

FEMCO, A MARK IV INDUSTRIES COMPANY  
MAINTENANCE MANUAL  
GROUND CHECK MONITORS GM8900/4000, /3125, AND /2250  
FILTERS FI2559, FI2569 AND FI2567

This manual is an extension of the Reference manual and is intended for use by technicians and maintenance personnel who maintain and repair the Ground Monitor.

Areas to be covered are:

Description

This section completely describes the Ground Monitor's operation through use of a Schematic diagram and circuit analysis.

Field and Bench Testing

This section provides information for use in troubleshooting the Ground Monitor when a failure occurs. This consists of instructions for performing tests to determine proper operation and a voltage chart for the unit.

Parts Identification

Necessary assemblies, along with parts lists, are provided to support the maintenance of the Ground Monitor.

For more information on the Ground Monitor ordering repair parts or requesting field service contact your local representative or customer service at Femco, P.O. Box 33, High Point, N.C. 27261-0033, Telephone (919)887-2611 or Fax 1-919-841-7267.

Femco Ground Monitor should be returned to the manufacturer or authorized representative for service. Substitution of components not approved by MSHA will void MSHA Acceptance number.

Circuitry described in this manual is covered by Femco Patent Nos. 3,728,582 and 3,855,501.

ARC TRAP - Femco registered Trademark  
GROUND SENTINEL - Femco registered Trademark

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## SECTION 1 DESCRIPTION

### Circuit Description (Refer to Schematic)

This unit can be divided into three sections: the power supply, the transmitter and the receiver sections.

The power supply provides 20 volts unregulated DC to the relay driver and 12 volts regulated DC to all other circuits. MOV1 protects the monitor from power line surges while R1 prevents nuisance blowing of FU1.

The transmitter contains a 4000, 3125 or 2250 HZ oscillator and push-pull line driver. R4 adjusts the frequency for optimum operation. MOV2 protects the monitor from voltage surges on the ground or signal wires. R12 limits the current output of the monitor and provides a signal voltage to the receiver circuit that is proportional to the quality of the ground circuit. The test switch provides a convenient way of testing the monitor operation. In the TEST position, a 75 ohm resistor is connected in series with the ground circuit. The monitor will indicate an open circuit trip by lighting both red LED's; the yellow LED will not be lit. In the UNIT CHECK position the .47 ohm resistor, R11, will simulate a shorted ground monitor input. The monitor will indicate a short circuit trip by lighting both red LED's; the yellow LED will not be lit.

The signal developed across R12 is coupled to the receiver circuit by T3. The strength of this signal, directly proportional to the quality of the ground circuit, is compared to a fixed reference voltage by IC3. If the ground circuit has fifteen ohms or less loop resistance, a good ground, 4000, 3125 or 2250 HZ pulses will be present at Pin 6 of IC3. These pulses are amplified by Q4 and fed to T4. The output of T4 is rectified and fed to the relay. C7 filters the relay voltage and provides a time delay to prevent false trips. The yellow LED3 indicates the presence of relay voltage and can be used as a rough tuning indicator. The absence of relay voltage, because of a bad ground or because the test switch is in test position is indicated by the two red LED's. LED3 is a latched trip indicator that continues to show that a trip occurred even when the relay is energized. Pressing the reset switch turns off this indicator.

Part of the signal at the secondary of T3 is rectified, filtered and compared with a fixed reference voltage by IC4. If this signal voltage is large enough, indicating a short circuit on the output of the ground monitor, the output of IC4 turns on Q7 and blocks the signal that would normally drive Q4. This causes a "short circuit" trip out.

## SECTION 2 FIELD AND BENCH TESTING

Preventive Maintenance. The latest version of the periodic checks required by Mine Safety and Health Administration should be followed. Semiannual tuning of the GM8900 per Step 5 below is recommended.

### Troubleshooting

- A. In the field - GM8900 is tripped, both red LED's lit and yellow LED out.

### Equipment Needed

VOM or digital voltmeter  
Spare Board

### Procedure

1. Place the TEST switch in its center or TEST position.
2. Both red LED's should be lit and the yellow LED should be out.
3. Observe all three LED's and move the TEST switch to the UNIT CHECK position. Hold the switch in this position. The yellow TUNE LED will light briefly and then go out; the red TRIP LED will go out briefly and then come back on. The red LATCH TRIP LED will stay lit.
4. Return the TEST switch to the NORM position. If the unit passes steps 2 and 3 continue to Step 5; if the unit fails, replace the PC board module and repeat test.
5. Tune the GM8900 by adjusting the frequency of the transmitter oscillator to the resonant frequency of the filters and stray cable impedance. The reactive components of the circuit impedance are tuned out and the GM8900 monitors circuit resistance.

This is accomplished by placing an AC voltmeter in TP1 and TP2 and adjusting R4 for a peak on the meter. This should occur at about 1.2V RMS with a short cable and decrease as the length of the cable monitored increases. (Also decreases with frequency.)

The trip may be checked by adding resistance into the circuit. With no cable (just two filters) the trip resistance should be between 13 and 17 ohms.

6. If the GM8900 does not tune, the problem is in the external circuit.

B. Bench Troubleshooting

Equipment Needed

Simpson or digital voltmeter  
Oscilloscope  
Frequency counter  
Ground Monitor Test Set-up

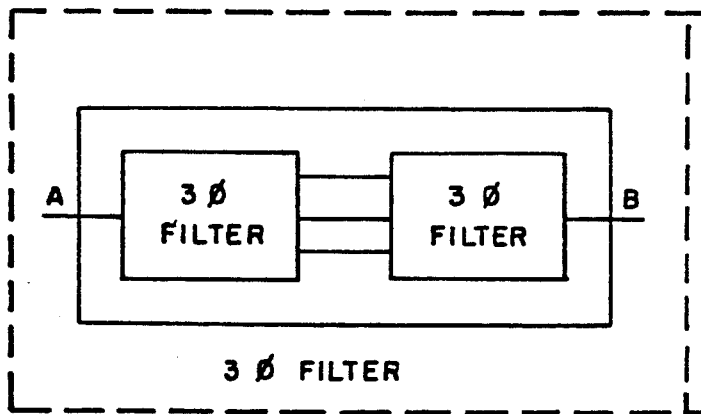
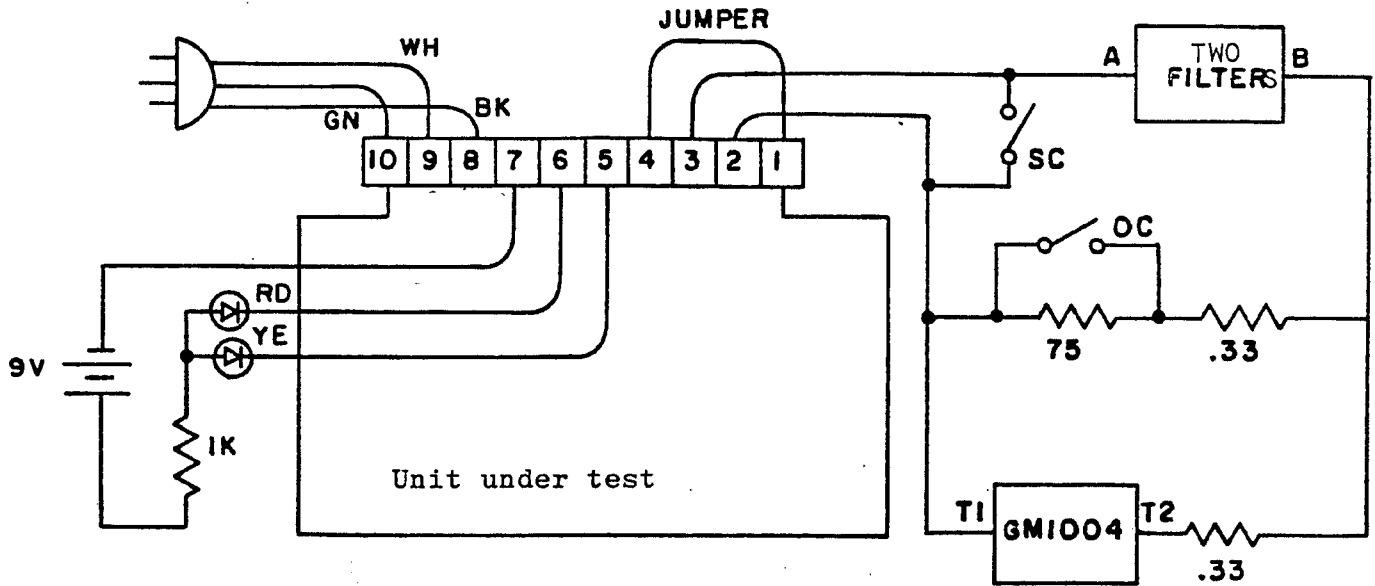
Parts Needed for the Test Set-up

1-Power Cord	1-1K 1/2 watt resistor	2-.33 ohm resistors
1-9 Volt Battery	1-Red LED	2-Spdt Switches
1-Battery Clip	1- Yellow LED	1-CN3840 Connector
	1-75 ohm 1/2W Resistor	1-GM1004
2-FI2559 or	2-FI2567 or	2-FI2569

Testing the GM8900

1. To test the GM8900 follow the field troubleshooting procedure given above, with the unit connected per Page 5.
2. Refer to the following voltage chart (Page 6) and drawings for troubleshooting.

EQUIPMENT SET-UP



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VOLTAGE CHART

TEST POINT		NORMAL OPERATION	OC SWITCH OPEN	SC SWITCH CLOSED
T1 Secondary		16.5VAC	18.8VAC	15.6VAC
+20V Unreg		18.2V	22.5V	16.6V
+12V		11.9V	11.9V	11.9V
Relay Volta		24.2V	0V	0V
IC2	Pin			
	1	0V	"	"
	2	4Vpp Sawtooth		
	3	12Vpp Square Wave		
	4	12V DC		
	5	7.9V DC		
	6	4Vp-p Sawtooth		
	7	12V PP Square Wave		
	8	12V DC		
IC3	Pin			
	1	NC	NC	NC
	2	6 VDC	5.7V	6V
	3	4Vpp Sine Wave 5.48VDC	1Vpp Semi Sq.Wave 4.9V	5.3Vpp Sq.Wave
	4	0	0	0
	5	NC	NC	NC
	6	12Vp-p Semi Sq.Wv	0V	11.5Vpp Semi Sq wave
	7	11.9V	11.9V	11.9V
	8	10.1V	11.9V	8.7V
IC4	Pin			
	1	NC	NC	NC
	2	3.6V	3.6V	3.6V
	3	2.5V	.4V	5.1V
	4	0V	0V	0V
	5	NC	NC	NC
	6	1.3V	1.3V	11.1V
	7	11.9V	11.9V	11.9V
	8	NC	NC	NC
Q1	S	0V	"	"
	G	12V pp Sq. Wave		
	D	12V pp Sq. Wave		
Q2	S	0V	"	"
	G	12V pp Sq. Wave		
	D	24V pp Sq. Wave		
Q3	S	0V	"	"
	G	12V pp Sq. Wave		
	D	24V pp Sq. Wave		
Q4	S	0V	0V	"
	G	5.5 pp Semi Sq. Wave	0V	
	D	24V pp Sq. Wave With Spike	22.3V	
Q5	E	11.9V	11.9V	11.9V
	B	23.3V	11.1V	11.2V
	C	0V	11.7V	11.8V
Q6	C	0V	0V	0V
	G	0V	.8V	.8V
	A	10.5V	.8V	.8V
Q7	E	0V	0V	0V
	B	.3V	.3V	.8V
	C	3V, 5.5V, Semi Sq. Wave	0V	0V

NC - NOT CONNECTED

\* - VOLTAGES AND WAVEFORMS DO NOT CHANGE

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## TESTING THE FILTERS

### Preliminary Set-Up

1. Connect a DVM or VOM set to the 2.0 or 2.5V AC range to the loop current test jacks TP1 and TP2.
2. Connect a frequency counter to the same test jacks.

### Testing the 3-Phase Filters

1. Replace one of the known good filters in the test set-up by the filter in question.
2. Set the switches for NORMAL operation.
3. Adjust R4 (TUNE) for maximum indication on the DVM or VOM. The indication should be approximately 1.3 volts and in no case less than 1 volt. The frequency, as indicated on the counter, should be as marked  $\pm 10\%$ .
4. If the frequency is outside this range or you cannot tune for a maximum indication on the DVM or VOM, the filter is bad and should be thrown away.
5. If the voltage indication is less than 1 volt, the filter is bad and should be thrown away.

### Testing the ARC TRAP

1. Jumper out the filters in the test set-up.
2. Set the OC and SC switches to the OPEN position. The GM8900 should be tripped out.
3. Replace the known good ARC TRAP with the ARC TRAP in question. The GM8900 should be tripped out. If it is not, the ARC TRAP is bad and should be thrown away.
4. Check the ARC TRAP for continuity with an ohmmeter.

**SECTION 3 PARTS IDENTIFICATION**

**Fenco GROUND MONITORS should be returned to the manufacturer or authorized representative for service. Substitution of components not approved by MSHA will void MSHA Acceptance.**

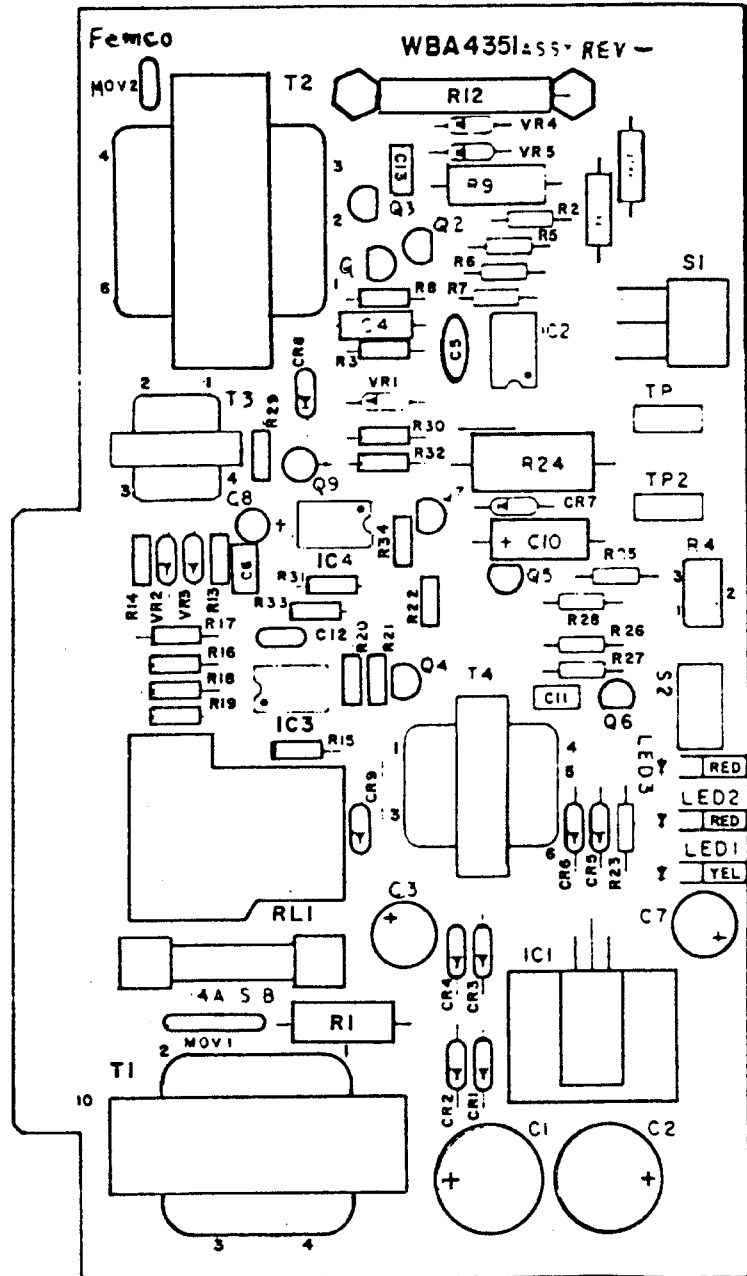
<i>GRI - GM8900/++++ - GROUND MONITOR</i>
<i>GR2 - GM8950/++++ - GROUND MONITOR WITH GROUND FAULT</i>

IT.	DESCRIPTION	PART NO.	DWG. NO.	GRI	GR2
1	HOUSING ASSEMBLY	B04869	882901-801GR	1	
2	GND. CHK. MONITOR BD. ASSY W/FACEPLATE	CE3101++++	862901-802GR2	1	
3					
4	MSHA LABEL	NP3017	882901-604	1	
5					
6					
7					
8	GROUND FAULT				1

<i>GRI - B04869 - HOUSING ASSY FOR GROUND MONITOR</i>

IT.	DESCRIPTION	PART NO.	DWG. NO.	GRI
1	HOUSING	B04746	832901-602	1
2	CONNECTOR	CN3840		1
3	CARD GUIDE	M04177		2
4	NAMEPLATE	NP2964	832901-605	1
5				
6				
7	SCREW #6-32 X 3/8 SSSL	SC3078		3
8	SCREW #6-32 X 5/8 SSSL	SC3100		1
9	NUT #6-32 HEX SSSL	NU2847		4
10	SPACER, HEX #6-32 TAP THRU, 1/4" LG	M04546		1
11	WASHER #6 EXT SHAKE SSSL	WA2867		5





GRI - WBA4351/++++ - GROUND CHECK MONITOR BOARD

GR2 - CE3101/++++ - WBA4351 GROUND CHECK MONITOR BOARD WITH FAC

++++ FREQUENCY SPECIFIED PER ORDER :

2250 HZ

3125 HZ

4000 HZ

\* R17 SELECTED DURING TEST

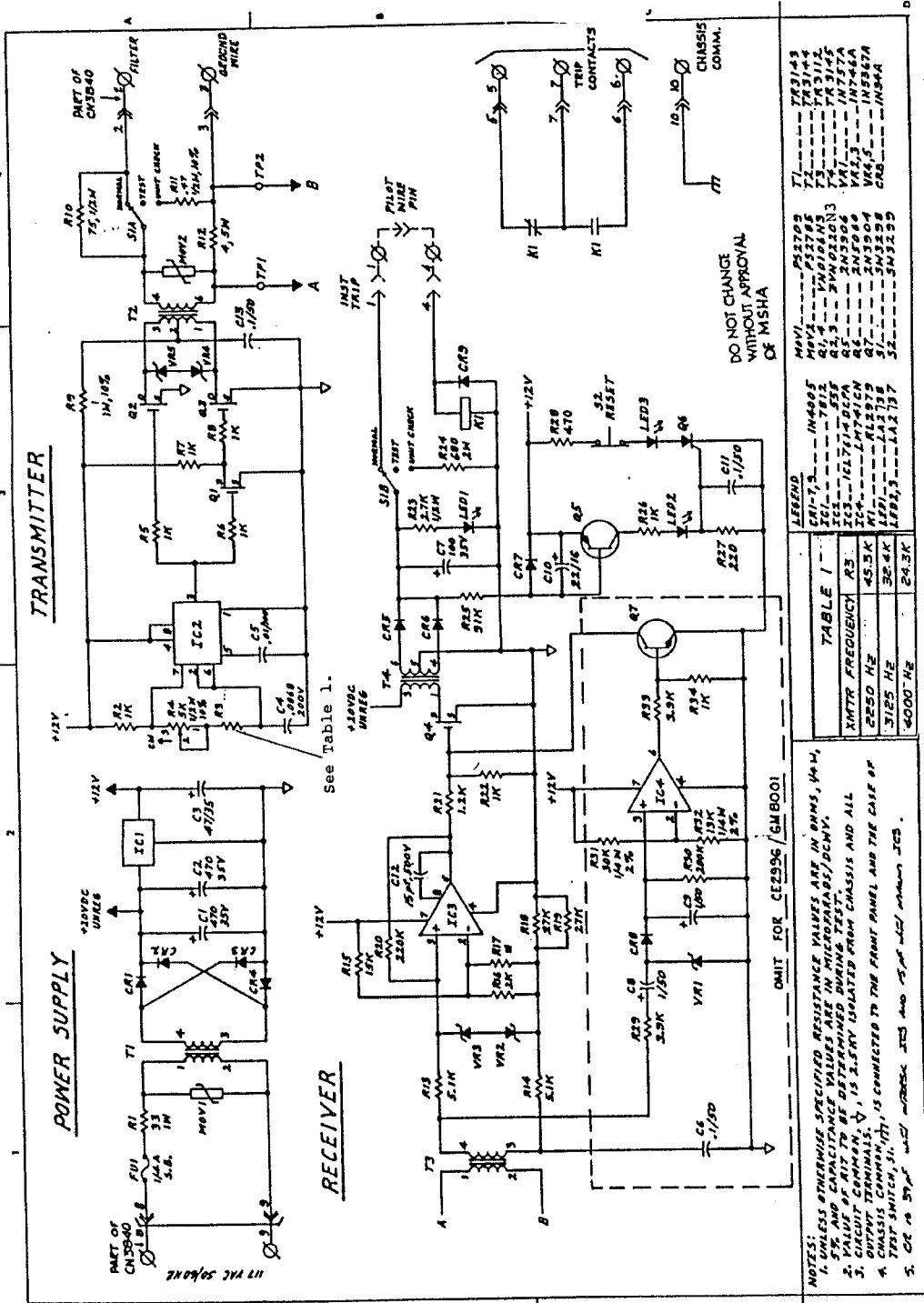
IT.	DESCRIPTION	PART NO.	DWG. NO.	GRI	GR2		
1	PRINTED CIRCUIT BOARD	WB4351	882901-601	1			
2							
3	RESISTOR, FC, 33, 1W, 5% R1	RE33035		1			
4	RESISTOR, FC, 1K, 1/4W, 5% <sup>RE1,5,6,7,8,</sup> <sub>RE2,26,34</sub>	RE10275		8			
5	RESISTOR, MF, SELECT/FREQ. R3	++++		1			
	24.3K, 1/8W, 1%	RE3067	(4000 HZ)				
	32.4K, 1/8W, 1%	RE3074	(3125 HZ)				
	45.3K, 1/8W, 1%	RE3093	(2250 HZ)				
	TAPE, BLUE 1" OF	MC4000	(2250 HZ)				
	TAPE, ORANGE 1" OF	MC4001	(3125 HZ)				
6	RESISTOR, POT, 5K, 1/2W, 10% R4	RE3681		1			
7	RESISTOR, FC, 1, 1W, 10% R9	RE10A31		1			
8	RESISTOR, FC, 75, 1/2W, 5% R10	RE75025		1			
9	RESISTOR, FC, .47, 1/2W, 10% R11	RE47B21		1			
10	RESISTOR, WW, 4, 5W, 5% R12	RE3682		1			
11	RESISTOR, FC, 5.1K, 1/4W, 5% R13, 14	RE51275		2			
12	RESISTOR, FC, 15K, 1/4W, 5% R15	RE3385		1			
13	RESISTOR, FC, 2K, 1/4W, 5% R16	RE20275		1			
14	RESISTOR, FC, *, 1/4W, 5% R17	*		1			
15	RESISTOR, FC, 27K, 1/4W, 5% R18, 19	RE27375		2			
16	RESISTOR, FC, 220K, 1/4W, 5% R20	RE22475		1			
17	RESISTOR, FC, 1.2K, 1/4W, 5% R21	RE3570		1			
18	RESISTOR, FC, 2.7K, 1/2W, 5% R23	RE27225		1			
19	RESISTOR, FC, 680, 2W, 5% R24	RE68145		1			
20	RESISTOR, FC, 91K, 1/4W, 5% R25	RE3388		1			
21	RESISTOR, FC, 220, 1/4W, 5% R27	RE3493		1			
22	RESISTOR, FC, 3.9K, 1/4W, 5% R29, 33	RE39275		2			
23	RESISTOR, FC, 200K, 1/4W, 5% R30	RE20475		1			
24	RESISTOR, MF, 30K, 1/4W, 2% R31	RE3616		1			
25	RESISTOR, MF, 13K, 1/4W, 2% R32	RE3659		1			
26	RESISTOR, FC, 470, 1/4W, 5% R28	RE47175		1			
27							
28	CAPACITOR, ELEC, 470 MFD, 35V C1, 2	CD9041		2			
29	CAPACITOR, ELEC, 47 MFD, 35V C3	CD9026		1			
30	CAPACITOR, FILM, .0068 MFD, 200V C4	CD3877		1			
31	CAPACITOR, CER, .01 MFD, 100V C5	CD5018		1			
32	CAPACITOR, CER, .1 MFD, 50V C6, 11, 13	CD5022		3			
33	CAPACITOR, ELEC, 100 MFD, 35V C7	CD9025		1			
34	CAPACITOR, ELEC, 1 MFD, 50V C8, 9	CD9030		2			

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IT.	DESCRIPTION	PART NO.	DWG. NO.	GR1	GR2		
35	CAPACITOR, ELEC, 22 MFD, 16V	C10	CD3362	3-7959	1		
36	CAPACITOR, MICA, 15 pF, 500V	C12	CD3482	3-7879	1		
37							
38							
39	DIODE (1N4005)	CR1,2,3,4,5,6,7,9	TU2500		8		
40	DIODE (1N34A)	CR8	TU2510		1		
41	DIODE, ZENER (1N757A)	VR1	TU2725		1		
42	DIODE, ZENER (1N746A)	VR2,3	TU2717		2		
43	DIODE, LIGHT EMITTING, YEL	LED1	LA2738		1		
44	DIODE, LIGHT EMITTING, RED	LED2,3	LA2737		2		
45	DIODE, ZENER (1N5367A)	VR4,5	TU4064		2		
46	TRANSISTOR (VNO10GN3)	Q1,4	TU6051		2		
47	TRANSISTOR (VNO220N3)	Q2,3	TU6052		2		
48	TRANSISTOR (2N3906)	Q5	TU2769		1		
49	TRANSISTOR (2N3904)	Q7	TU2767		1		
50	THYRISTOR (2N5060)	Q6	TU2804		1		
51	VARISTOR	MOV1	PS2709		1		
52	VARISTOR	MOV2	PS2785		1		
53							
54	INTEGRATED CIRCUIT (7812)	IC1	TU2586		1		
55	INTEGRATED CIRCUIT (555)	IC2	TU2579		1		
56	INTEGRATED CIRCUIT (ICL7614DCPA)	IC3	TUB153		1		
57	INTEGRATED CIRCUIT (LM741CN)	IC4	TUB152		1		
58							
59	TRANSFORMER, POWER	T1	TR3143	2*TR3143	1		
60	TRANSFORMER, LINE DRIVER	T2	TR3144	2*TR3144	1		
61	TRANSFORMER, INPUT	T3	TR3112		1		
62	TRANSFORMER, RELAY DRIVER	T4	TR3145	2*TR3145	1		
63							
64	RELAY, 24V	K1	RL2979		1		
65	RELAY COVER		RL2981		1		
66	SWITCH, DP, 3 POS. TOGGLE	S1	SW3298		1		
67	SWITCH, DPDT MOM. PUSHBUTTON	S2	SW3299		1		
68	STUD, OVAL HEAD		MO3887			1	
69	TEST JACK	TPI,2	TE3061		2		
70	SNAP RING		MO3886			1	
71	FUSE, 1/4 AMP SLO-BLO	FU1	FU2520		1		
72	FUSE CLIP		FU2586		2		
73	RTV		MC3896		X		
74	HEAT SINK	HS1	HS2640		1		
75	SCREW, #4-40 X 3/8 PAN HD SLOT		SC2910		1		
76	WASHER, #4 INT SHAKE		WA2503		1		
77	WASHER, COMPRESSION		WA2658		1		
78	NUT, HEX #4-40		NU2537		1		
79	STANDOFF, PLASTIC		MO4267		2		
80	TURRET TERMINAL		TE2862		2		
81	WIRE, ELEC, 20 AWG, BARE COPPER 1" OF		WI2863		3		
82	MONITOR BOARD ASSEMBLY	WBA4351	882901-801	GR1	1		
83							
84	FACEPLATE	BO4748	882901-602		1		



**TRANSMITTER**

**POWER SUPPLY**

**RECEIVER**

See Table 1.

OMIT FOR CE296/SM8001

NOTES:  
 1. UNLESS OTHERWISE SPECIFIED RESISTANCE VALUES ARE IN OHMS, 10<sup>3</sup> OHMS, 10<sup>4</sup> OHMS, 5% AND CAPACITANCE VALUES ARE IN P.F., MICROFARADS, OR P.P.M.  
 2. VALUES IN PARENTS ARE TO BE DETERMINED DURING TEST.  
 3. VALUE OF CHASSIS COMMON, V, IS VERY ISOLATED FROM CHASSIS AND ALL OUTPUT TERMINALS.  
 4. CHASSIS COMMON, W, IS CONNECTED TO THE FRONT PANEL AND THE CASE OF TEST SWITCH, S1.  
 5. CE 10 57<sup>1</sup> AND 57<sup>2</sup> ARE NOT SHOWN ICS.

TABLE 1

XMTR FREQUENCY	R3	45.3K
TEST FREQ	S1	30-4K
TEST FREQ	S2	24.3K

LEGEND

IC1-3	LM4905
IC4	741
IC5	741
IC6	741
IC7	741
IC8	741
IC9	741
IC10	741
IC11	741
IC12	741
IC13	741
IC14	741
IC15	741
IC16	741
IC17	741
IC18	741
IC19	741
IC20	741
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IC95	741
IC96	741
IC97	741
IC98	741
IC99	741
IC100	741

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SCHEMATIC GROUND CHECK MONITOR GM8900/++++  
 Plug-In CE3101  
 PC Board WBA4351