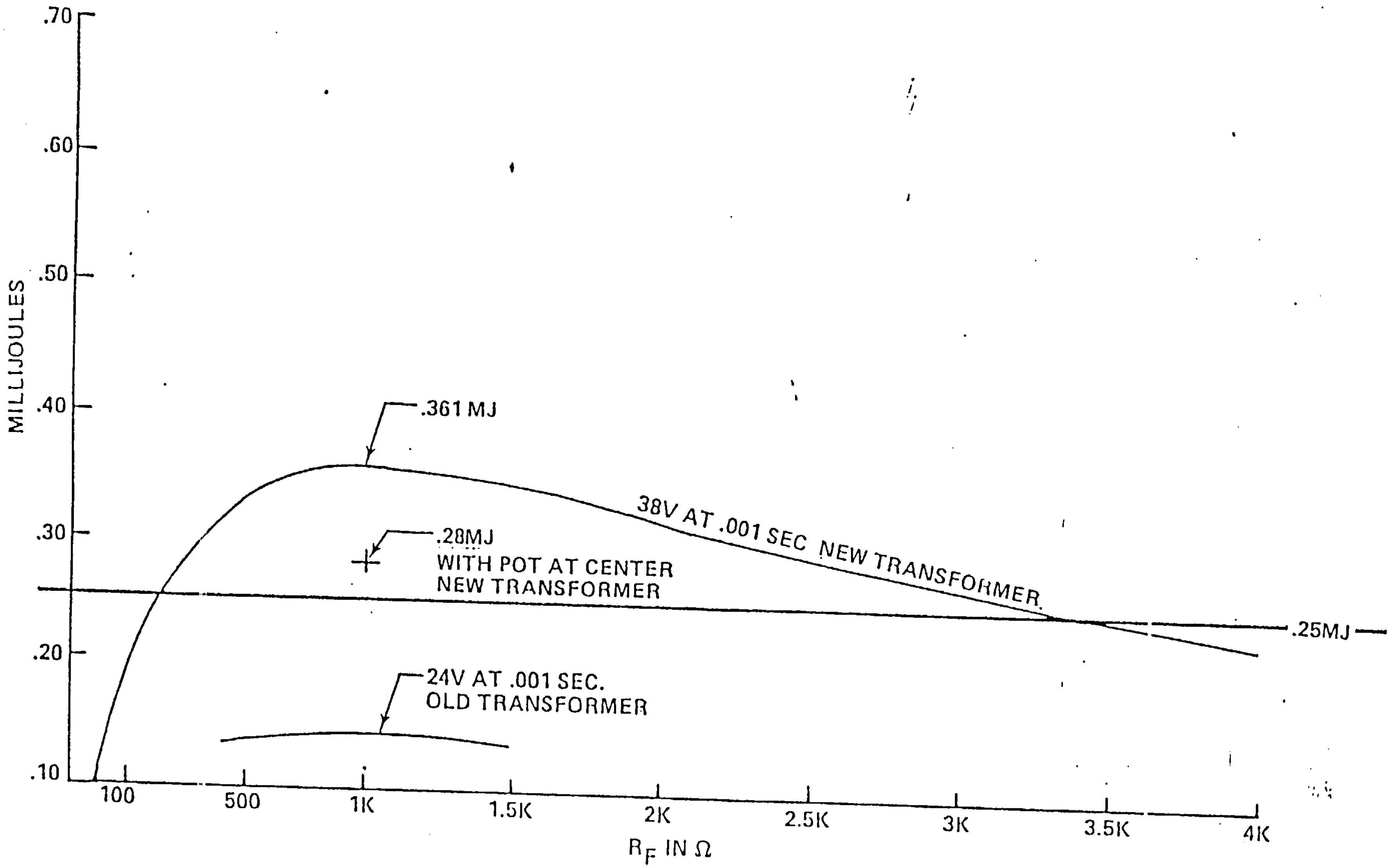


FIGURE 4

FAULT POWER CHART.

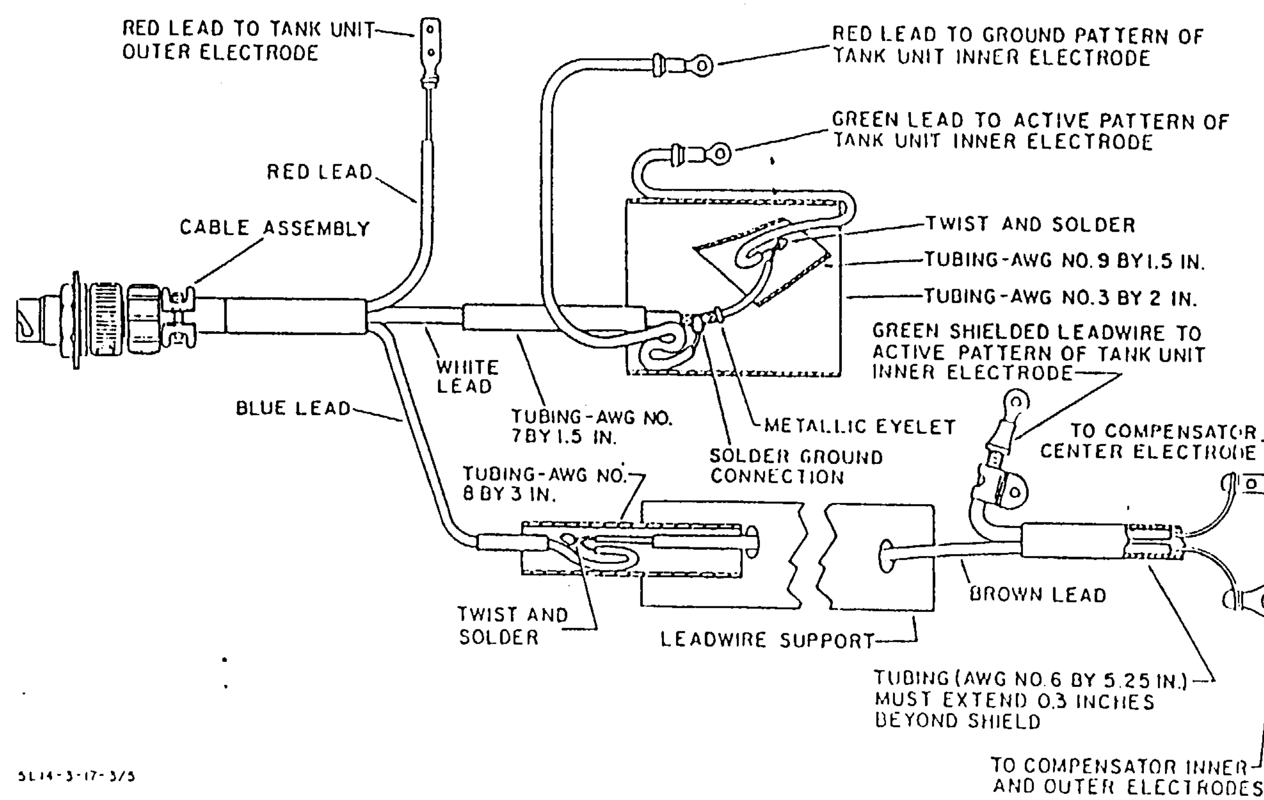


FIGURE 5

TANK UNIT-COMPENSATOR WIRING

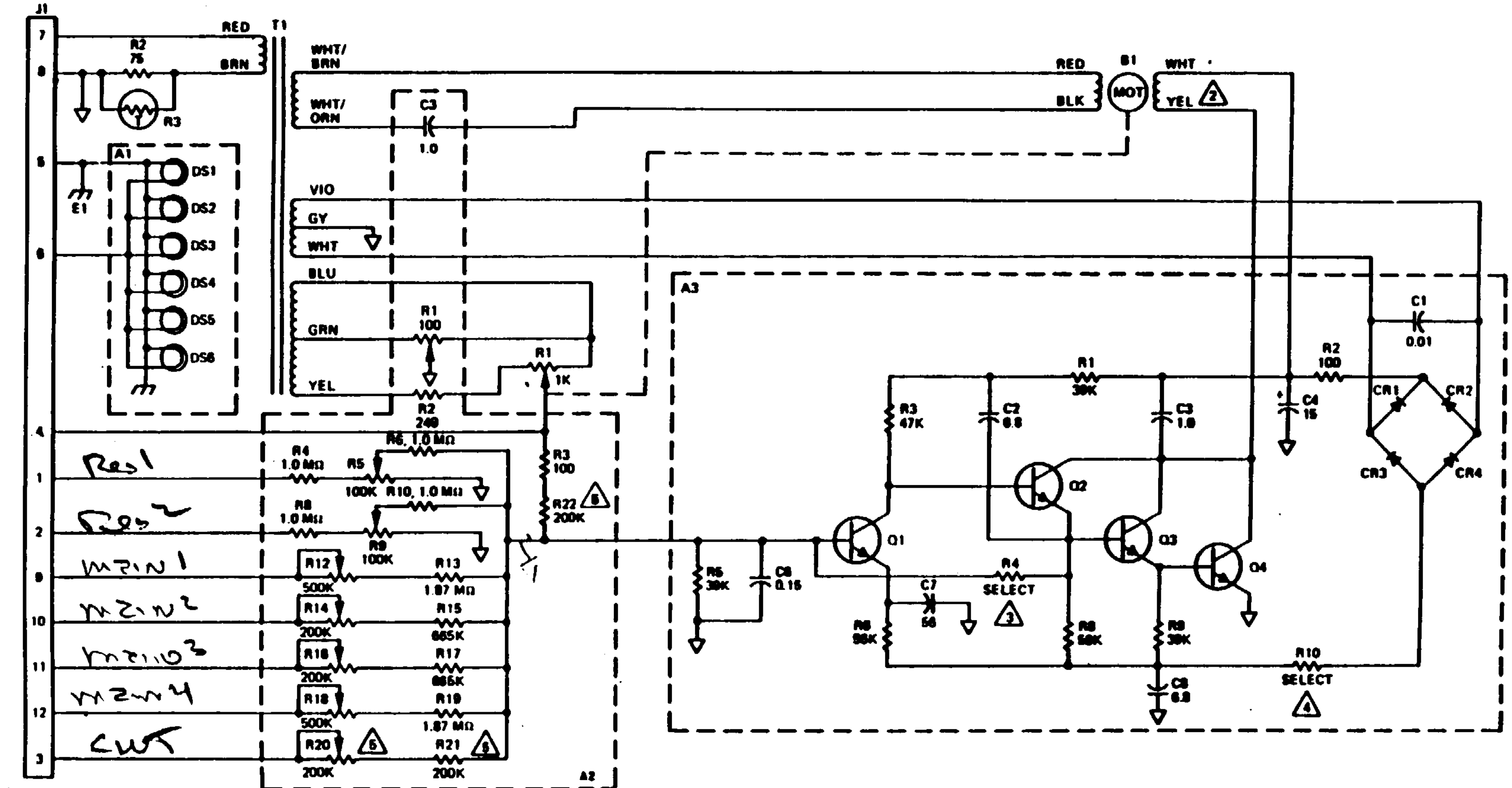
ACTIVE SHEET RECORD

SHEET NO.	REV LTR	ADDED SHEETS SHEET NO.	REV LTR	ADDED SHEETS SHEET NO.	REV LTR	SHEET NO.	REV LTR	ADDED SHEETS SHEET NO.	REV LTR	ADDED SHEETS SHEET NO.	REV LTR
1.											
2.											
3.											
4.											
5.											
6.											
7.											
8.											
9.											
10.											
11.											
12.											
13.											
14.											

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

Attached Documents from Totalizer Examination

January 11, 1999, at Honeywell, Minneapolis



NOTES:

1. ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

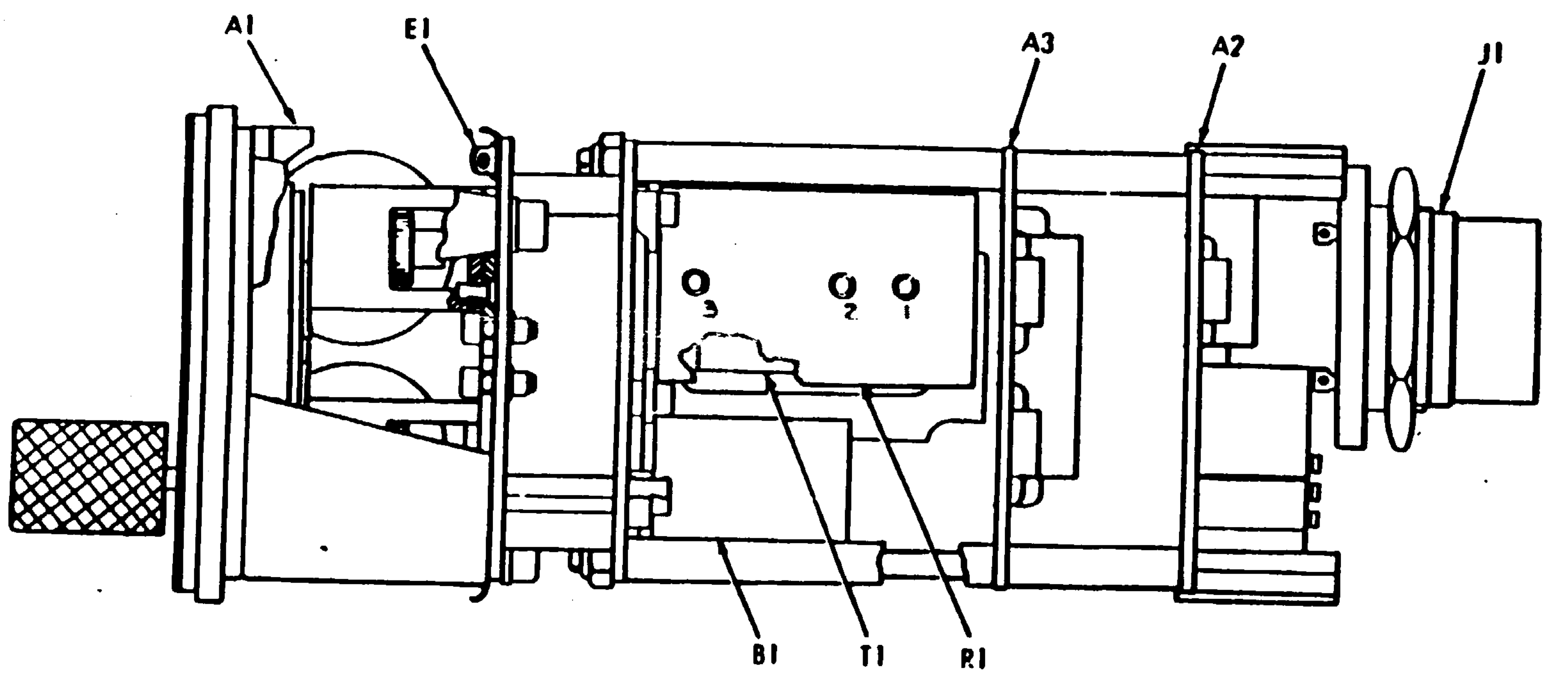
△2 YELLOW AND WHITE LEADWIRES ARE INTERCHANGED ON JG613C45 INDICATOR. (JG613C1 SHOWN).

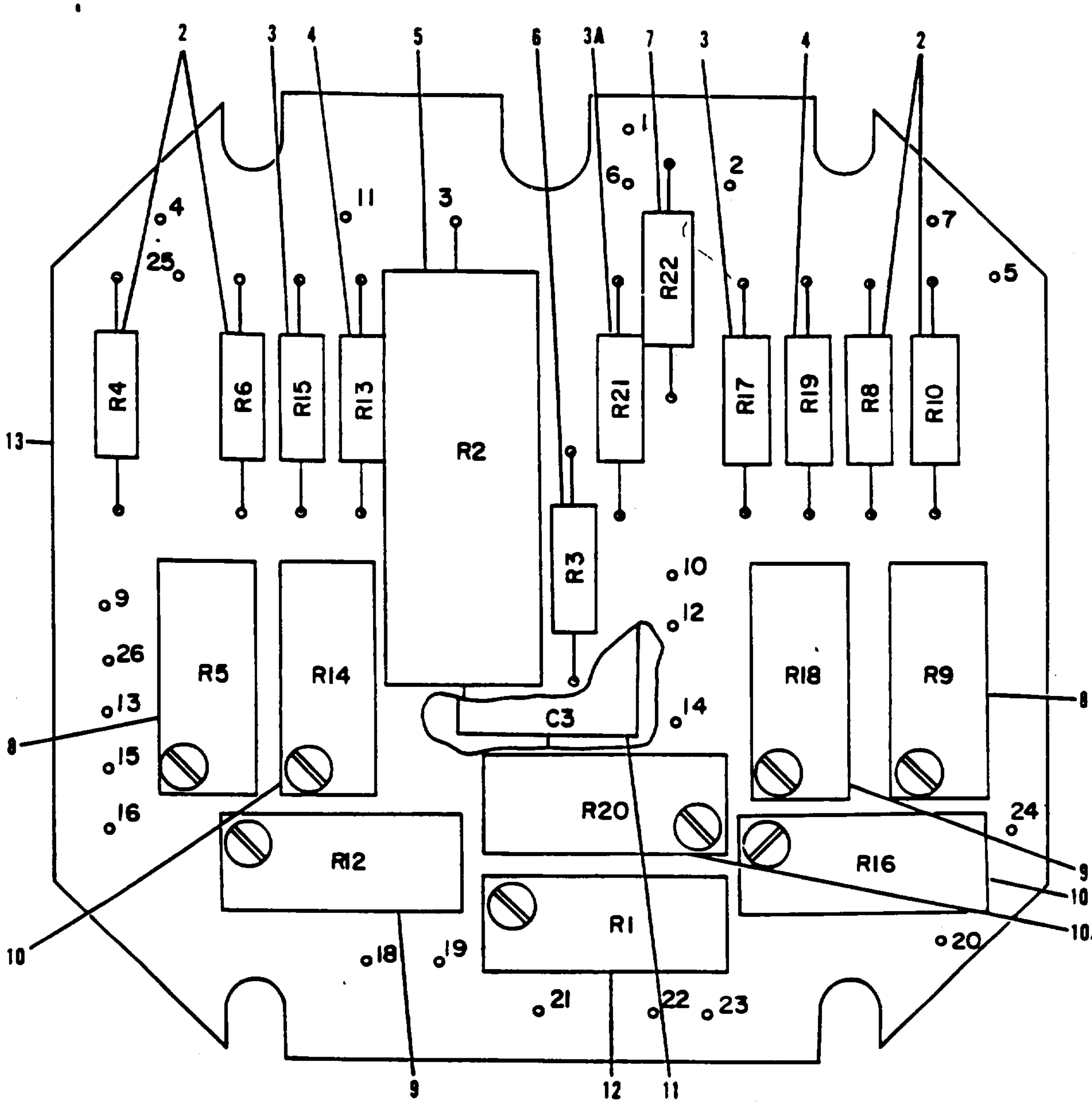
△3 SELECTED FROM: 22K, 24K, 27K, 30K, 33K, 36K, 39K, 43K, 47K, OR 51K.

△4 SELECTED FROM: 6.2K, 6.8K, 7.5K, 8.2K, 9.1K, 10K, 11K, 12K, 13K, 15K, OR 16K.

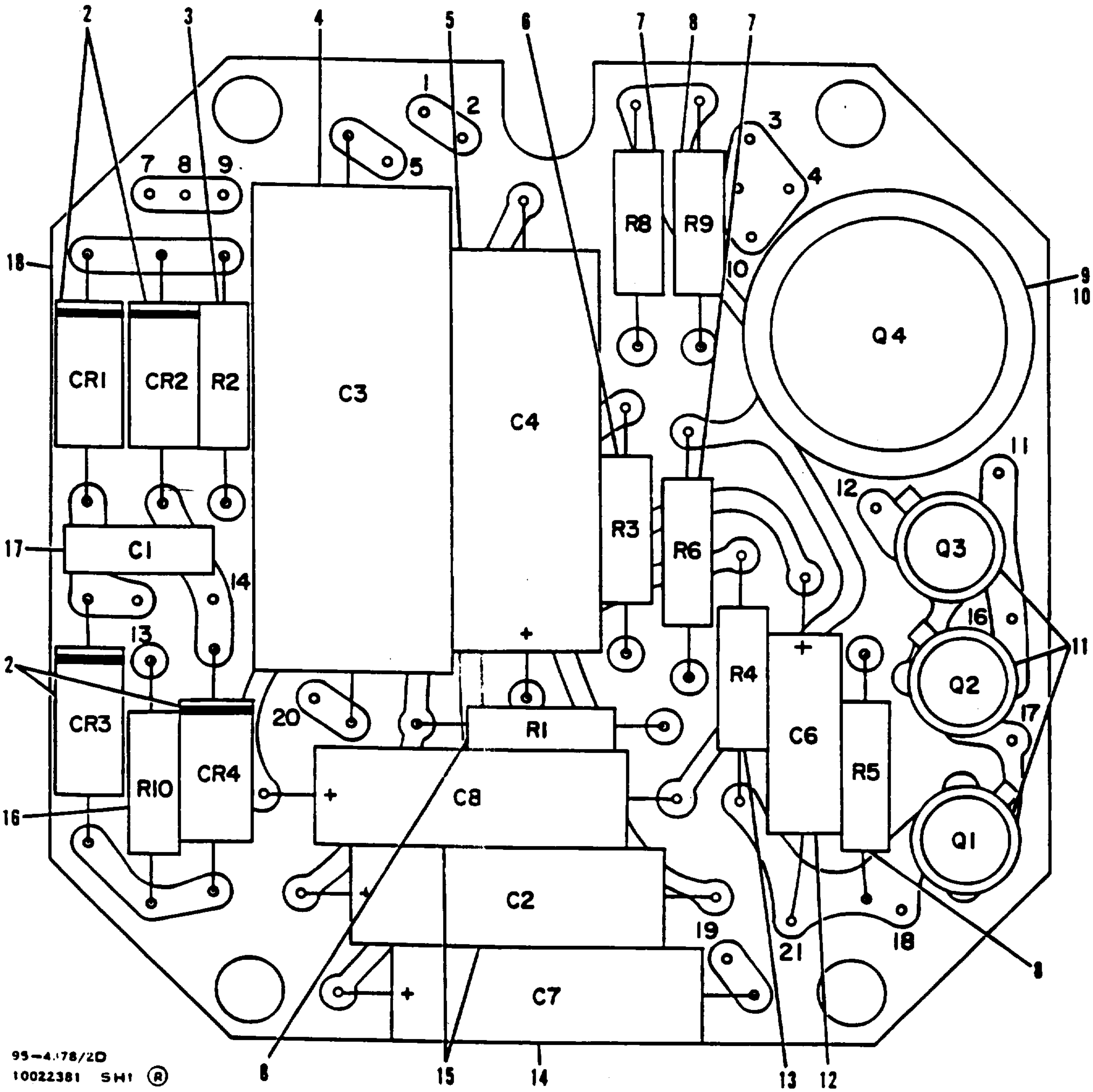
△5 RESISTANCE VALUES SHOWN ARE FOR JG613C1 AND JG613C45 ONLY. VALUES FOR JG613C53 AND JG613C54 ARE AS FOLLOWS: A2R20- 100K, A2R21- 499K, A2R22- 178K.

C1338?AA04
C1338?AA06
C1338?AA08
C1338?AA0?


A1
E1
A3
A2
J1
B1
T1
R1
1
2
3



10022382 Summing Bridge A2 - Parts Identification View
Figure 1103



10022381 Totalizer Amplifier and Power Supply A3 - Parts Identification View
Figure 1102

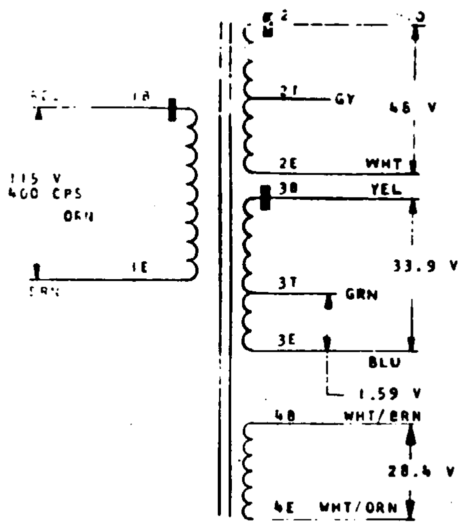
INTERPRET DRAWING IN ACCORDANCE WITH MIL-D-1000, FORM 2

DIMENSIONING AND TOLERANCING PER MIL-STD-8

HONEYWELL PART NO.

REVISIONS

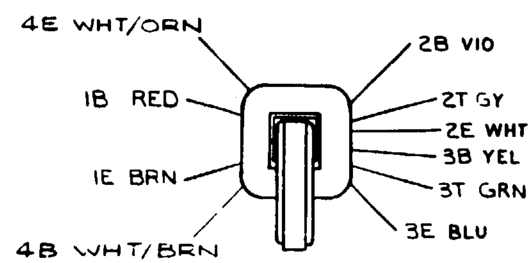
ZONE	LTR	DESCRIPTION	DATE	APPROVED
		CONTROLLED DRAWING		
-	A	REV PER EO [illegible] IN COIL WINDING TAB, WIRE COL. DC RES 81 WAS 80 [illegible] 14 WAS 13; RE. MADE ON SH1 & 2	5369	68-[illegible]
BZ	B	ADD (1)	[illegible]	[illegible]
	C	REV SH 2 PER ECO 75-11954	5-27-75	[illegible]
	D	REV PER ECO 80-10170	[illegible]	[illegible]
	E	REV PER EO 81-10485	81-3-17	[illegible]

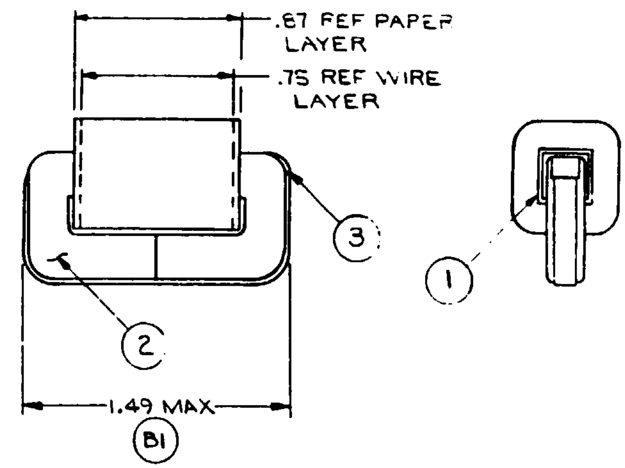


SCHEMATIC DIAGRAM

COIL WINDING DATA TABLE

WINDING TAP NO.	ACCUM TURNS	WIRE DC RES.	WIRE DIA	AWG REF (2)	LAYERS OF INSULATION OVER WINDING
1B	0	81 (14)	.0045	37	2
~~1T~~	~~1060~~				
1E	1230				
2B	0	51 (15)	.004	38	2
2T	254				
2E	508				
3B	0	13.0 (13)	.0071	33	2
3T	342				
3E	359				
4B	0	11.5 (15)	.0071	33	2
4E	315				





PARTS LIST

QTY REQD	ITEM	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	REMARKS
1	3	409529	SEAL - CORE BANDING	(12)
1	2	423384-4	CORE, TRANSFORMER	(B AC • 13 KG) (12)
1	1	435649CK	FORM, COIL	

TOLERANCES UNLESS NOTED OTHERWISE: .X ± .XX ± .XXX ± 90° FORMED ANGLES +2° -1°

DEV [illegible] SUPSD

FINISH — SEE NOTE

MATERIAL

DRAFTSMAN	[illegible]
CHECK	[illegible]
MATL & FINISH	
APPL ENGR	
DEV ENGR	
PROJ ENGR	
PROD ENGR	[illegible]
RELIABILITY	

HONEYWELL INC. MILITARY PRODUCTS GROUP
☒ AERO MPLS. ☐ AERO ST. PETERSBURG ☐ BOSTON RADIATION CENTER ☐ ORD HOPKINS ☐ ORD SEATTLE ☐ ORD CALOC ☐ SYSTEMS & RD MPLS.

TRANSFORMER, POWER, STEP-DOWN — BRIDGE

SIZE C | CODE IDENT NO. 94580 | DRAWING NO. 10023072

SCALE NONE | WT | SHEET 1 OF 2

NEXT ASSY	USED ON
10022478	JG61[illegible]

APPLICATION

SH 1 2 / REV E E

FOR NOTES SEE SHEET 2

10023072

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	—	CONTROLLED DRAWING	[illegible]	[illegible]
	A	ADD NOTE 14	5-9-69	63-15764
	C	REV PER ECO 75-11954	5-27-75	J.Na.
	E	REV PER EO 81-10485	81-3-17	GBA

1 - PROCESS PER SPEC 4306 AND INSPECT PER SPEC 4836

2 - LAYER WIND WITH NYLON MAGNET WIRE MIL-W-583 TYPE B (MATL SPEC 7020)

3 - ATTACH NO. 30 AWG TEFLON LEADWIRE MIL-W-16878/4 (MATL SPEC 6057) TO ALL WINDINGS. SEE SCHEMATIC DIAGRAM SHEET 1 FOR WIRE COLORS

4 - COIL AND CORE ARE IMPREGNATED WITH MATL SPEC 6293H PER SPEC 4843 (NO EPOXY BUILD-UP PERMISSIBLE ON EXTERNAL CORE SURFACES)

5 - RATED EXCITATION: RED & BRN LEADS: 115 V RMS 400 CPS

6 - NO LOAD CURRENT WITH RATED EXCITATION: 21 MA MAX
NO LOAD POWER WITH RATED EXCITATION: 0.45 W MAX

7 - TURNS RATIO ERROR 1% MAX, REF TO WINDING NO. 1 (OR 1 TURN, WHICHEVER IS GREATER). CENTER TAP ERROR: 300 MV MAX

8 - APPLY POLARITY CHECK

9 - APPLY DIELECTRIC STRENGTH TEST: 500 V RMS BETWEEN WINDINGS AND BETWEEN WINDINGS AND CORE

10 - APPLY INDUCED VOLTAGE TEST

11 - MARK PART NO. AND 94580 PER SPEC 13205, TYPE I

12 - VENDOR ITEM - SEE SOURCE CONTROL OR SPEC CONTROL DRAWING

13 - DC RESISTANCE ±1.0 OHM

14 - DC RESISTANCE ±3.0 OHMS

15 - DC RESISTANCE ± 25 PERCENT

SIZE	CODE IDENT NO.	DRAWING NO.
C	94580	10023072
SCALE NONE	WT	SHEET 2

10023072 E

January 11, 1999

TEST PLAN

747 Classic FQS Totalizer - JG613C1

1. Visual of as-is condition.

2. Pictures as indicated

3. Without removing A/C connector attached to device, strip wires for Ohm meter measurements. {Prepare a data sheet}

4. Verify that measurements in step 3 are consistent with device schematic. Remove connector and repeat measurement using a breakout box. Compare results to verify that measurements are consitant.

5. Remove case from instrument. This may be a destructive removal as there is distortion in the case.

6. Visual the internals of the instrument. Pay particular attention to wire routing and condition of components. Visual the transformer.

7. Pictures as indicated.

8. Make transformer winding continuity and interwinding continuity measurements

9. Determine if there is value to trying to make device run. There are at least two paths that can be taken at this point.

   a) There is a possibility that making some voltage measurements, to verify gain etc, may be sufficient without needing physical motion. If the device is powered, measure transformer secondary voltages. A low voltage may be sufficient to make these measurements..
   b) Replace mechanical parts as required and apply power. Connections are through a break out box and stimulus is from the engineering VSO tester. These are the same signals as used in the aircraft, the compensator Lo-Z.

10. If it was determined that the device was not able to be powered and transformer is sufficiently in tact, remove from totalizer.

13. Pictures of transformer as indicated.

14 Measure continuity of windings and inter winding resistance. Perform incoming inspection on the transformer. (This was done for the CWT indicator transformer.)

15. Measure resistances on Summing Bridge card.

CONNECTOR/CABLE MEASUREMENTS

747 Classic FQS Totalizer - JG613C1

Date: 1-11-99 (Measurement 1) Test Inst.: FLUKE 77 Notes: S/N: A8

Device: JG613C1 Personnel: Mike Fossum Robert Gille

Series: 5 Indicator & Connector

	1	2	3	4	5	6	7	8	9	10	11	12
1	--	2.2m	1.95m		open	open	open	1.12m	3.43m	2.01m	2.00m	open
2	2.14m	--	1.9m		open	open	open	1.09m	3.37m	1.96m	1.95m	open
3	1.91m	1.92m	--		open	open	open	.85m	2.87m	1.45m	1.43m	open
4				--								
5	open	open	open		--	1.5Ω	open	open	open	open	open	open
6	open	open	open		1.5Ω	--	open	open	open	open	open	open
7	open	open	open		open	open	--	open	open	open	open	open
8	1.09m	1.09m	.84m		open	open	open	--	2.31m	.89m	.88m	open
9	3.38m	3.38m	2.86m		open	open	open	2.31m	--	2.91m	2.90m	open
10	1.96m	1.97m	1.45m		open	open	open	.89m	2.90m	--	1.49m	open
11	1.96m	1.96m	1.44m		open	open	open	.89m	2.90m	1.48m	--	open
12	open	open	open		open	open	open	open	open	open	open	--

Use of Table:

- Always put the negative lead of the ohm meter on the pin called in the vertical column.
- Values in K ohms unless otherwise noted.

PIN 5 TO CASE IS LESS THAN 1Ω

CONNECTOR/CABLE MEASUREMENTS

747 Classic FQS Totalizer - JG613C1

Date: January 11 1999 Measurement 2 Test Inst.: Fluke 77 Notes: Connector and A/C wiring only

Device: JG613C1 Personnel: Mike Fossum, Robert Gille

Series: 5

	1	2	3	4	5	6	7	8	9	10	11	12
1	--	820m	920m		740m	1.6 919	1.6 919	>1 919	>1 919	>1 919Ω	>1 919	>1 919
2	860m	--	880m		940m	>1 919Ω	890m	890m	850m	940m	>1 919Ω	>1 919
3	740m	690m	--		860m	>1 919	990m	>1 919	1.0 919	970m	940m	860m
4				--								
5	900m	>1 919	>1 919		--	>1 919	>1 919	>1 919	>1 919	>1 919	>1 919	>1 919
6	>1 919	>1 919	>1 919	~~>1 919~~ NT	>1 919	--	>1 919	>1 919	>1 919	>1 919	>1 919	>1 919
7	970m	950m	>1 919		940m	>1 919	--	900m	>1 919	>1 919	>1 919	>1 919
8	>1 919	820m	>1 919		>1 919	>1 919	790m	--	860m	>1 919	>1 919	>1 919
9	>1 919	850m	>1 919		>1 919	>1 919	>1 919	880m	--	890m	>1 919	>1 919
10	>1 919	940m	1.0 919Ω		>1 919	>1 919	>1 919	>1 919	890m	--	>1 919	>1 919
11	>1 919	>1 919	1.0 919		>1 919	>1 919	>1 919	>1 919	>1 919	>1 919	--	>1 919
12	>1 919	>1 919	960m		1.0 919	>1 919	>1 919	>1 919	>1 919	>1 919	1.1 919	--

Use of Table:

- Always put the negative lead of the ohm meter on the pin called in the vertical column.
- Values in K ohms unless otherwise noted.
- >1 919 = greater than 1 919. ohms.
- m = meg ohm

Jan 11, 1998
Measurement 3
Wire ID w/R
To pin numbers

Wire No's

			dia. with insulation	
1	W186	Q608	.053	
2		Q638	.052	
3		Q623	.052	
4		Plugged	—	
5		L914	.052	
6		L913	.053	
7		Q753 Smaller diam.	.042	copper (.030)
8		Q743	.052	
9		Q613	.050	Copper (.038)
10		Q618	.052	Copper (.038)
11		Q628	.052	19 strand
12		Q633	.052	

AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

CONNECTOR/CABLE MEASUREMENTS

747 Classic FQS Totalizer - JG613C1

Date: January 11 1997 measurement 4 Test Inst.: Fluke 77 * Notes: Measured used Break-out box to acquire Device connector

Device: JG613C1 Personnel: Mike Fossum

Series: 5 S/N A8 Robert Gillo

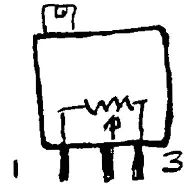
	1	2	3	4	5	6	7	8	9	10	11	12
1	--	2.20m	1.96m	1.13m	>1919 open	>1919 open	>1919 open	1.15m	>1919 open	2.03m	2.02m	open
2	2.18m	--	1.93m	1.10m	>1919 open	>1919 open	>1919 open	1.10m	open	1.97m	1.96m	open
3	1.94m	1.93m	--	.85m	>1919 open	>1919 open	>1919 open	.85m	open	1.45m	1.44m	open
4	1.11m	1.10m	.85m	--	>1919 open	>1919 open	>1919 open	250Ω	open	.89m	.88m	open
5	>1919 open	>1919 open	>1919 open	>1919 open	--	1.6Ω	900m open	>1919 open	open	>1919 open	>1919 open	open
6	>1919 open	>1919 open	>1919 open	>1919 open	1.5Ω	--	900m open	>1919 open	open	>1919 open	>1919 open	open
7	>1919 open	>1919 open	>1919 open	>1919 open	>1919 open	>1919 open	--	>1919 open	open	>1919 open	>1919 open	open
8	1.11m	1.10m	.85m	250Ω	>1919 open	>1919 open	>1919 open	--	open	.89m	.88m	open
9	open	open	open	open	open	open	open	open	--	open	open	open
10	1.99m	1.98m	1.45m	.90m	>1919 open	>1919 open	>1919 open	.90m	open	--	1.49m	open
11	1.97m	1.97m	1.44m	.89m	>1919 open	>1919 open	>1919 open	.89m	open	1.49m	--	open
12	open	open	open	open	open	open	open	open	open	open	open	--

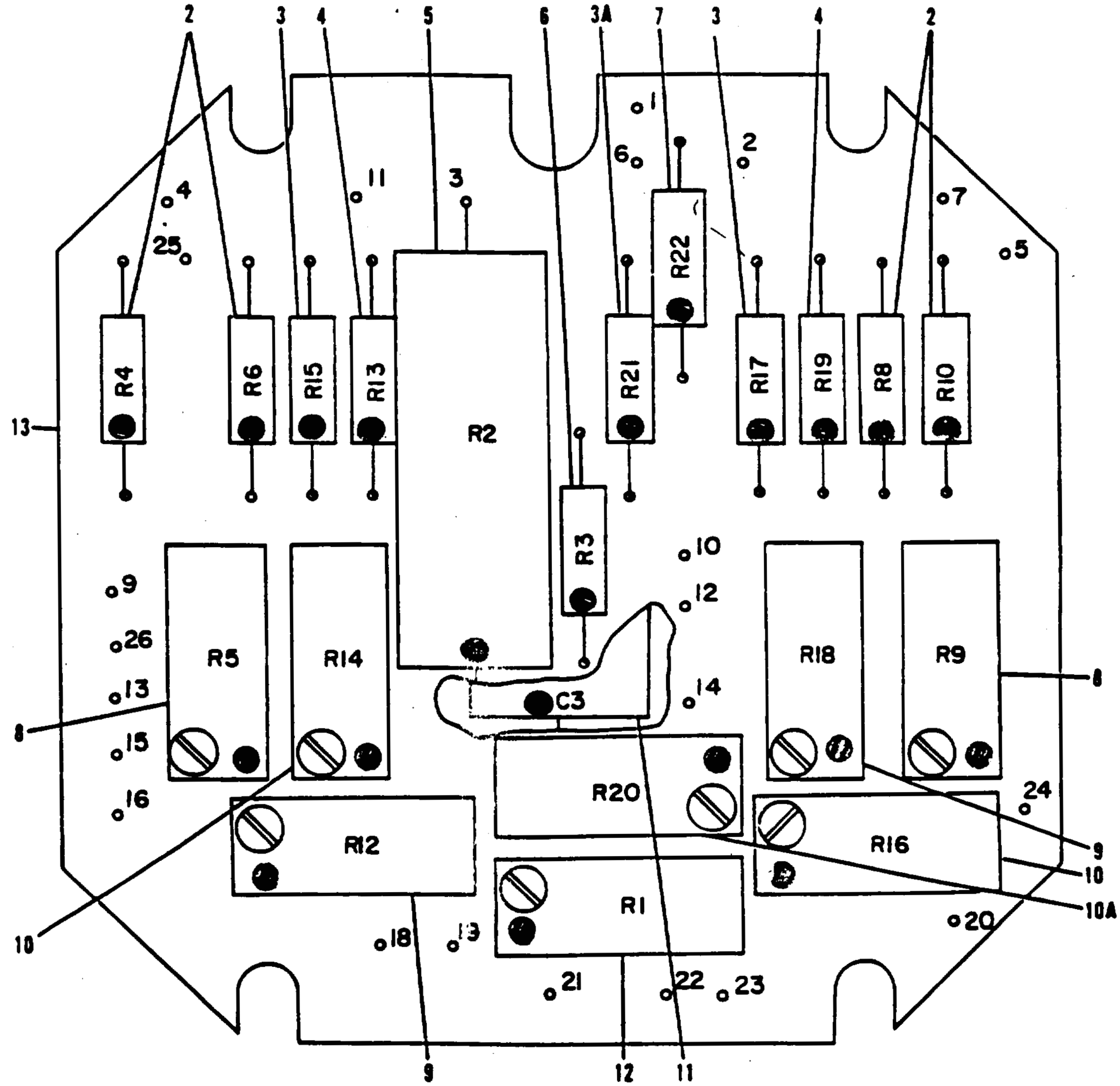
Use of Table:

- Always put the negative lead of the ohm meter on the pin called in the vertical column.
- Values in K ohms unless otherwise noted.

* Hi R measurements made with HP 3457A

* Pin 5 To Chassis Less than 1Ω





95-4878/38
JG613C

Dots are negative

10022382 Summing Bridge A2 - Parts Identification View
Figure 1103

SUMMING BRIDGE A2

747 Classic FQS Totalizer - JG613C1

Date: January 12, 1999 (1) Jim's measurement 1   Test Inst.: Fluke 77   Notes: Board IN Assy

Device: JG613C1   Personnel: Robert Gillo

Series: 5 S/N A8   Randy Dodd

Circuit Card Assembly Identification:

Honeywell Part Number: ______________ Serial Number: ______________

Other Identification: ______________

Reference Designator	Part Type	Value	Normal Polarity	Reverse Polarity
R1 End to End		100 Ohms	0	0
R1 Dot to Wiper		--	22.8 Ω	22.8 Ω
R2	RN70E2490F	249 Ohm	201 Ω	201 Ω
R3	RC07101 5%	100 Ohm	100.6 Ω	100.6 Ω
R4		1 M Ohm	1 m	1 m
R5 End to End		100 k Ohm	150 K	145 K ≃
R5 Dot to Wiper		--	91 K ≃	90 K
R6		1 M Ohm	186 K	181 K
R8		1 M Ohm	998 K	998 K
R9 End to End		100 k Ohm	97.4 K	97.4 K
R9 Dot to Wiper		--	38.4 K	38.4 K
R10		1. M Ohm	188 K	189 K

MISCELANEOUS PARTS

747 Classic FQS Totalizer - JG613C1

Date: 1/12/99 (2) Measurement 2 Test Inst.: ______ Notes: Frame Mounted Parts

Device: ______ Personnel: Robert Gille

Series: ______ Randal Dodd

The following parts are installed on the frame:

Reference Designator	Part Type	Value	Normal Polarity	Reverse Polarity
A1 R1 End to End	Duncan 1k ±.03% MOD. 3200-1310-2	1 k Ohm	208.6 Ω	210 Ω
R1 End to Dot			314 Ω	314 Ω
R2		75 Ohm	60 Ω	
R3		Thermistor	60 Ω	
B1 Red to Blk		Servo Motor	110 Ω	110 Ω
B1 Wht to Yel			110 Ω	110 Ω
B1 Red to Wht			open	open

Paralleled (R2, R3)

neg trans fr side

opened to case Servo motor

[illegible] continuity

Disconnect CW and CCW ends of A1 R1 (feedback pot)

End to End 1013 Ω (Both potentiometers)

CW to wiper 722/723 ohms

A3 R5/C6

Forward 41.3K Ω

Reverse 32.5K Ω

(some variability in measurement – 1st Board [illegible] on discolored brownish – mechanical damage (crack) near front board)

TRANSFORMER MEASUREMENTS

747 Classic FQS Totalizer - JG613C1

Date: 12 Jan 99 (3) Measurement 3 Test Inst.: ______ Notes: ______

Device: JG613C1 SNA8 Personnel: Bob Gille

Series: ______ Lou Taylor

Transformer Identification:

Manufacturer: 94580 (Honeywell) Honeywell Part Number: 10023072-101

Other Marking: ______

	Red	Brn	Wht/Brn	Wht/Orn	Vio	Gy	Wht	Blu	Grn	Yel	Core
Red	--	145Ω	Open		Open			Open			Open
Brn	145Ω	--									
Wht/Brn	Open		--	13Ω	Open			Open			Open
Wht/Orn			13Ω	--							
Vio	Open		Open		--	24Ω	50Ω	Open			Open
Gy					24Ω		26Ω				
Wht					50Ω	25Ω		--			
Blu	Open		Open		Open				1Ω		Open
Grn								1Ω	~~[illegible]~~	12Ω	
Yel									12Ω		--
Core	Open	~~Open~~	Open		Open			Open			--

Vert column is negative

~~Forward, 39M Ω (?) 41.3 KΩ~~

~~Reverse 32.5 KΩ~~

Mikelyn N. Bridges
Sr. Application Engineer
1200 Columbia Avenue
Riverside, CA 92507
Phone: (909) 781-5395
Fax: (909) 781-5006

BOURNS, INC.

RJ22
Mexico 8625M

Fax

To:	Ross Reagan, Honeywell	**From:**	Mike Bridges
Fax:	(612) 957-4502	**Pages:**	1 of 1
Phone:		**Date:**	January 12, 1999
Re:		**CC:**	

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

• **Comments**

The Bourns commercial models 3250 and 3252 as well as the military RT22 and RJ22 date codes are three digits and a letter. The first digit represents the year, the second two digits the week, and the letter is the manufacturing plant code.

An example would be 813M, would be equal to the 13th manufacturing week of 1998, and M is plant code for Mexico.

RTR22 and RJR22 military products have the four digit date codes, where the first two digits are the year, the second two the week, the first letter, the manufacturing plant code, and the last letter, the lot code.

Grayle,

Mikelyn from Bourns did not know when they changed Date code marking from the 4 digit to the 3 digit code. All she could say is that the above is their present marking guidelines.

Note: 8625 would indicate that there was a repair/rework activity on the device at some point if the device was originally built in '69.

Ross

For technical assistance call the Trimmer Products number on the back cover.

Honeywell P/N 966034

AVAILABLE THROUGH DISTRIBUTION

BOURNS

Features

- Multiturn / Wirewound / Sealed
- Listed on the QPL for style RT22 per MIL-R-27208 and RTR22 per High-Rel MIL-R-39015
- Panel Mount option available (see page 66 for details)

3250/RT22/RTR22 - 1/2" Square Trimming Potentiometer

[illegible]ctrical Characteristics

Standard Resistance Range
- 3250 ....10 to 50K ohms
- RT22 ....50 to 20K ohms
- RTR22 ....500 to 20K ohms
- (see standard resistance table)

Resistance Tolerance ....±5% std. (tighter tolerance available)

Absolute Minimum Resistance ....0.1% or 1 ohm max. (whichever is greater)

Noise ....100 ohms ENR max.

Resolution ....See Resistance Table

Insulation Resistance ....500 vdc. 1,000 megohms min.

Dielectric Strength
- Sea Level ....1,000 vac
- 80,000 Feet ....400 vac

Adjustment Travel ....25 turns nom.

[illegible]ironmental Characteristics

Power Rating @ 85°C
- 3250 ....1.0 watt
- RT22/RTR22 ....0.75 watt

Power Rating @ 150°C ....0 watt

Temperature Range ....-65°C to +150°C

Temperature Coefficient
- 3250 ....±50ppm/°C
- RT22/RTR22 ....±50ppm/°C

Seal Test ....85°C Fluorinert* (pin styles only)

Humidity ....MIL-STD-202 Method 106
- 3250 ....(2% ΔTR; 100 Megohms IR)
- RT22 ....(1% ΔTR; 10 Megohms IR)
- RTR22 ....(1% ΔTR; 100 Megohms IR)

Vibration ....30G (1% ΔTR; 0.5% + resolution ΔVR)

Shock ....100G (1% ΔTR; 0.5% + resolution ΔVR)

Load Life
- 3250 ....1,000 hours 1.0 watt @ 85°C (2% ΔTR; 500 ohms ENR)
- RT22 ....1,000 hours 0.75 watt @ 85°C (2% ΔTR; 2% + resolution ΔVR)
- RTR22 ....10,000 hours 0.75 watt @ 85°C (3% ΔTR; 2% + resolution ΔTR)

Rotational Life ....200 cycles
- 3250 ....(2% ΔTR; 500 ohms ENR)
- RT22/RTR22 ....(2% ΔTR)

[illegible]

Torque ....5.0 oz-in. max.

Mechanical Stops ....Wiper idles

Terminals
- 3250 ....Solderable printed circuit pins
- [illegible] Flexible leads (7 strands of 30 AWG)
- RT22/RTR22 ....MIL-STD-202; Method 208

[illegible] ....0.06 oz.

Machine Screw Mounting
- [illegible] ....12 oz-in. max.

[illegible] ....Manufacturer's trademark, resistance code, terminal numbers, date code, manufacturer's model number and style
- [illegible]RTR22 ....Mil-spec part number

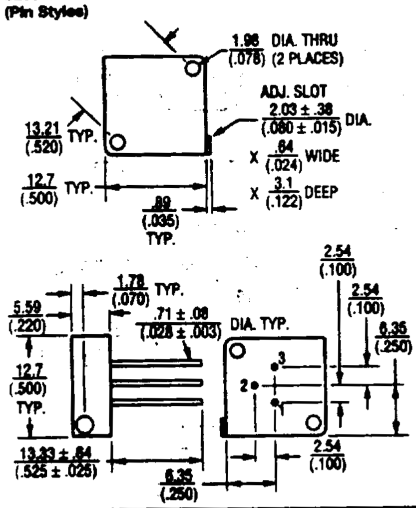
[illegible] ....Set at CW end

[illegible] ....................U.L. 94V-0

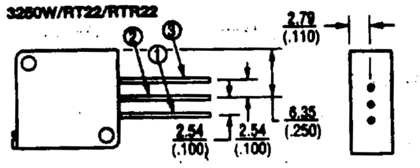
[illegible] Packaging
- [illegible] ....25 pcs. per tube
- [illegible] ....25 pcs. per bag

[illegible] Tool H-90

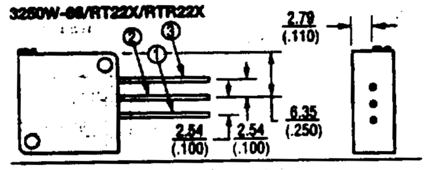
3250P/RT22/RTR22 Common Dimensions (Pin Styles)



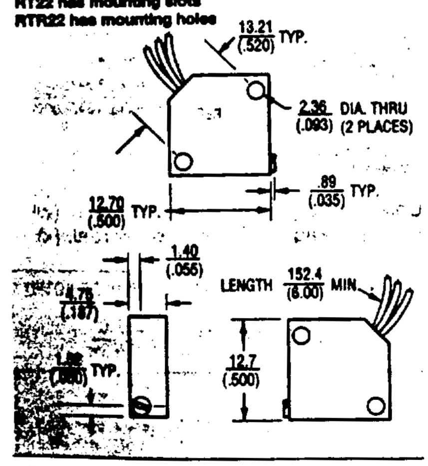
3250W/RT22/RTR22



3250W-66/RT22X/RTR22X



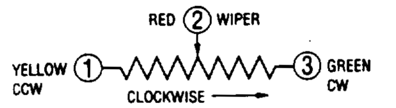
"L" Flex Lead Type
RT22 has mounting slots
RTR22 has mounting holes



TOLERANCES: ± 0.25 (.010) EXCEPT WHERE NOTED

DIMENSIONS ARE: METRIC / (INCHES)

*"FLUORINERT" IS A REGISTERED TRADEMARK OF 3M CO.



How To Order

3250 L - 1 - 103 M

- Model
- Style
- Standard or Modified Product Indicator
  - -1 = Standard Product
- Resistance Code
- Optional Suffix Letter
  - M = Panel Mount (Factory Installed)

See page 72 for RT22/RTR22 ordering information.

Consult factory for other available options.

Standard Resistance Table

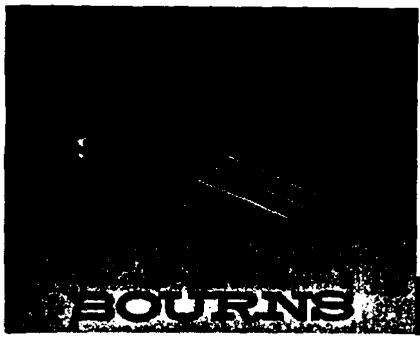
Resistance (Ohms)	Nominal Resistance Code	Resolution (Percent)
10	100	1.30
20	200	1.00
50	500	0.80
100	101	0.90
200	201	0.70
500	501	0.60
1,000	102	0.40
2,000	202	0.30
5,000	502	0.25
10,000	103	0.19
20,000	203	0.16
25,000	253	0.14
50,000	503	0.13

Popular values listed in boldface. Special resistances available.

SHADED AREAS TYPICALLY NOT STOCKED BY DISTRIBUTORS AND NOT RECOMMENDED FOR NEW DESIGNS.

For technical assistance call the Trimmer Products number on the back cover.

Honeywell P/N 10025148



Features

- Multiturn / Cermet / Sealed
- Listed on the QPL for style RJ22 per MIL-R-22097
- Panel mount option available (see page 66 for details)

3252/RJ22 - 1/2" Square Trimming Potentiometer

[illegible]

Standard Resistance Range
- 3252 ....10 to 2 megohms
- RJ22 ....10 to 1 megohm (see standard resistance table)

Resistance Tolerance ....±10% std. ....(tighter tolerance available)

Absolute Minimum Resistance
- 3252 ....1% or 2 ohms max. (whichever is greater)
- RJ22 ....1 ohm max.

Contact Resistance Variation
- 3252 ....1% or 2 ohms max. (whichever is greater)
- RJ22 ....2% or 2 ohms max. (whichever is greater)

Adjustability
- Voltage ....±0.01%
- Resistance ....±0.05%

Resolution ....Infinite

Insulation Resistance ....500 vdc. 1,000 megohms min.

Dielectric Strength
- Sea Level ....1,000 vac
- 80,000 Feet ....400 vac

Effective Travel ....25 turns nom.

[illegible] Characteristics

Power Rating @ 85°C (400 volts max.)
- 3252 ....0.75 watt
- RJ22 ....0.50 watt

Power Rating @ 150°C ....0 watt

Temperature Range ....-65°C to +150°C

Temperature Coefficient ....±100ppm/°C

Seal Test ....85°C Fluorinert* (pin styles only)

Humidity
- 3252 ....MIL-STD-202 Method 103; 96 hours (1% ΔTR; 100 Megohms IR)
- RJ22 ....MIL-STD-202 Method 106 (1% ΔTR; 10 Megohms IR)

Vibration
- 3252 ....30G (1% ΔTR; 1% ΔVR)
- RJ22 ....20G (1% ΔTR; 1% ΔVR)

Shock ....100G (1% ΔTR; 1% ΔVR)

Load Life
- 3252 ....1,000 hours 0.75 watt @ 85°C (3% ΔTR; 3% or 3 ohms, whichever is greater, CRV)
- RJ22 ....1,000 hours 0.5 watt @ 85°C (2% ΔTR; 1%ΔVR)

Rotational Life ....200 cycles
- 3252 ....(2% ΔTR; 3% or 3 ohms, whichever is greater, CRV)
- RJ22 ....2% ΔTR

[illegible]

Torque ....5.0 oz-in. max.

Mechanical Stops ....Wiper idles

Terminals
- 3252 ....Solderable printed circuit pins
- RJ22 ....MIL-STD-202; Method 208
- Flexible leads ....(7 strands of 30 AWG)

Weight ....0.065 oz.

Wiper ....Set at CW end

Flammability ..............................U.L. 94V-0

[illegible]

Torque ....12 oz-in. max.

* Marking
- 3252 ....Manufacturer's trademark, resistance code, wiring diagram, date code, manufacturer's model number and style
- RJ22 ....Mil-spec part number

Standard Packaging
- X, P&W Styles ....25 pcs. per tube
- L Style ....25 pcs. per bag

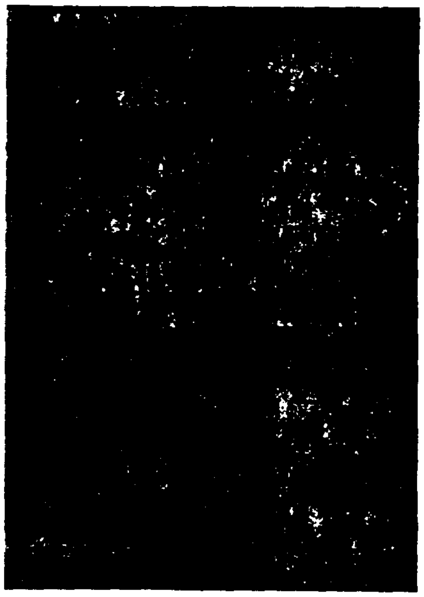
Adjustment Tool H-90

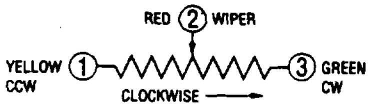
[illegible]

3252 L - 1 - 103 M

- Model
- Style
- Standard or Modified Product Indicator
  - -1 = Standard Product
- Resistance Code
- Optional Suffix Letter
  - M = Panel Mount (Factory Installed)

See page 73 for RJ22 ordering information.
Consult factory for other available options.





TOLERANCES: ± 0.25 (.010) EXCEPT WHERE NOTED

DIMENSIONS ARE: METRIC / (INCHES)

[illegible]

Resistance (Ohms)	Resistance Code
[illegible]	[illegible]

Popular values listed in boldface. Special resistances available.

SHADED AREAS TYPICALLY NOT STOCKED BY DISTRIBUTORS AND NOT RECOMMENDED FOR NEW DESIGNS.

*"FLUORINERT" IS A REGISTERED TRADEMARK OF 3M CO.

Specifications are subject to change without notice.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

Attached Documents pertaining to
Tear-down of CWT Indicator
from December 11 through 13, 1996

Date Code 76-1 on PWB

Serial T-1 was the CWT indicator

Bridge Assembly Resistance Measurements:

Assembly #: 10022294-103 S/N: PWB (10022-06-101)

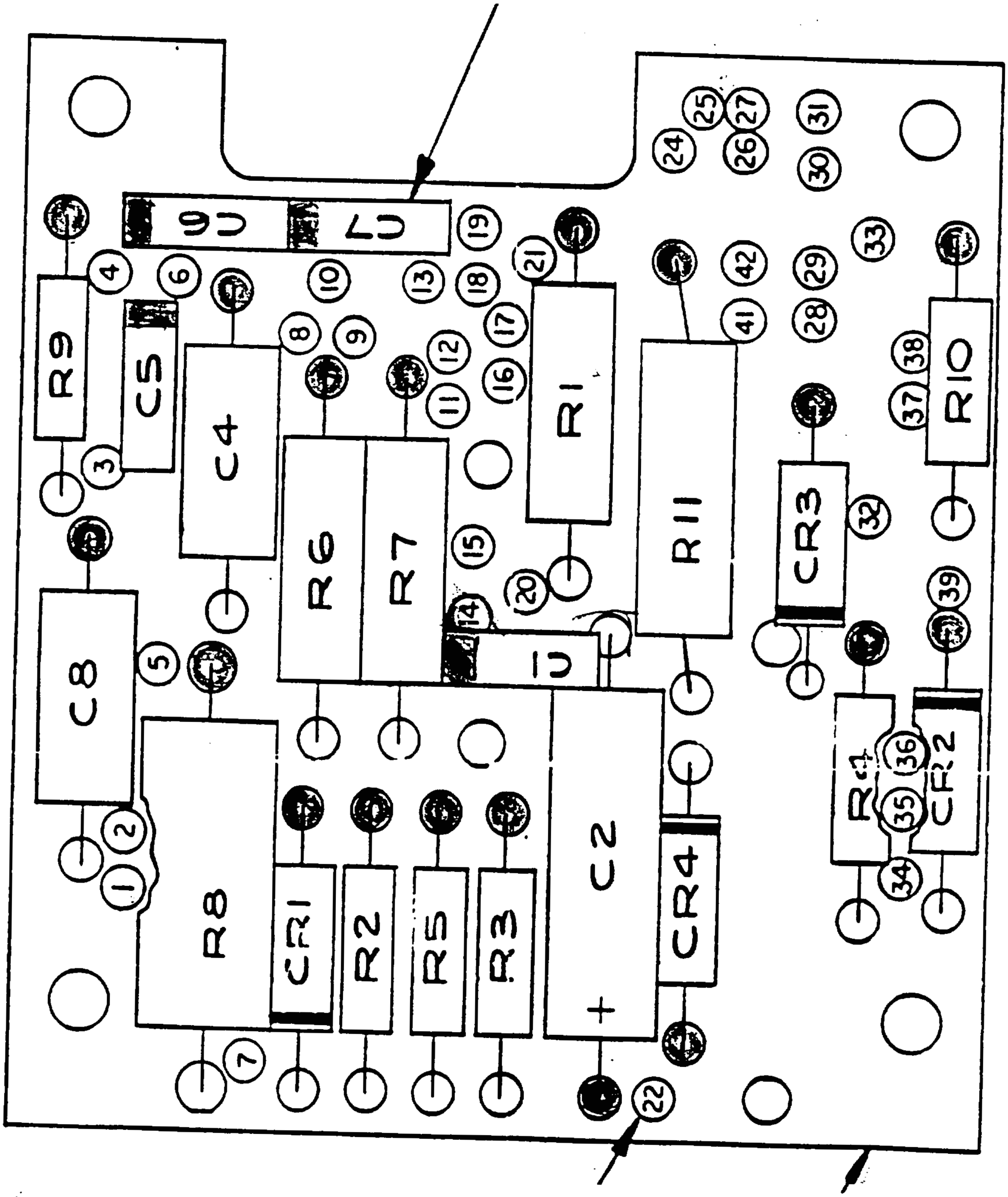
Date: 12-11-96 Test Condition: POST CLEANING

Test Equipment: Same Fluke as SN1

Test #	Component Desig.	Component Type	Normal Polarity		Reverse Polarity		Other Measurements or Comments
B1	R1	RC07GF300J	43.9		43.9		
B2	R2	RC07GF270J	29.9		29.9		
B3	R3	RC07GF682J	7.34K		7.33K		
B4	R4	RC07GF682J	open		open		MISSING
B5	R5	RC07GF682J	7.24K		7.25K		
B6	R6	RN60C75R0F	72.6		72.6		
B7	R7	RWR80S2431FP 478100-2431	123.2		123.3		
B8	R8	RW79U1000F	100.2		100.2		
B9	R9	RC07GF332J	3.67K		3.67K		
B10	R10	RL07S392G	57.1		57.1		
B11	R11	RW79U1000F	99.9		100.1		
B12	C1	941004-29 CK06 .01uF	44.4		44.4		
B13	C2	478020-49S CS13 6.8 uF	2.24M		2.35M		
B14	C3	NOT USED					NOT USED
B15	C4	CY10C131F	open		open		
B16	C5	10022409-108 CK06 120 pF	open		open		
B17	C6	10022409-108 CK06 120 pF	open		open		
B18	C7	941004-23 CK06 3.3 nF	open		open		
B19	C8	CY10C131F	open		open		
B20	CR1	468169-1 1N645	2.34M	.614	2.2M	1.80	
B21	CR2	468169-1 1N645	2.3M	1.8	2.2M	2.05	MISSING
B22	CR3	468169-1 1N645	open	open	open	open	MISSING
B23	CR4	468169-1 1N645	2.2M	.601	2.3M	1.8	

DATA SET 3 [signature]

Colored Dot is positive for normal ohmeter polarity.



PWB DATE CODE 7618

Amplifier Assembly Resistance Measurements:

Assembly #: 10022295 ~~S/N:~~ (PWB 10022306-101)

Date: Dec 11, 1996 Test Condition:

Test Equipment: Simo Fluke 73 Set 1

Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	---------		-----------	----------	----------------------------
A1	R1	RC07GF393J	40.8K	40.8K	
A2	R2	RC07GF101J	109.5	109.4	
A3	R3	RC07GF473J	51.2K	~~2~~ 51.2K	
A4	R4	RC07GF393J	48K	48K	(NOISY / DAMAGED)
A5	R5	RC07GF563J	57.8K	58.2K	
A6	R6	RC07GF563J	60.5K	60.5K	
A7	R7	RC07GF393J	43.7K	43.7K	
A8	R8	RC07GFXXXJ	9.42K	9.42K	Select Resistor
A9	C1	941004-29 CK06 .01 uF	47K	47K	
A10	C2	478020-49S CS13 6.8 uF	142K	163K	
A11	C3	478020-110S CS13 4.7 uF	148.6	149.2	
A12	C4	478020-110S CS13 4.7 uF	258.2	258.1	
A13	C5	478020-19S CS13 .15 uF	43.5K	42.1K	
A14	C6	478020-67S CS13 56 uF	99K	120K	
A15	C7	941004-XX CK06	163K	145K	Select Capacitor NOISY
A16	C8	478020-49S CS13 6.8 uF	43.1K	59.6K	
A17	CR1	468169-1 1N645	290.3 | .176	290.3 | .176	
A18	CR2	468169-1 1N645	289.3 | .176	289.1 | .176	
A19	CR3	468169-1 1N645	68.3K | .579	52.2K | OPEN	
A20	CR4	468169-1 1N645	67.5K | .581	53K | OPEN	

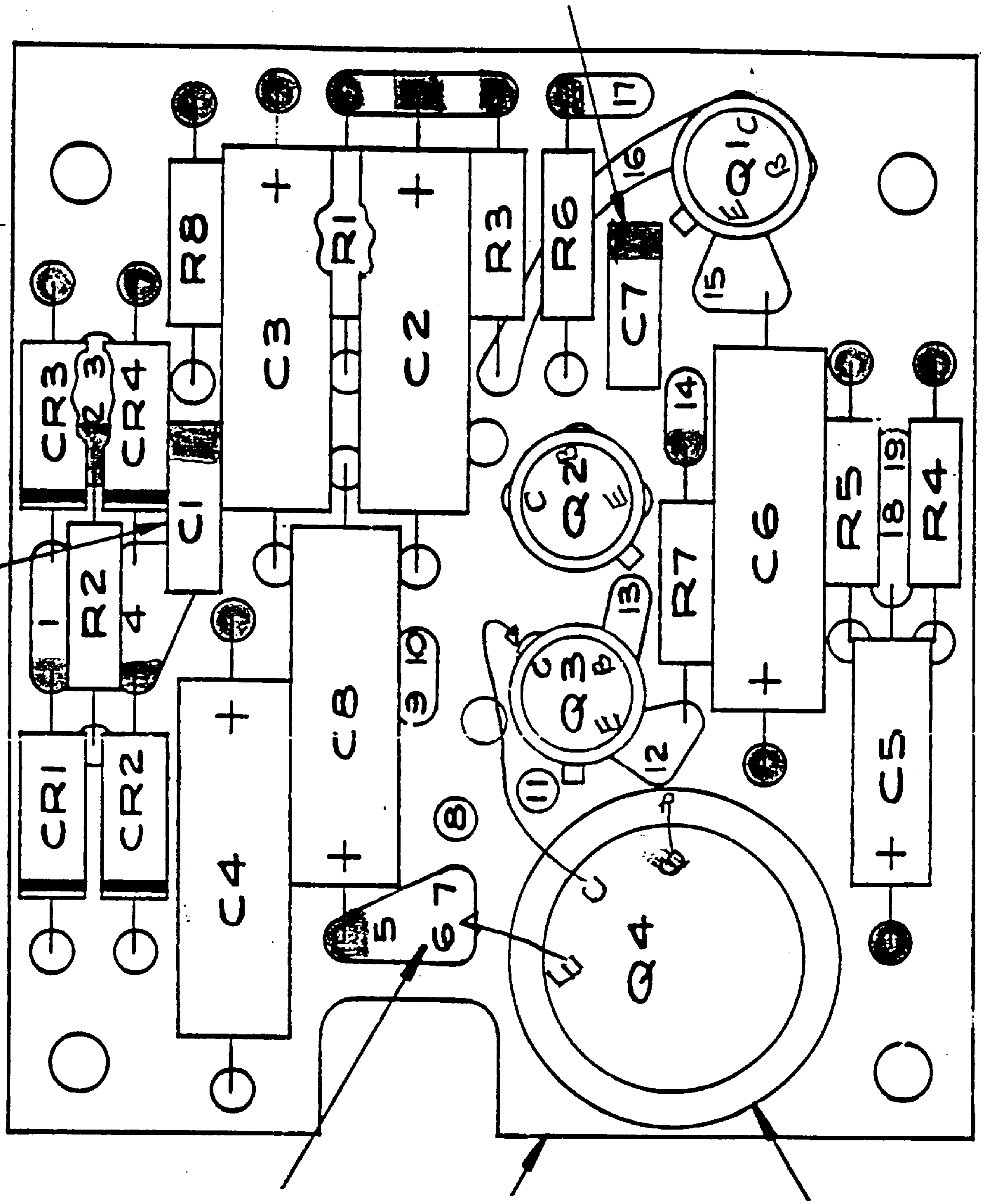
X

Set 3 R. [signature]

Test #	Component Desig.	Component Type	Normal Polarity		Reverse Polarity		Other Measurements or Comments
A21	Q1 B-E	956686-2 2N930	143K	.665	160K	open	Normal -> B = +
A22	Q1 C-B	956686-2 2N930	138K	open	135K	.654	Normal -> C = +
A23	Q1 C-E	956686-2 2N930	188K	1.14	320K	open	Normal -> C = +
A24	Q2 B-E	956686-2 2N930	187K	.658	428K	open	Normal -> B = +
A25	Q2 C-B	956686-2 2N930	92.2K	2.06	94K	.644	Normal -> C = +
A26	Q2 C-E	956686-2 2N930	95K	.783	298K	.646	Normal -> C = +
A27	Q3 B-E	956686-2 2N930	105K	.659	103K	1.15	Normal -> B = +
A28	Q3 C-B	956686-2 2N930	82K	.784	133K	.647	Normal -> C = +
A29	Q3 C-E	956686-2 2N930	3.9K	.449	4.1K	.433	Normal -> C = +
A30	Q4 B-E	948182-5 2N1484	2.75K	.449	2.97K	.478	Normal -> B = +
A31	Q4 C-B	948182-5 2N1484	3.25K	.459	4.4K	.437	Normal -> C = +
A32	Q4 C-E	948182-5 2N1484	43.9	.028	43.9	.028	Normal -> C = +

Set 3 [signature]

Colored Dot is positive for normal ohmeter polarity.



Other Indicator Electronic Components:

Front Panel -> (A1) Pin #s
Back Plate -> Contains E__ Terminals

Assembly #: ______________________ S/N: ______________

Date: Dec 11, 1996 Test Condition: ______________________

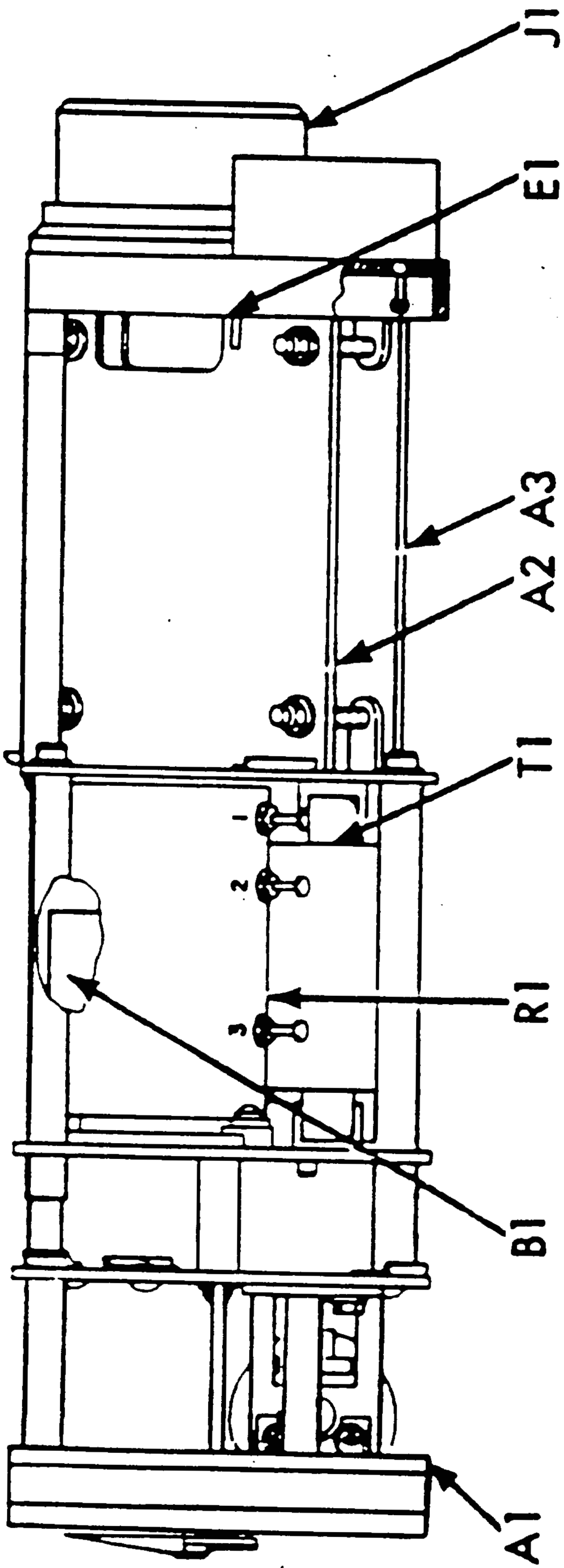
Test Equipment: Same Fluke as Set 1

Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	---------		-----------	----------	------------------------------
C1	R1	Rebalance Pot	972	972	Normal -> S to CW
C2	R1	Rebalance Pot	38.1	38.1	Normal -> S to CCW
C3	R1	Rebalance Pot	1008	1008	Normal -> CW to CCW yellow wire E3 Blk-Brn
C4	R2	Full Trim Pot	62.1	62.1	Normal -> Red to Yel BP Pin E2 to BP Pin E3
C5	R2	Full Trim Pot	103.3	103.3	Normal -> Yel to Grn BP Pin E3 to BP Pin E4
C6	R2	Full Trim Pot	41 6	41.8	Normal -> Grn to Red BP Pin E4 to BP Pin E2
C7	R3	Empty Trim Pot	477	252.7	Normal -> Red to Yel BP Pin E5 to BP Pin E6
C8	R3	Empty Trim Pot	998	998	Normal -> Yel to Grn BP Pin E6 to BP Pin E7
C9	R3	Empty Trim Pot	520	519	Normal -> Grn to Red BP Pin E7 to BP Pin E5
C10	R4, R5		55.7	55.7	Normal -> Brn lead Pos
C11	C1		115.3	115.6	Normal -> Blu to Red A1 Pin 1 to A1 Pin 4
C12	C2		104.5	104.2	Normal -> Close to C1 A1 Pin 2 to A1 Pin 7
C13	B1	Servo Motor Primary	104.6	104.6	Normal -> Red to Blk A1 Pin 4 to A1 Pin 3
C14	B1	Servo Motor Secondary	SEE TEST C12		Normal -> Yel to Wht A1 Pin 2 to A1 Pin 7

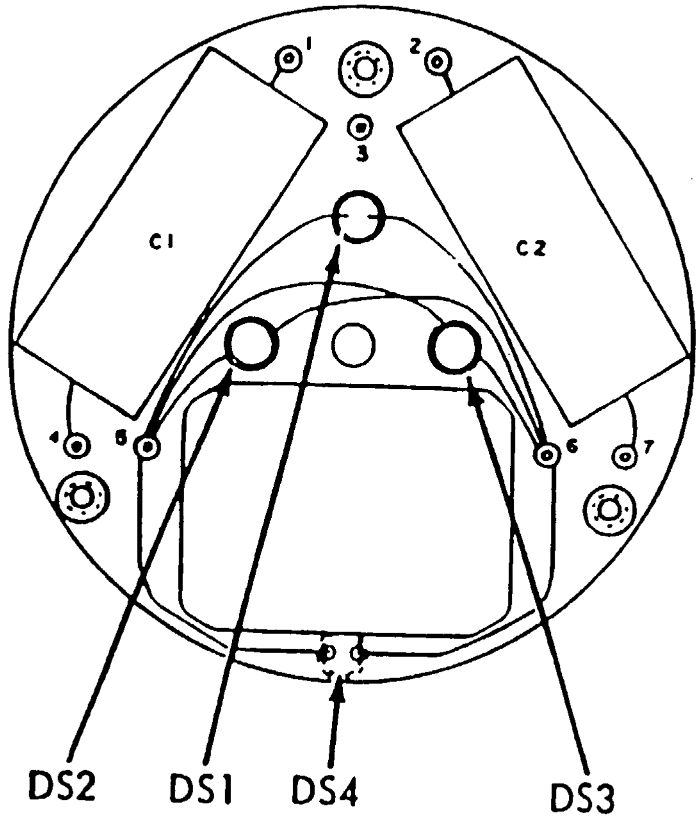
1002971-101

Set 3 [signature]

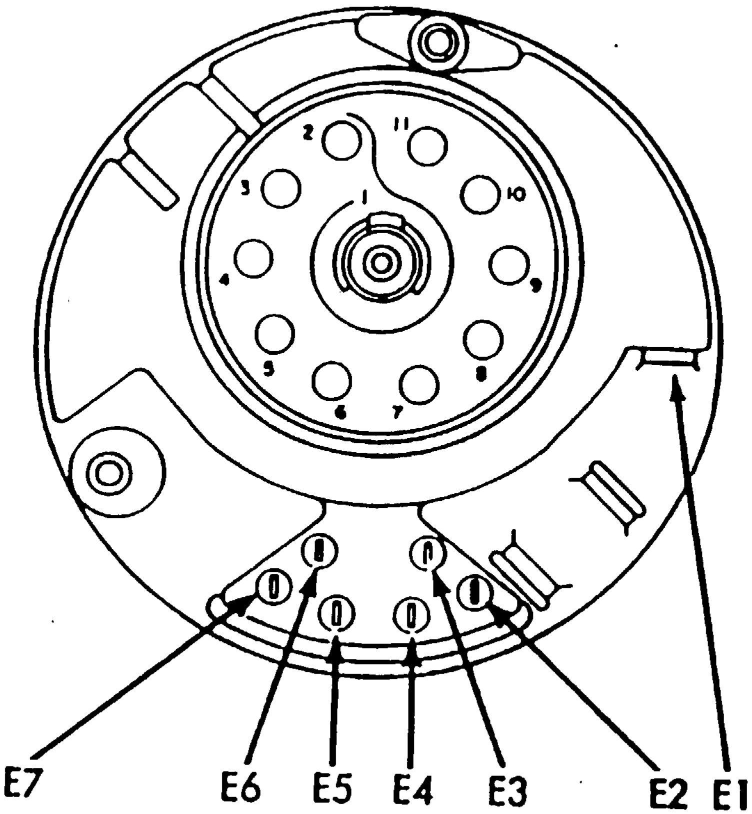
Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
C15	T1	Pwr Xfmr. Primary			Normal -> Red to Brn J1 Pin 7 to R4
C16	T1	Pwr Xfmr Secondary 1 Servo M Ex			Normal -> Blu to Vio A1 Pin 1 to A1 Pin 3
C17	T1	Pwr Xfmr Secondary 2 Amp PS			Normal -> Gy to Wt A3 Pin 4 to A3 Pin 7
C18	T1	Pwr Xfmr Secondary 2 Amp PS			Normal -> Wht to Blk A3 Pin 7 to A3 Pin 1
C19	T1	Pwr Xfmr Secondary 2 Amp PS			Normal -> Gy to Blk A3 Pin 4 to A3 Pin 1
C20	T1	Pwr Xfmr Secondary 3 T.U. Ex.			Normal -> Wht/Blk to Wht/Vio A2 Pin 20 to A2 Pin 34
C21	T1	Pwr Xfmr Secondary 4 I Limit			Normal -> Wht/Brn to Wht/Red A2 Pin 14 to A2 Pin 39
C22	T1	Pwr Xfmr Secondary 5 Rebalance			Normal -> Grn to Yel A2 Pin 8 to BP Pin E3
C23	T1	Pwr Xfmr Secondary 5 Rebalance			Normal -> Yel to Orn BP Pin E3 to BP Pin E4
C24	T1	Pwr Xfmr Secondary 5 Rebalance			Normal -> Grn to Orn A2 Pin 8 to BP Pin E4
C25	T1	Pwr Xfmr Secondary 6 Comp. Ex.			Normal -> Wht/Blu to Wht/Grn A2 Pin 29 to A2 Pin 37
C26	T1	Pwr Xfmr Secondary 6 Comp. Ex.			Normal -> Wht/Grn to Wht/Yel A2 Pin 37 to A2 Pin 35
C27	T1	Pwr Xfmr Secondary 6 Comp. Ex.			Normal -> Wht/Yel to Wht Orn A2 Pin 35 to BP Pin E7
C28	T1	Pwr Xfmr Secondary 6 Comp. Ex.			Normal -> Wht Blu to Wht/Yel A2 Pin 29 to A2 Pin 35



INDICATOR WITH HOUSING REMOVED



CONNECTIONS FOR LAMPS
AND CAPACITORS A1C1 AND A1C2
(REAR VIEW OF A1)



LOCATION OF
CONNECTOR J1 PINS
AND BACKPLATE TERMINALS
(FRONT VIEW)

Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	---------		-----------	----------	-----------------------------
C29	T1	Pwr Xfmr. Pri to Sec 1	open	open	Normal -> Red to J1-7 to A1 Pin 1
C30	T1	Pwr Xfmr. Pri to Sec 2	open	open	Normal -> Red to J1-7 to A3 PIN 2
C31	T1	Pwr Xfmr. Pri to Sec 3	open	open	Normal -> Red to J1-7 to A2 PIN 20
C32	T1	Pwr Xfmr. Pri to Sec 4	open	open	Normal -> Red to J1-7 to A2 PIN 14
C33	T1	Pwr Xfmr. Pri to Sec 5	open	open	Normal -> Red to J1-7 to A2 PIN 8
C34	T1	Pwr Xfmr. Pri to Sec 6	open	open	Normal -> Red to J1-7 to A2 PIN 29
C35	T1	Pwr Xfmr. Sec 1 to Sec 2			Normal ->Blu to Gy A1 Pin 1 to A3 Pin 4
C36	T1	Pwr Xfmr. Sec 1 to Sec 3			Normal -> Blu to Wht/Blk A1 Pin 1 to A2 Pin 20
C37	T1	Pwr Xfmr. Sec 1 to Sec 4			Normal -> Blu to Wht/Brn A1 Pin 1 to A2 Pin 14
C38	T1	Pwr Xfmr. Sec 1 to Sec 5			Normal -> Blu to Grn A1 Pin 1 to A2 Pin 8
C39	T1	Pwr Xfmr. Sec 1 to Sec 6			Normal -> Blu to Wht/Blu A1 Pin 1 to A2 Pin 29
C40	T1	Pwr Xfmr. Sec 2 to Sec 3			Normal -> Gy to Wht/Blk A3 Pin 4 to A2 Pin 14
C41	T1	Pwr Xfmr. Sec 2 to Sec 4			Normal -> Gy to Wht/Brn A3 Pin 4 to A2 Pin 14
C42	T1	Pwr Xfmr. Sec 2 to Sec 5			Normal -> Gy to Brn A3 Pin 4 to A2 Pin 8
C43	T1	Pwr Xfmr. Sec 2 to Sec 6			Normal -> Gy to Wht/Blu A3 Pin 4 to A2 Pin 29
C44	T1	Pwr Xfmr. Sec 3 to Sec 4			Normal -> Wht/Blk to Wht/Brn A2 Pin 20 to A2 Pin 14
C45	T1	Pwr Xfmr. Sec 3 to Sec 5			Normal -> Wht/Blk to Grn A2 Pin 20 to A2 Pin 8
C46	T1	Pwr Xfmr. Sec 3 to Sec 6			Normal -> Wht/Blk to Wht/Blu A2 Pin 20 to A2 Pin 29
C47	T1	Pwr Xfmr. Sec 4 to Sec 5			Normal -> Wht/Brn to Grn A2 Pin 14 to A2 Pin 8
C48	T1	Pwr Xfmr. Sec 4 to Sec 6			Normal -> Wht/Brn to Wht/Blu A2 Pin 14 to A2 Pin 29
C49	T1	Pwr Xfmr. Sec 5 to Sec 6			Normal ->Grn to Wht/Blu A2 Pin 8 to A2 Pin 29

Set 3 [illegible]

JG603 C3 S/N T1 (CWT indicator) Errors 7

Official Data

Bridge Assembly Resistance Measurements:

Assembly #: 10022294-103 S/N:

Date: Dec 10, 1996 Test Condition: Pre Wash

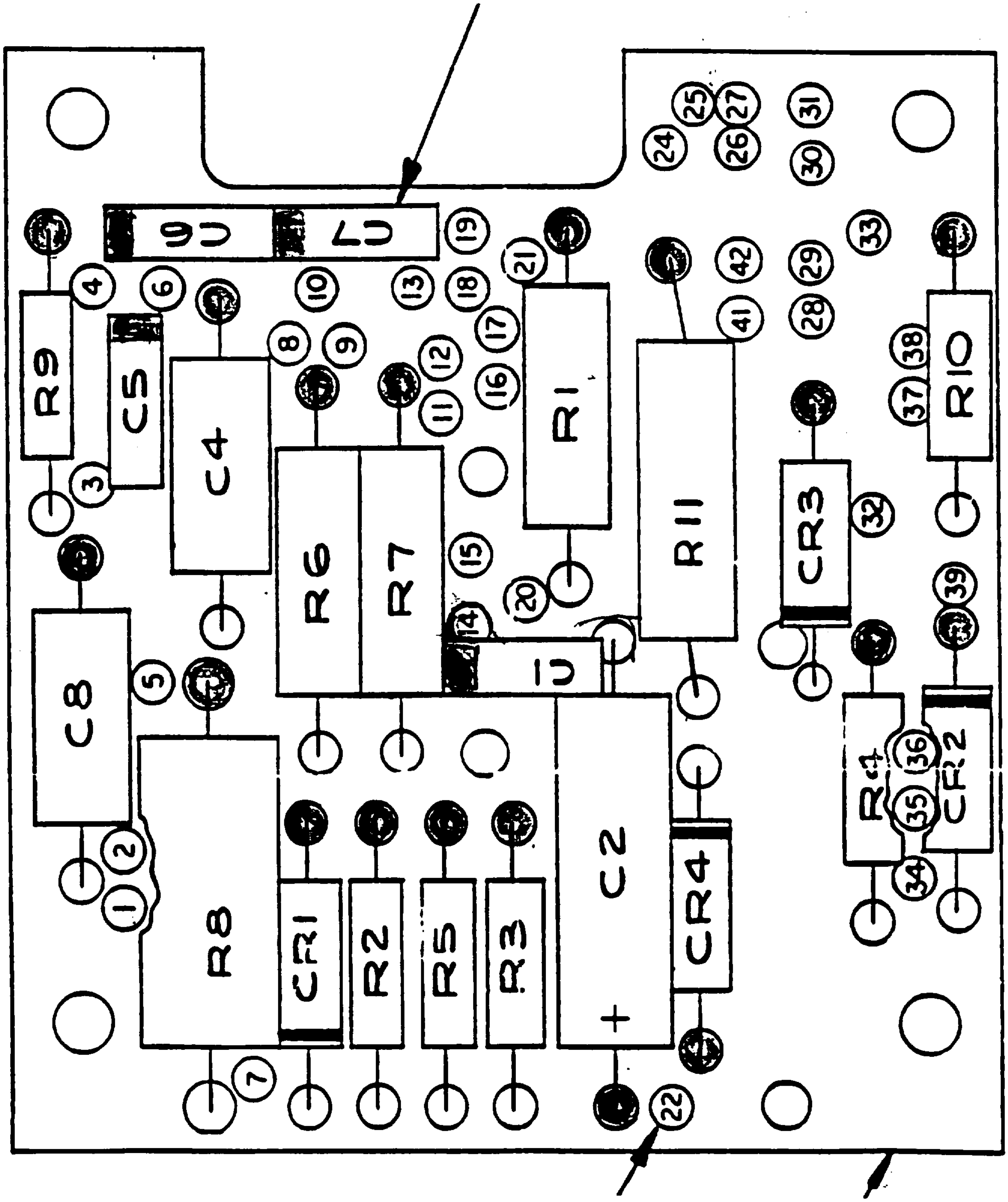
Test Equipment: Fluke 77 CFS-1500-005 Cert To 6/14/98

Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	---------		----------	----------	----------------------------
B1	R1	RC07GF300J	43.7	43.7	
B2	R2	RC07GF270J	30.0	30.0	
B3	R3	RC07GF682J	7.34K	7.34K	
B4	R4	RC07GF682J	open	open	MISSING
B5	R5	RC07GF682J	7.24K	7.25K	
B6	R6	RN60C75R0F	72.5	72.6	
B7	R7	RWR80S2431FP 478100-2431	106.5	106.5	
B8	R8	RW79U1000F	100.1	100.1	(DATE CODE 7608)
B9	R9	RC07GF332J	3.69K	3.69K	
B10	R10	RL07S392G	57.0	57.0	
B11	R11	RW79U1000F	100.1	100.1	(DATE CODE 7608) DAMAGE NON DOT END
B12	C1	941004-29 CK06 .01uF	44.2	44.3	
B13	C2	478020-49S CS13 6.8 uF	2.3M	2.4M	
B14	C3	NOT USED			NOT USED
B15	C4	CY10C131F	open	open	
B16	C5	10022409-108 CK06 120 pF	open	open	
B17	C6	10022409-108 CK06 120 pF	open	open	
B18	C7	941004-23 CK06 3.3 nF	open	open	
B19	C8	CY10C131F	open	open	
B20	CR1	468169-1 1N645	2.3M | .614	2.2M | open	
B21	CR2	468169-1 1N645	2.3M	2.2M	MISSING
B22	CR3	468169-1 1N645	open	open	MISSING
B23	CR4	468169-1 1N645	2.2M | .601	2.4M | 1.8	

For CR, second # is -▷|- scale on Fluke 77

S/N T1 [signature]

Colored Dot is positive for normal ohmeter polarity.



J660363 S/N T1 Series 7

Amplifier Assembly Resistance Measurements:

Assembly #: 10022295 S/N:

Date: Dec 10, 1996 Test Condition: Pre Wash

Test Equipment: Fluke 77 CFS-1500-005 Cert to 6/14/98

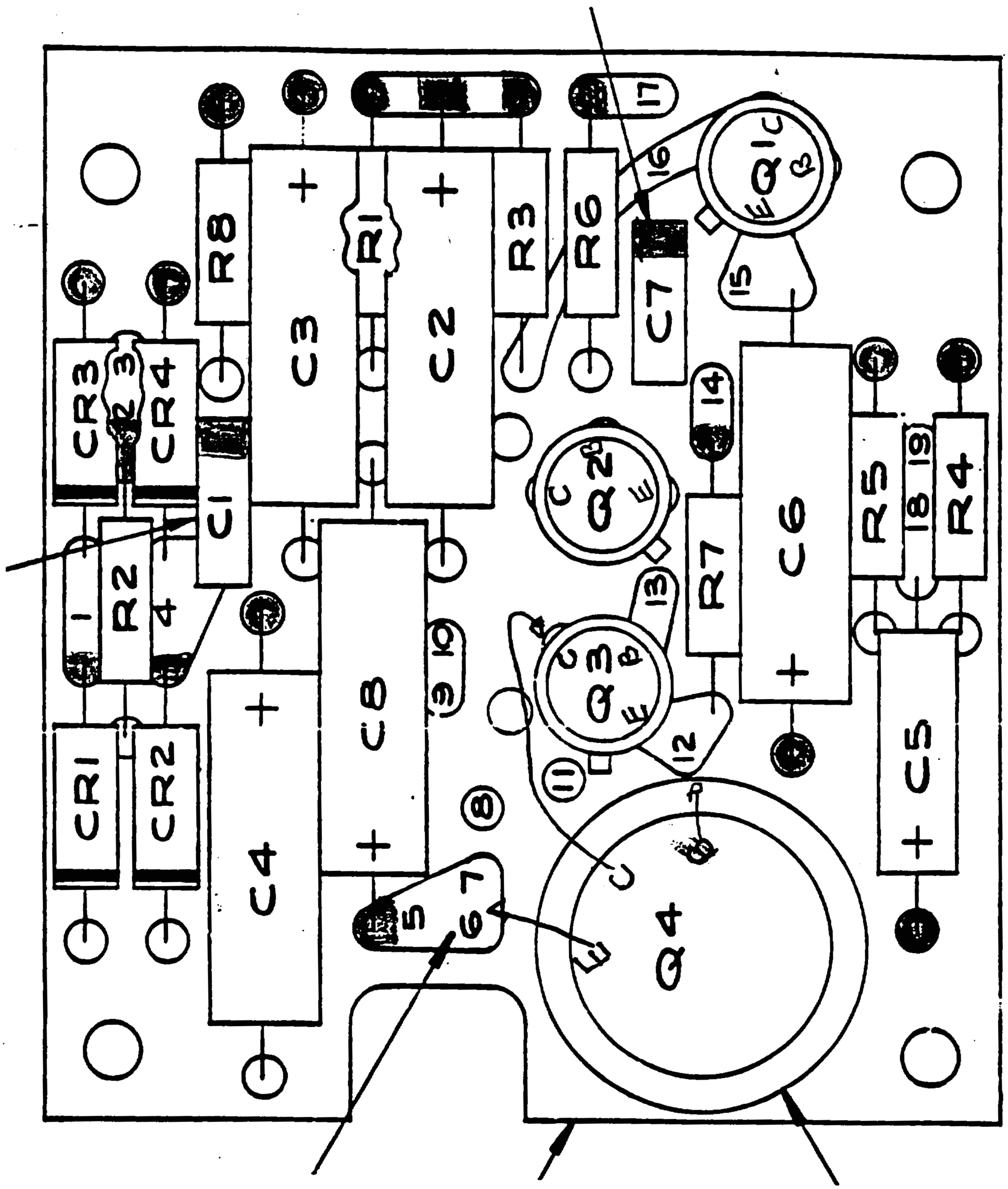
Test #	Component Desig.	Component Type	Normal Polarity		Reverse Polarity		Other Measurements or Comments
----	----------		-----------		----------		------------------------------
A1	R1	RC07GF393J	40.8K		40.8K		
A2	R2	RC07GF101J	109.5		109.3		
A3	R3	RC07GF473J	51.2K		51.2K		
A4	R4	RC07GF393J	3.85M		OPEN		DAMAGED
A5	R5	RC07GF563J	58K		57.7K		
A6	R6	RC07GF563J	60.4K		60.4K		
A7	R7	RC07GF393J	43.5K		43.5K		
A8	R8	RC07GFXXXJ	9.40K		9.40K		Select Resistor
A9	C1	941004-29 CK06 .01 uF	63.2		63.2		
A10	C2	478020-49S CS13 6.8 uF	175K		175K		CAP WAS CHARGING
A11	C3	478020-110S CS13 4.7 uF	148.3		148.3		
A12	C4	478020-110S CS13 4.7 uF	258		258		
A13	C5	478020-19S CS13 .15 uF	42.3K		3.86M		
A14	C6	478020-67S CS13 56 uF	130K		140K		CHARGING (DATE CODE 9517)
A15	C7	941004-XX CK06	3.66M		OPEN		Select Capacitor
A16	C8	478020-49S CS13 6.8 uF	75K		76K		CHARGING
A17	CR1	468169-1 1N645	290.3	.176	290.3	.176	
A18	CR2	468169-1 1N645	289.5	.175	289.4	.175	
A19	CR3	468169-1 1N645	100K	.575	70K	OPEN	CHARGING
A20	CR4	468169-1 1N645	75K	.578	75K	OPEN	CHARGING

Set 1 [signature]

Test #	Component Desig.	Component Type	Normal Polarity		Reverse Polarity		Other Measurements or Comments
----	----------		------------		----------		------------------------------
A21	Q1 B-E	956686-2 2N930	3.76M	.667	OPEN	OPEN	Normal -> B = +
A22	Q1 C-B	956686-2 2N930	OPEN	OPEN	3.72M	.657	Normal -> C = +
A23	Q1 C-E	956686-2 2N930	175K	OPEN	175K	OPEN	Normal -> C = + CHARGING
A24	Q2 B-E	956686-2 2N930	DISCHARGING 350K	.660	CHARGING 200K	OPEN	Normal -> B = + ~~DISCHARGING~~
A25	Q2 C-B	956686-2 2N930	92.2K	OPEN	92.2	.647	Normal -> C = +
A26	Q2 C-E	956686-2 2N930	CHAR. 120K	.786	CHAR. 120K	.648	Normal -> C = +
A27	Q3 B-E	956686-2 2N930	CHAR. 100K	.658	CHAR 100K	1.169	Normal -> B = +
A28	Q3 C-B	956686-2 2N930	CHAR 55K	.785	CHAR 600K	.647	Normal -> C = +
A29	Q3 C-E	956686-2 2N930	CHAR 22K	.462	CHAR 16K	.452	Normal -> C = +
A30	Q4 B-E	948182-5 2N1484	CHAR 3K	.440	CHAR 3.2K	.466	Normal -> B = +
A31	Q4 C-B	948182-5 2N1484	CHAR 2.7K	.438	CHAR 2.5K	.439	Normal -> C = +
A32	Q4 C-E	948182-5 2N1484	43.6	.028	440	.028	Normal -> C = +

Set 1 R. [illegible]

Colored Dot is positive for normal ohmeter polarity.



J6 603 C3 S/N J1

Other Indicator Electronic Components:

Front Panel -> (A1) Pin #s
Back Plate -> Contains E__ Terminals

Assembly #:______________ S/N:______________

Date:______________ Test Condition: (CW TO R1 CUT) Pre Wash

Test Equipment: Fluke 77 CFS-1500-005 Cal to 6/14/98

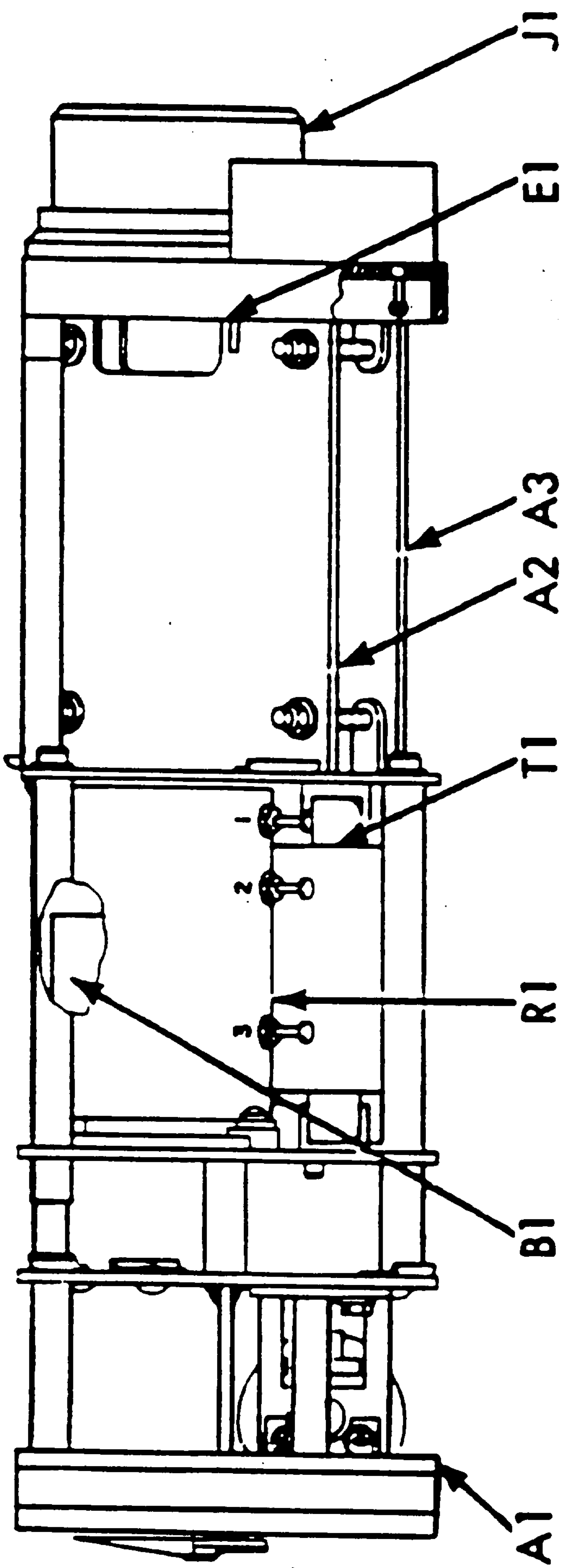
Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	----------		-----------	----------	----------------------------
C1	R1	Rebalance Pot	972	972	Normal -> S to CW
C2	R1	Rebalance Pot	38.6	38.6	Normal -> S to CCW
C3	R1	Rebalance Pot	1008	1008	Normal -> CW to CCW
C4	R2	Full Trim Pot	62.0 ~~41.5~~	62.3 ~~41.5~~	Normal -> Red to Yel BP Pin E2 to BP Pin E3
C5	R2	Full Trim Pot	103.1	103.1	Normal -> Yel to Grn BP Pin E3 to BP Pin E4
C6	R2	Full Trim Pot	41.5	41.5	Normal -> Grn to Red BP Pin E4 to BP Pin E2
C7	R3	Empty Trim Pot	252.2	477	Normal -> Red to Yel BP Pin E5 to BP Pin E6
C8	R3	Empty Trim Pot	12.6	12.5	Normal -> Yel to Grn BP Pin E6 to BP Pin E7
C9	R3	Empty Trim Pot	252.9	252.9	Normal -> Grn to Red BP Pin E7 to BP Pin E5
C10	R4, R5		55.0	55.0	Normal -> Brn lead Pos
C11	C1		116.1	117.1	Normal -> Blu to Red A1 Pin 1 to A1 Pin 4
C12	C2		104.7	105.3	Normal -> Close to C1 A1 Pin 2 to A1 Pin 7
C13	B1	Servo Motor Primary	105.0	105.1	Normal -> Red to Blk A1 Pin 4 to A1 Pin 3
C14	B1	Servo Motor Secondary	See Test	C12	Normal -> Yel to Wht A1 Pin 2 to A1 Pin 7

Set 1 [signature]

Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
C15	T1	Pwr Xfmr. Primary	79.8	79.7	Normal -> Red to Brn J1 Pin 7 to R4
C16	T1	Pwr Xfmr Secondary 1 Servo M Ex	10.5	10.5	Normal -> Blu to Vio A1 Pin 1 to A1 Pin 3
C17	T1	Pwr Xfmr Secondary 2 Amp PS	30.6	30.6	Normal -> Gy to Wt A3 Pin 4 to A3 Pin 7
C18	T1	Pwr Xfmr Secondary 2 Amp PS	31.8	31.8	Normal -> Wht to Blk A3 Pin 7 to A3 Pin 1
C19	T1	Pwr Xfmr Secondary 2 Amp PS	62.6	62.7	Normal -> Gy to Blk A3 Pin 4 to A3 Pin 1
C20	T1	Pwr Xfmr Secondary 3 T.U. Ex.	15.6	15.5	Normal -> Wht/Blk to Wht/Vio A2 Pin 20 to A2 Pin 34
C21	T1	Pwr Xfmr Secondary 4 I Limit	44.3	44.3	Normal -> Wht/Brn to Wht/Red A2 Pin 14 to A2 Pin 39
C22	T1	Pwr Xfmr Secondary 5 Rebalance	115.3	115.4	Normal -> Grn to Yel A2 Pin 8 to BP Pin E3
C23	T1	Pwr Xfmr Secondary 5 Rebalance	103.1	103.1	Normal -> Yel to Orn BP Pin E3 to BP Pin E4
C24	T1	Pwr Xfmr Secondary 5 Rebalance	12.3	12.3	Normal -> Grn to Orn A2 Pin 8 to BP Pin E4
C25	T1	Pwr Xfmr Secondary 6 Comp. Ex.	57.0	57.1	Normal -> Wht/Blu to Wht/Grn A2 Pin 29 to A2 Pin 37
C26	T1	Pwr Xfmr Secondary 6 Comp. Ex.	6.0	6.1	Normal -> Wht/Grn to Wht/Yel A2 Pin 37 to A2 Pin 35
C27	T1	Pwr Xfmr Secondary 6 Comp. Ex.	6.1	6.1	Normal -> Wht/Yel to Wht Orn A2 Pin 35 to BP Pin E7
C28	T1	Pwr Xfmr Secondary 6 Comp. Ex.	63.3	63.3	Normal -> Wht Blu to Wht/Yel A2 Pin 29 to A2 Pin 35

[illegible]

INDICATOR WITH HOUSING REMOVED



Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	----------		-----------	----------	-----------------------------
C29	T1	Pwr Xfmr. Pri to Sec 1	Open	open	Normal -> Red to J1-7 to A1 Pin 1
C30	T1	Pwr Xfmr. Pri to Sec 2	OPEN	Open	Normal -> Red to J1-7 to A3 PIN 2
C31	T1	Pwr Xfmr. Pri to Sec 3	OPEN	open	Normal -> Red to J1-7 to A2 PIN 20
C32	T1	Pwr Xfmr. Pri to Sec 4	Open	Open	Normal -> Red to J1-7 to A2 PIN 14
C33	T1	Pwr Xfmr. Pri to Sec 5	Open	open	Normal -> Red to J1-7 to A2 PIN 8
C34	T1	Pwr Xfmr. Pri to Sec 6	Open	open	Normal -> Red to J1-7 to A2 PIN 29
C35	T1	Pwr Xfmr. Sec 1 to Sec 2	open	open	Normal ->Blu to Gy A1 Pin 1 to A3 Pin 4
C36	T1	Pwr Xfmr. Sec 1 to Sec 3	Open	open	Normal -> Blu to Wht/Blk A1 Pin 1 to A2 Pin 20
C37	T1	Pwr Xfmr. Sec 1 to Sec 4	Open	open	Normal -> Blu to Wht/Brn A1 Pin 1 to A2 Pin 14
C38	T1	Pwr Xfmr. Sec 1 to Sec 5	OPEN	open	Normal -> Blu to Grn A1 Pin 1 to A2 Pin 8
C39	T1	Pwr Xfmr. Sec 1 to Sec 6	Open	open	Normal -> Blu to Wht/Blu A1 Pin 1 to A2 Pin 29
C40	T1	Pwr Xfmr. Sec 2 to Sec 3	Open	Open	Normal -> Gy to Wht/Blk A3 Pin 4 to A2 Pin ~~14~~ 20
C41	T1	Pwr Xfmr. Sec 2 to Sec 4	OPEN	open	Normal -> Gy to Wht/Brn A3 Pin 4 to A2 Pin 14
C42	T1	Pwr Xfmr. Sec 2 to Sec 5	open	open	Normal -> Gy to Brn A3 Pin 4 to A2 Pin 8
C43	T1	Pwr Xfmr. Sec 2 to Sec 6	open	open	Normal -> Gy to Wht/Blu A3 Pin 4 to A2 Pin 29
C44	T1	Pwr Xfmr. Sec 3 to Sec 4	CHARGE 2.1M/2.04	1.80 2.3M	Normal -> Wht/Blk to Wht/Brn A2 Pin 20 to A2 Pin 14
C45	T1	Pwr Xfmr. Sec 3 to Sec 5	14.68K/1.93	14.65K/1.91	Normal -> Wht/Blk to Grn A2 Pin 20 to A2 Pin 8
C46	T1	Pwr Xfmr. Sec 3 to Sec 6	Open	open	Normal -> Wht/Blk to Wht/Blu A2 Pin 20 to A2 Pin 29
C47	T1	Pwr Xfmr. Sec 4 to Sec 5	CHARGE 2.3M/1.80	2.22M/.677	Normal -> Wht/Brn to Grn A2 Pin 14 to A2 Pin 8
C48	T1	Pwr Xfmr. Sec 4 to Sec 6	open	open	Normal -> Wht/Brn to Wht/Blu A2 Pin 14 to A2 Pin 29
C49	T1	Pwr Xfmr. Sec 5 to Sec 6	open	open	Normal ->Grn to Wht/Blu A2 Pin 8 to A2 Pin 29

Lot 1 R. [illegible]

JG603C3 S/N B14
Series 3

Bridge Assembly Resistance Measurements:

Serial B-14 was the operational gage that the CWT components were tested in.

Assembly #: 10022294-103 S/N: ____________

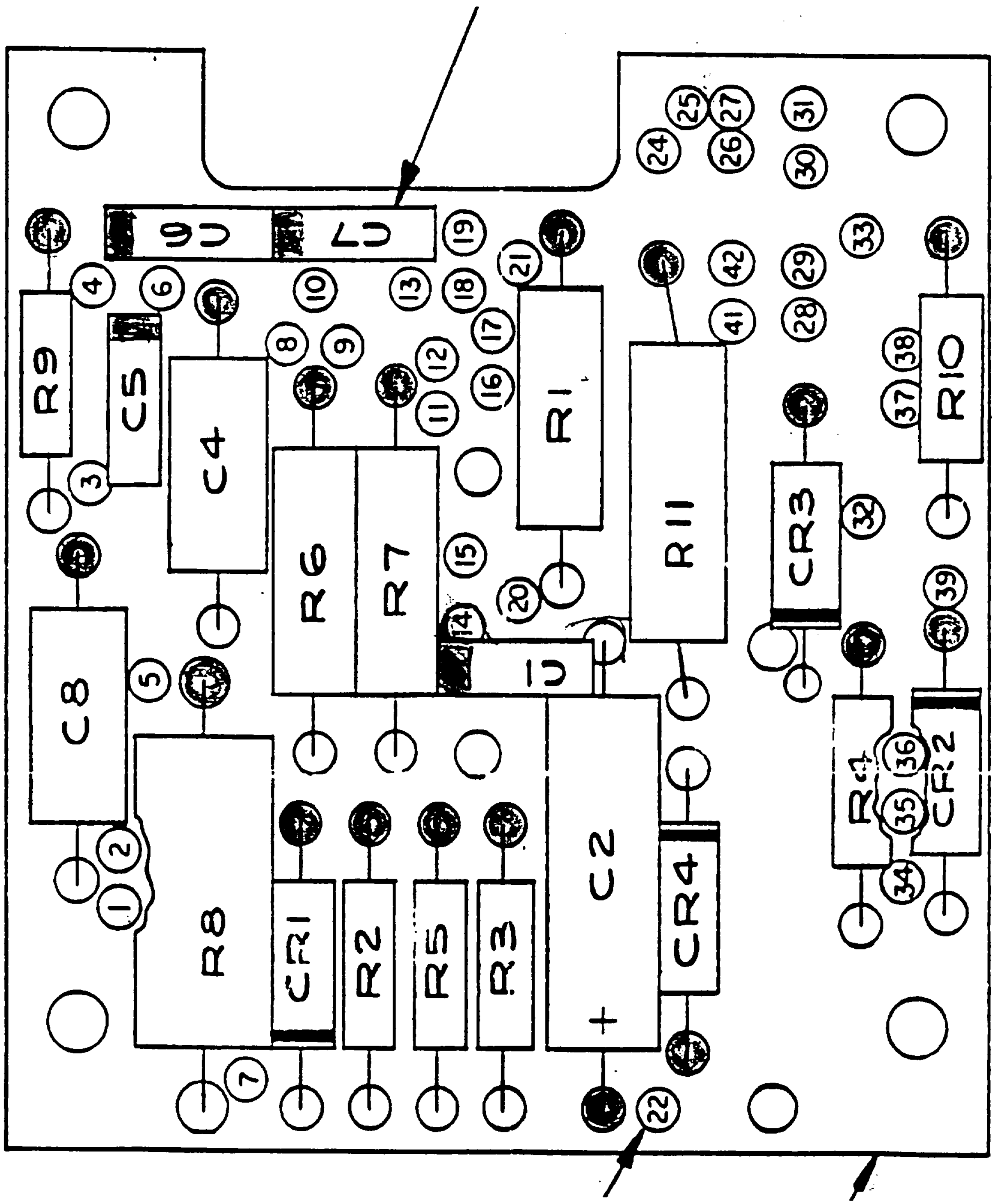
Date: Dec 10, 1996 Test Condition: Operational Device

Test Equipment: Same Fluke as Set 1

Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	---------		----------	----------	-----------------------------
B1	R1	RC07GF300J	37.0	37.1	
B2	R2	RC07GF270J	32.1	32.1	
B3	R3	RC07GF682J	6.98K	6.98K	
B4	R4	RC07GF682J	7.01K	7.01K	
B5	R5	RC07GF682J	7.28K	7.28K	
B6	R6	RN60C75R0F	72.6	72.7	
B7	R7	RWR80S2431FP 478100-2431	105.5	105.6	
B8	R8	RW79U1000F	101.2	101.2	
B9	R9	RC07GF332J	3.56K	3.56K	
B10	R10	RL07S392G	59.6	59.6	
B11	R11	RW79U1000F	—	—	NOT APLICABLE TO SERIES 3
B12	C1	941004-29 CK06 .01uF	45.1	45.3	
B13	C2	478020-49S CS13 6.8 uF	1.61M	2.03M	
B14	C3	NOT USED			NOT USED
B15	C4	CY10C131F	53.3K	53.3K	
B16	C5	10022409-108 CK06 120 pF	open	open	
B17	C6	10022409-108 CK06 120 pF	open	open	
B18	C7	941004-23 CK06 3.3 nF	open	open	
B19	C8	CY10C131F	open	open	
B20	CR1	468169-1 1N645	2.01M	.537	1.60M	1.24	
B21	CR2	468169-1 1N645	2.03M	1.76	252K	.528	
B22	CR3	468169-1 1N645	1.61M	.550	2.02M	1.76	
B23	CR4	468169-1 1N645	253K	.536	2.02M	1.77	

Set 2 [illegible signature]

Colored Dot is positive for normal ohmeter polarity.



Amplifier Assembly Resistance Measurements:

Assembly #: 10022295 S/N:

Date: Dec 10, 1996 Test Condition: Operation at Room

Test Equipment: Same Fluke as Set 1

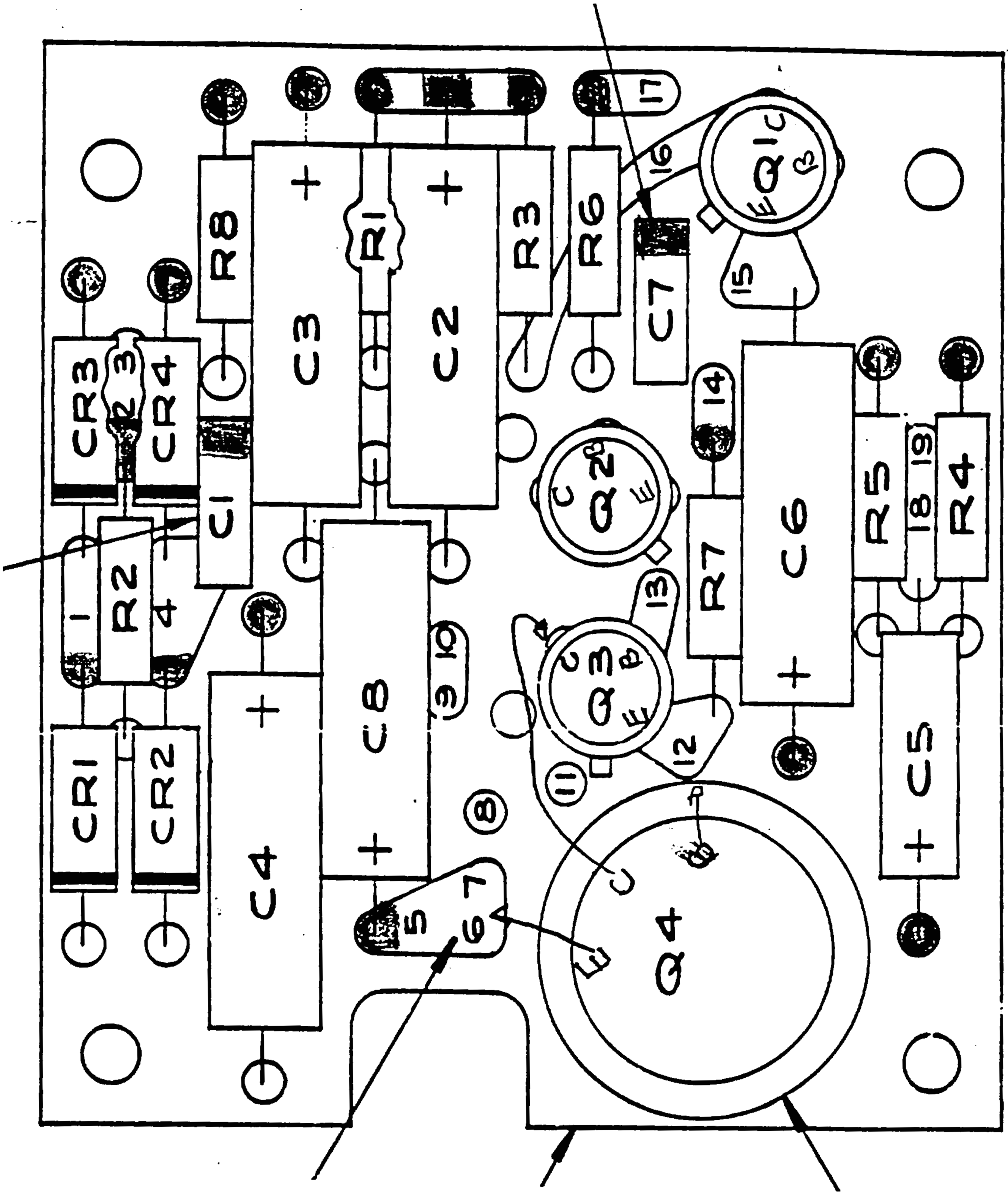
Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
A1	R1	RC07GF393J	38.9K	38.9K	
A2	R2	RC07GF101J	111.1	111.1	
A3	R3	RC07GF473J	47.5K	47.5K	
A4	R4	RC07GF393J	38.7K	38.7K	
A5	R5	RC07GF563J	55.3K	55.2K	
A6	R6	RC07GF563J	55.9K	55.9K	
A7	R7	RC07GF393J	38.3K	38.3K	
A8	R8	RC07GFXXXJ	8.61K	8.61K	Select Resistor
A9	C1	941004-29 CK06 .01 uF	65.2	65.2	
A10	C2	478020-49S CS13 6.8 uF	CHARGING 3.9M	1.37M	
A11	C3	478020-110S CS13 4.7 uF	CHARGING 3.0M	260K	
A12	C4	478020-110S CS13 4.7 uF	7.2M	260K	
A13	C5	478020-19S CS13 .15 uF	38.7K	38.7K	
A14	C6	478020-67S CS13 56 uF	CHARGING 1.3M	DISCHARGING 1.6M	
A15	C7	941004-XX CK06	CHARGING 1M	1.1M	Select Capacitor
A16	C8	478020-49S CS13 6.8 uF	CHARGING 1M	CHARGING 250K	
A17	CR1	468169-1 1N645	CHARGING 1.28 | .523	5.11M | 1.59	
A18	CR2	468169-1 1N645	1.010M | .527	7.57M | 1.59	
A19	CR3	468169-1 1N645	1.7M | .540	4.3M | OPEN	
A20	CR4	468169-1 1N645	260K | .538	4.3M | OPEN	

Set 2 [signature]

Test #	Component Desig.	Component Type	Normal Polarity		Reverse Polarity		Other Measurements or Comments
A21	Q1 B-E	956686-2 2N930	3.95M	.712	2.1M	open	Normal -> B = +
A22	Q1 C-B	956686-2 2N930	7.6M	open	2.0M	.707	Normal -> C = +
A23	Q1 C-E	956686-2 2N930	3.85M	1.98	1.5M	open	Normal -> C = +
A24	Q2 B-E	956686-2 2N930	4.0M	.711	1.1M	open	Normal -> B = +
A25	Q2 C-B	956686-2 2N930	86.9K	open	86.8K	.707	Normal -> C = +
A26	Q2 C-E	956686-2 2N930	4.05M	.812	1.20M	.707	Normal -> C = +
A27	Q3 B-E	956686-2 2N930	94.5K	.710	93K	1.22	Normal -> B = +
A28	Q3 C-B	956686-2 2N930	4.05M	.813	1.32M	.707	Normal -> C = +
A29	Q3 C-E	956686-2 2N930	4.23M ~~1.164M~~	1.16	222K	.486	Normal -> C = +
A30	Q4 B-E	948182-5 2N1484	1.56M	.497	4.25M	1.93	Normal -> B = +
A31	Q4 C-B	948182-5 2N1484	3.62M	1.27	220K	.486	Normal -> C = +
A32	Q4 C-E	948182-5 2N1484	5.5M	1.56	1.54M	.626	Normal -> C = +

Set 2 [signature]

Colored Dot is positive for normal ohmeter polarity.



Other Indicator Electronic Components:

Front Panel -> (A1) Pin #s
Back Plate -> Contains E__ Terminals

Assembly #: A1 S/N:

Date: Dec 10, 1996 Test Condition:

Test Equipment: Same Fluke as Set 1

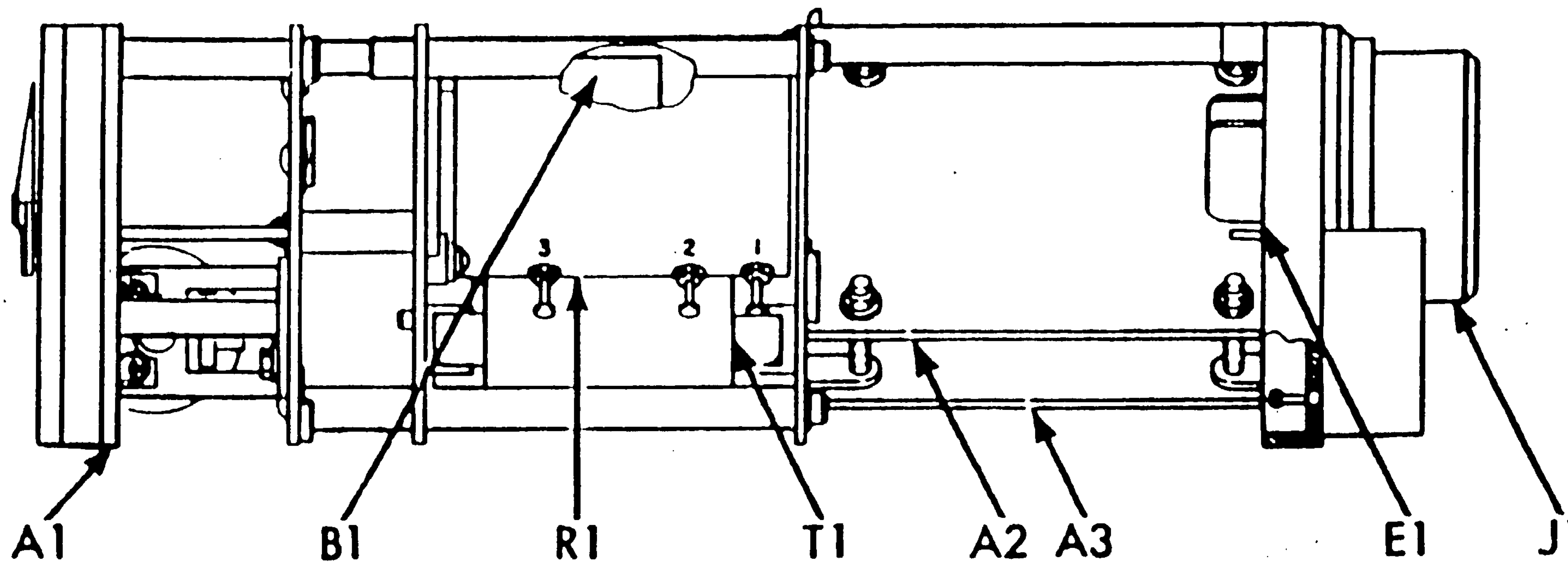
Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	---------		----------	----------	----------------------------
C1	R1	Rebalance Pot	964	964	Normal -> S to CW
C2	R1	Rebalance Pot	38.7	38.9	Normal -> S to CCW
C3	R1	Rebalance Pot	1000	1000	Normal -> CW to CCW
C4	R2	Full Trim Pot	25.4	25.7	Normal -> Red to Yel BP Pin E2 to BP Pin E3
C5	R2	Full Trim Pot	1.6	1.7	Normal -> Yel to Grn BP Pin E3 to BP Pin E4
C6	R2	Full Trim Pot	25.0	24.9	Normal -> Grn to Red BP Pin E4 to BP Pin E2
C7	R3	Empty Trim Pot	250.6	250.6	Normal -> Red to Yel BP Pin E5 to BP Pin E6
C8	R3	Empty Trim Pot	13.4	13.4	Normal -> Yel to Grn BP Pin E6 to BP Pin E7
C9	R3	Empty Trim Pot	250.4	250.5	Normal -> Grn to Red BP Pin E7 to BP Pin E5
C10	R4, R5	NOT	AVAILABLE IN	SERIES 3	Normal -> Brn lead Pos
C11	C1		117.6	117.4	Normal -> Blu to Red A1 Pin 1 to A1 Pin 4
C12	C2		106.1	106.2	Normal -> Close to C1 A1 Pin 2 to A1 Pin 7
C13	B1	Servo Motor Primary	106.3	106.3	Normal -> Red to Blk A1 Pin 4 to A1 Pin 3
C14	B1	Servo Motor Secondary	SEE TEST	C12	Normal -> Yel to Wht A1 Pin 2 to A1 Pin 7

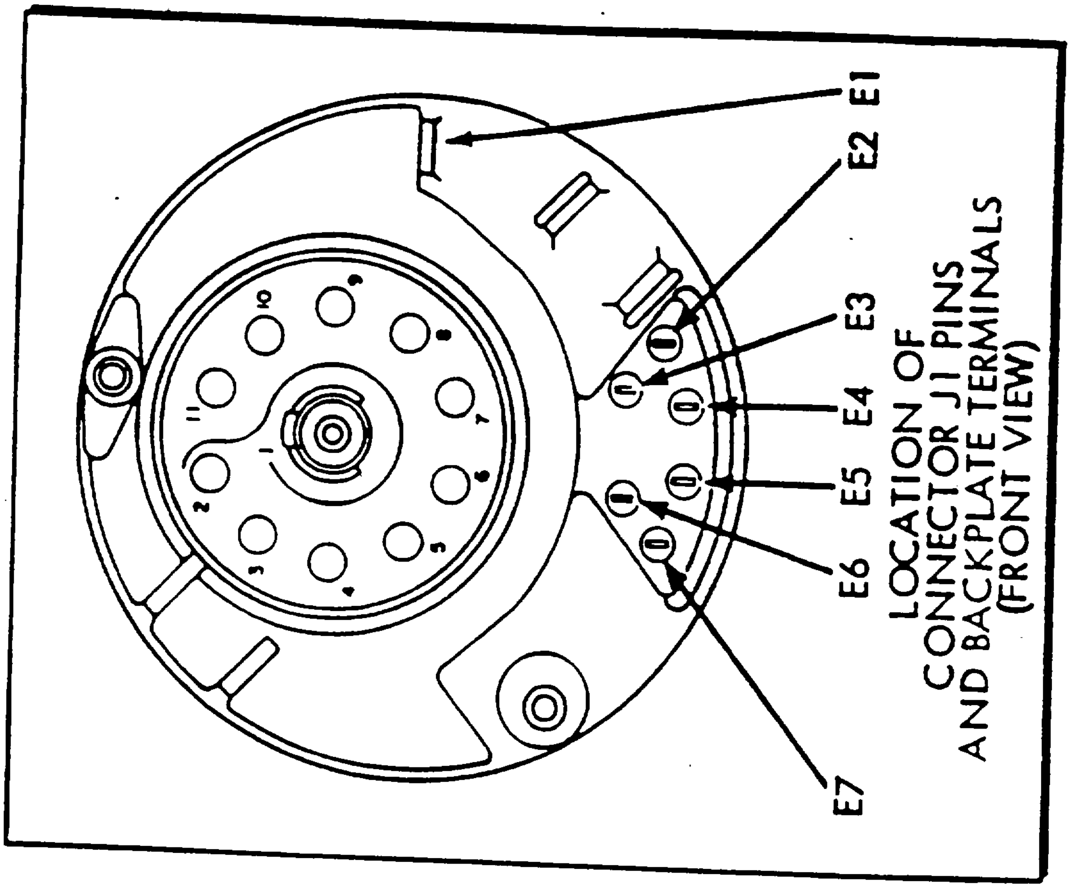
Set 2 [signature]

Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	---------		-----------	----------	-----------------------------
C15	T1	Pwr Xfmr. Primary	80.8	80.9	Normal -> Red to Brn J1 Pin 7 to R4
C16	T1	Pwr Xfmr Secondary 1 Servo M Ex	11.0	11.0	Normal -> Blu to Vio A1 Pin 1 to A1 Pin 3
C17	T1	Pwr Xfmr Secondary 2 Amp PS	32.1	32.2	Normal -> Gy to Wt A3 Pin 4 to A3 Pin 7
C18	T1	Pwr Xfmr Secondary 2 Amp PS	33.1	33.1	Normal -> Wht to Blk A3 Pin 7 to A3 Pin 1
C19	T1	Pwr Xfmr Secondary 2 Amp PS	65.4	65.5	Normal -> Gy to Blk A3 Pin 4 to A3 Pin 1
C20	T1	Pwr Xfmr Secondary 3 T.U. Ex.	16.6	16.6	Normal -> Wht/Blk to Wht/Vio A2 Pin 20 to A2 Pin 34
C21	T1	Pwr Xfmr Secondary 4 I Limit	45.8	45.8	Normal -> Wht/Brn to Wht/Red A2 Pin 14 to A2 Pin 39
C22	T1	Pwr Xfmr Secondary 5 Rebalance	10.7	10.8	Normal -> Grn to Yel A2 Pin 8 to BP Pin E3
C23	T1	Pwr Xfmr Secondary 5 Rebalance	1.5	1.6	Normal -> Yel to Orn BP Pin E3 to BP Pin E4
C24	T1	Pwr Xfmr Secondary 5 Rebalance	12.4	12.5	Normal -> Grn to Orn A2 Pin 8 to BP Pin E4
C25	T1	Pwr Xfmr Secondary 6 Comp. Ex.	60.3	60.4	Normal -> Wht/Blu to Wht/Grn A2 Pin 29 to A2 Pin 37
C26	T1	Pwr Xfmr Secondary 6 Comp. Ex.	6.7	6.5	Normal -> Wht/Grn to Wht/Yel A2 Pin 37 to A2 Pin 35
C27	T1	Pwr Xfmr Secondary 6 Comp. Ex.	6.7	6.7	Normal -> Wht/Yel to Wht Orn A2 Pin 35 to BP Pin E7
C28	T1	Pwr Xfmr Secondary 6 Comp. Ex.	66.9	67.1	Normal -> Wht Blu to Wht/Yel A2 Pin 29 to A2 Pin 35

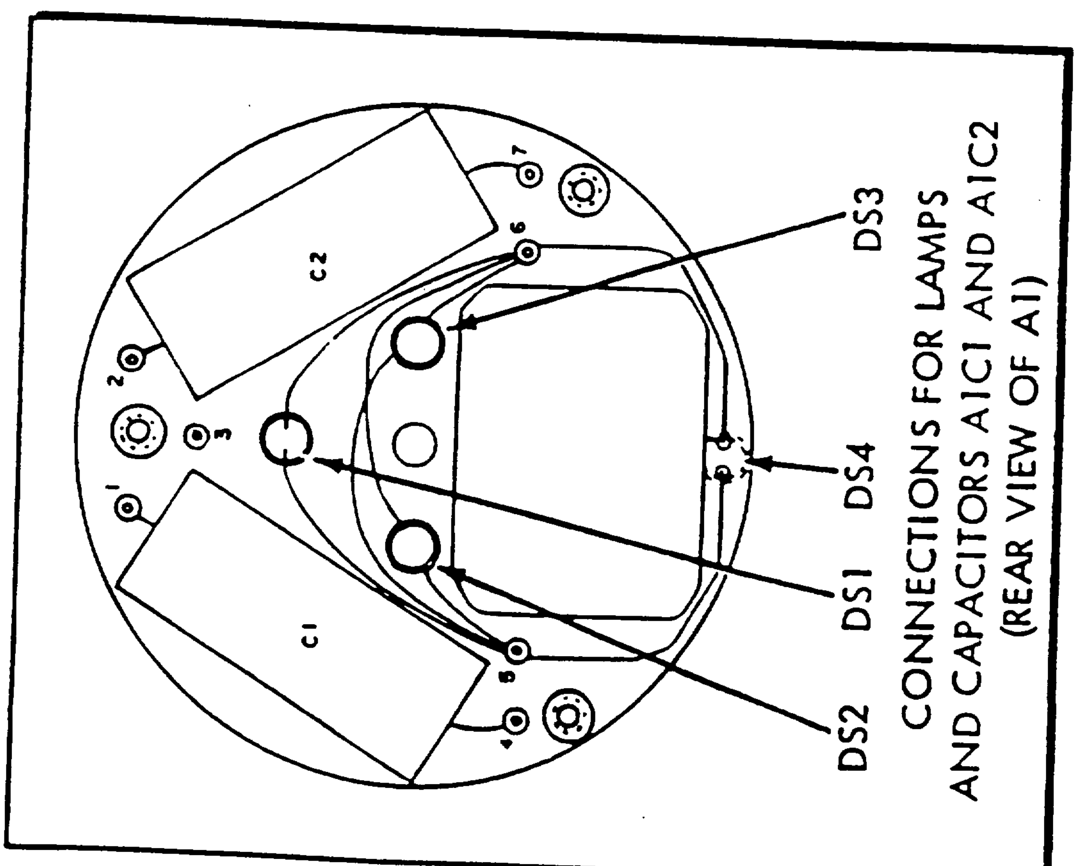
Set 2 [signature]

INDICATOR WITH HOUSING REMOVED





LOCATION OF CONNECTOR J1 PINS AND BACKPLATE TERMINALS (FRONT VIEW)



CONNECTIONS FOR LAMPS AND CAPACITORS A1C1 AND A1C2 (REAR VIEW OF A1)

Test #	Component Desig.	Component Type	Normal Polarity	Reverse Polarity	Other Measurements or Comments
----	----------		-----------	----------	----------------------------
C29	T1	Pwr Xfmr. Pri to Sec 1	open	open	Normal -> Red to J1-7 to A1 Pin 1
C30	T1	Pwr Xfmr. Pri to Sec 2	open	open	Normal -> Red to J1-7 to A3 PIN 2
C31	T1	Pwr Xfmr. Pri to Sec 3	open	open	Normal -> Red to J1-7 to A2 PIN 20
C32	T1	Pwr Xfmr. Pri to Sec 4	open	open	Normal -> Red to J1-7 to A2 PIN 14
C33	T1	Pwr Xfmr. Pri to Sec 5	open	open	Normal -> Red to J1-7 to A2 PIN 8
C34	T1	Pwr Xfmr. Pri to Sec 6	open	open	Normal -> Red to J1-7 to A2 PIN 29
C35	T1	Pwr Xfmr. Sec 1 to Sec 2	open	open	Normal ->Blu to Gy A1 Pin 1 to A3 Pin 4
C36	T1	Pwr Xfmr. Sec 1 to Sec 3	open	open	Normal -> Blu to Wht/Blk A1 Pin 1 to A2 Pin 20
C37	T1	Pwr Xfmr. Sec 1 to Sec 4	open	open	Normal -> Blu to Wht/Brn A1 Pin 1 to A2 Pin 14
C38	T1	Pwr Xfmr. Sec 1 to Sec 5	open	open	Normal -> Blu to Grn A1 Pin 1 to A2 Pin 8
C39	T1	Pwr Xfmr. Sec 1 to Sec 6	open	open	Normal -> Blu to Wht/Blu A1 Pin 1 to A2 Pin 29
C40	T1	Pwr Xfmr. Sec 2 to Sec 3	14.03K	14.04K	Normal -> Gy to Wht/Blk A3 Pin 4 to A2 Pin ~~14~~ 20
C41	T1	Pwr Xfmr. Sec 2 to Sec 4	253.7K	2.022M	Normal -> Gy to Wht/Brn A3 Pin 4 to A2 Pin 14
C42	T1	Pwr Xfmr. Sec 2 to Sec 5	14.40K	14.41K	Normal -> Gy to Brn A3 Pin 4 to A2 Pin 8
C43	T1	Pwr Xfmr. Sec 2 to Sec 6	open	open	Normal -> Gy to Wht/Blu A3 Pin 4 to A2 Pin 29
C44	T1	Pwr Xfmr. Sec 3 to Sec 4	1.6M	2.02M	Normal -> Wht/Blk to Wht/Brn A2 Pin 20 to A2 Pin 14
C45	T1	Pwr Xfmr. Sec 3 to Sec 5	14.35K	14.35K	Normal -> Wht/Blk to Grn A2 Pin 20 to A2 Pin 8
C46	T1	Pwr Xfmr. Sec 3 to Sec 6	open	open	Normal -> Wht/Blk to Wht/Blu A2 Pin 20 to A2 Pin 29
C47	T1	Pwr Xfmr. Sec 4 to Sec 5	2.02M	253K	Normal -> Wht/Brn to Grn A2 Pin 14 to A2 Pin 8
C48	T1	Pwr Xfmr. Sec 4 to Sec 6	open	open	Normal -> Wht/Brn to Wht/Blu A2 Pin 14 to A2 Pin 29
C49	T1	Pwr Xfmr. Sec 5 to Sec 6	open	open	Normal ->Grn to Wht/Blu A2 Pin 8 to A2 Pin 29

Set 2 [signature]

(A.) P/N 10022879-101 CAPACITOR, Metalized Polycarbonate

Tests At 1000 HZ @ 1V Rms Hp 4192A LF Impedance Analyzer

	CAPACITANCE	Dissipation	100 VDC Insulation Resistance
spec:	1.0 ± 2%	Less than 0.5%	Greater Than 40,000 MΩ
A1C1	0.902 nF	1.47 %	2.7 MΩ (Gen Rad #1864 megohmmeter)
A1C2	1.712 ~~p~~F	4.15 %	1.15 MΩ (FLUKE 8010)

(B) P/N 10022971-101 Transformer

FLUKE 8505A Digital Multimeter

Test		Spec.	Reading
No Load Current - 115V Rms 400 HZ		25 ma max	27.187 ma
No Load Power - same		.5 W max	
DC Resistance of Winding #3		11.0 ± 0.5 Ω	10.860 Ω
Turns Ratio - Refr to Primary (1Vrms 400HZ)	ORN-Yel #2		45.2 mV
	Yel-GRN #3		213.1 mV
	BLU-Vio #4		245.1 mV
	GRY-wht #5		204.6 mV
	wht-BK #6		204.5 mV
	wht/GRN-wht/Red #7		213.3 mV

12/13/96 2/2

P/N 10022971 Transformer (Continued)

Test	Spec	Reading
wht/orn - wht/orn		35.36 mV
wht/grn - wht/Blu		167.3 mV
wht/vio - wht/BLK		44.20 mV
Polarity Relative to Primary (Tektronix 2230 scope)		~~[illegible]~~ All Polarity Correct.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC

Attached Systems Group Photographs of Fuel Quantity Indicators

Notes:

1. No negatives available.
2. Large photos taken at NASA in August 1996.
3. Small photos taken at Honeywell on January 11, 1999.
4. EQA 1858T photos taken by Boeing on October 28, 1998.