Rebirth of the Eico 221

Turn this flea-market regular into a super-sensitive voltmeter. Then count the money you saved.

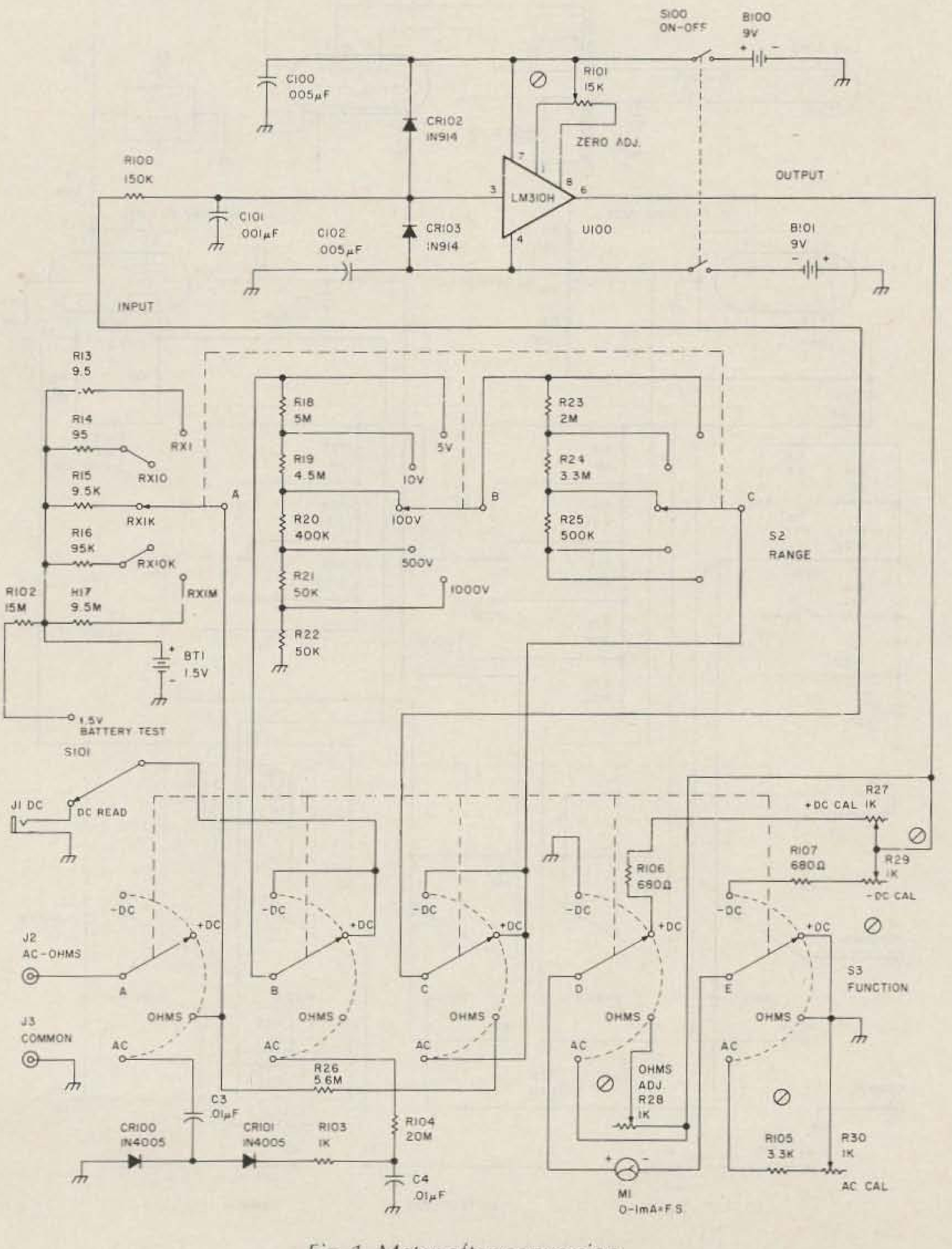

Fig. 1. Meter after conversion.

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If you have scanned the meter pages of electronics catalogs lately looking for a meter with high sensitivity, you quickly become "sensitive" to high prices. Most ham auctions and sales usually will yield an Eico 221 for about five bucks. Mine cost low, as the transformer was scorched.

This conversion permits very sensitive measurements at 10 megohms per volt in solid-state circuitry and applications where ac power for a VTVM is not readily available (such as mobile gear, etc.). Though unable to measure current as some VOMAs and DVMs, its cost and sensitivity offset this shortcoming.

Mike Kaufman K6VCI did a good job on his article in *Ham Radio Magazine*, December, 1974 ("How to Convert Your VTVM to an IC Voltmeter"). He shows you how to convert the Heath IM-11. In comparing his arti-

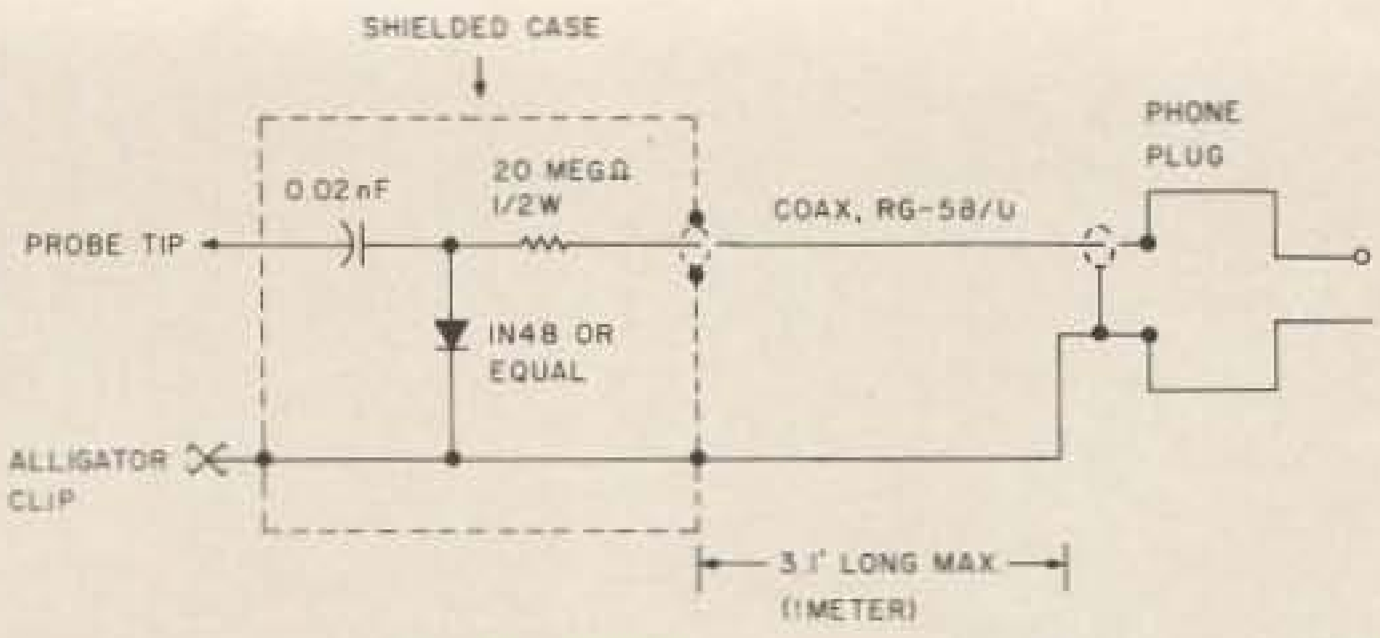

Fig. 2. Rf probe circuit.

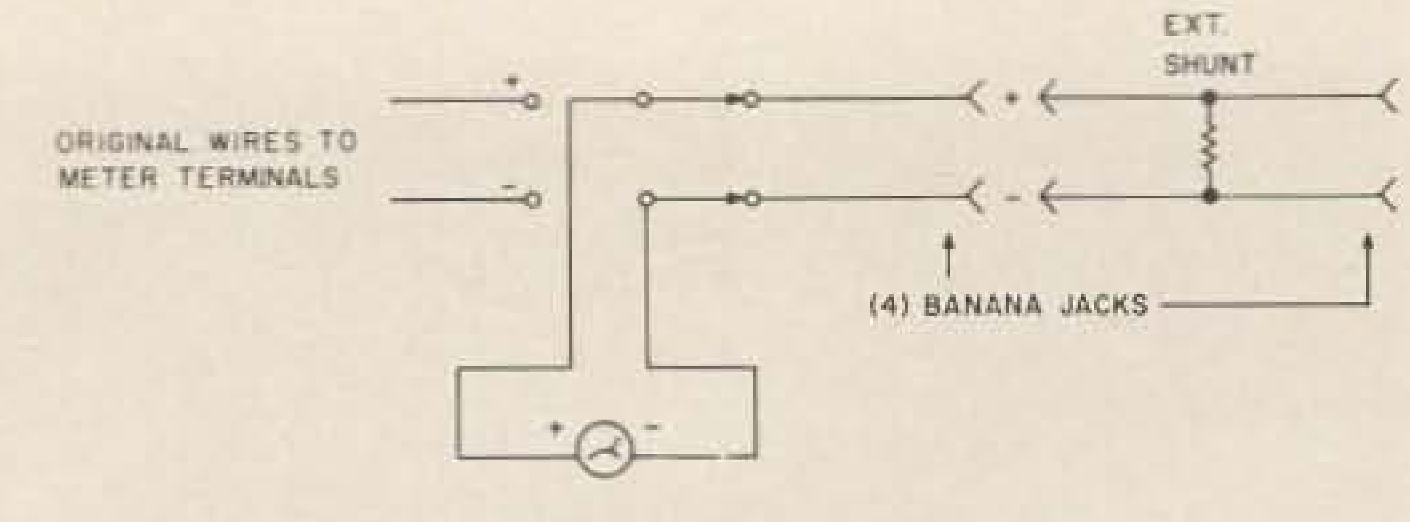

Fig. 3. Milliammeter circuit.

cle with converting the Eico 221, I noticed some differences.

This article will show you how to enjoy the original features of the Eico 221, yet have a meter that is totally battery-operated. Conversion is relatively simple for the average builder-hobbyist.

Fig. 1 shows the meter after conversion. It would be helpful to have the original construction manual when doing the modifications. I didn't enclose photos of the conversion as the text is fairly descriptive.

Note the parts in Fig. 1 designated "100" as "U100". These are new parts you add. Most are available from Radio Shack, Poly Paks, etc. See the parts list for descriptions.

This conversion is begun by removing unnecessary components. See your Eico 221 book for parts locations if they are not clear. Parts with an asterisk (*) are on the Function switch, S3. Remove (and put in your junk box): The ac line cord, On-Off switch (S1), power transformer (T1), pilot lamp (B1) and holder, all tubes (V1-V3), resistors R1 (10k, 2 W), R2 (33k, 2 W), R3 (20k), R4 and R6 (1.5 megohms), R7 (5 megohms), R8* (1 megohm), R9 (5 megohms), R10 and R11* (1k), capacitors C1 and C5* (0.002 µF), C2 (filter), and C4* (0.01 µF). Save C4* for conversion. Also remove potentiometers R5 (2 megohms, Ac Zero Adjust) and R12 (2k, Zero Adjust).

Install R101 (15k) in the front panel hole where R12 was. If you strip the chassis clean, except for adjustment pots and their wiring, you removed all of the above parts. Do not disturb the wires on or to Function or Range switches at this time. Cut any of the wires from these switches at the chassis end and tag them as to original connections. If you use the tube sockets for the new circuit, leave them as is. Enlarge the hole in the panel where the pilot lamp holder was to 1/2-inch (12.7mm) diameter and

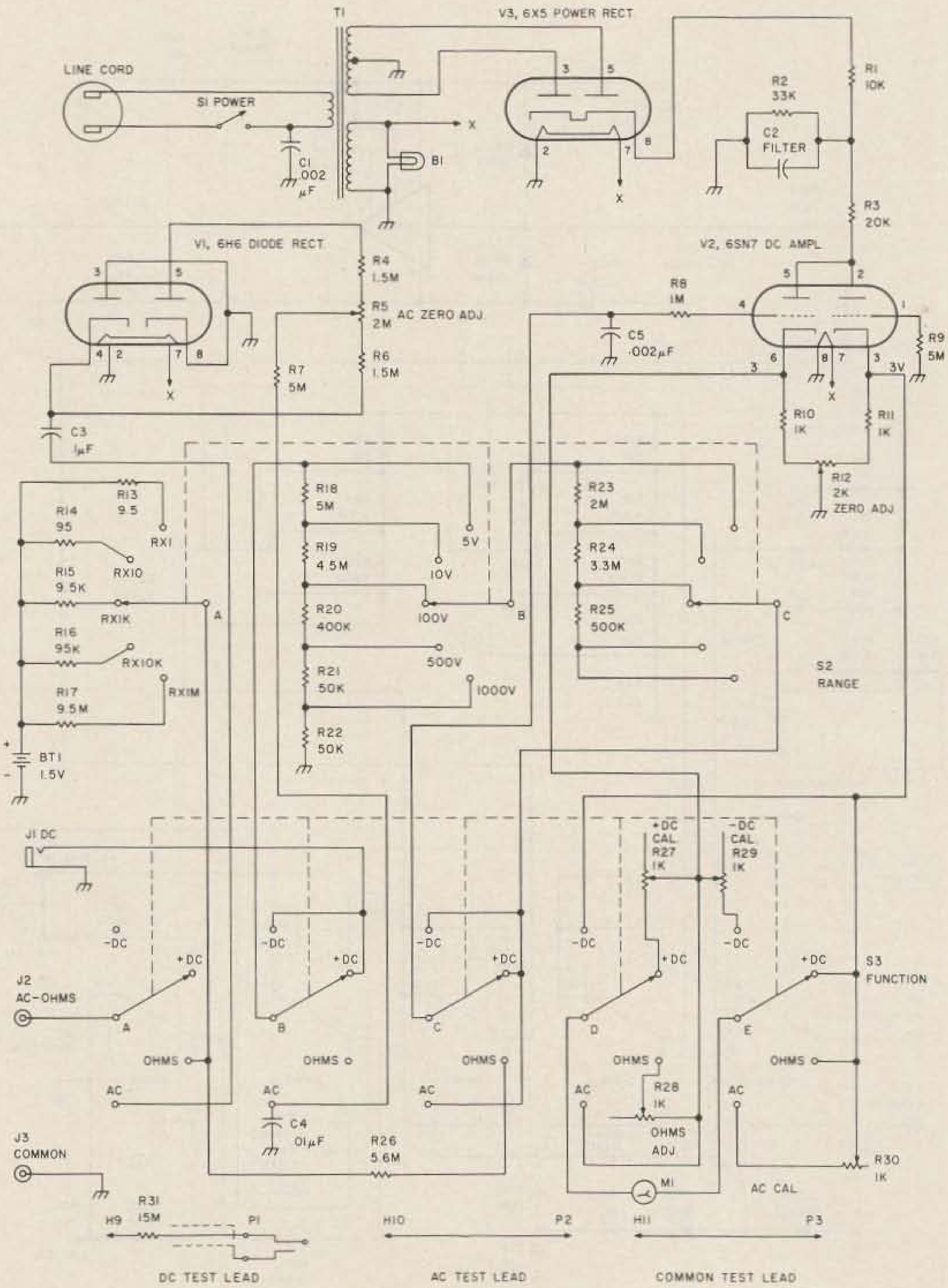

Fig. 4. Meter before conversion.

Parts List	
B100, B101	9.0-volt transistor battery with connectors (battery holders optional)
C100, C102	0.005-μF, 50-volt mica
C101	0.001-μF,50-volt mica
CR100, CR101	1N4005 or equivalent 600-piv,1-Amp diode
R100	150k, 1/4 W, 10%
R101	Pot. 15k, 1/2 Watt, panel-mount type
R102	15 meg, 1/4 Watt, 10%
R103	1k, 1/4 Watt, 10% (can use old R10 or R11)
R104	20 meg, 1/4 Watt, 10% or (2) 10 meg, 1/4 Watt, 10% in series
R105	3.3k, 1/4 Watt, 10%
R106, 107	680 Ohms, 1/4 Watt, 10%
S100	toggle switch, DPST
S101	toggle switch, SPDT
U100	IC, National Semiconductor LM-310H voltage follower

mount switch S101 (1.5-V Battery Test switch). This switch does two things—it fills a vacant hole, but more important, it allows you to test the ohmmeter 1.5-volt battery. Break the wire from the Function switch to J1 (dc jack) and wire in this switch. R102, the 15-megohm resistor, can be mounted on Range switch S2.

Mount switch S100 in the hole where the original On-Off switch (S1) was located. Batteries B100 and B101 may be mounted in special clips available for them or mounted to the chassis with cable ties or strapping tape. Use connectors that mate them or make your own from discarded 9.0-volt batteries. Batteries need replacing periodically, so soldering them is not advisable. U100 can be soldered into one of the existing tube sockets or push out one of the transformer grommets and insert a round nylon 8-pin IC socket in the hole and wire to the socket.

All remaining parts may be wired to the two remaining sockets or mount to some 3-lug solder strips mounted on the chassis. A perforated Vectorboard® could also be used. This part of the conversion is mostly left up to the hobbyist's ingenuity. C4 was on the Function switch and is relocated on the chassis. Use insulated hookup wire for all wiring. Lead dress is not critical, but capacitors C100, C101, and C102 should be wired close to U100. R106 and R107 can be mounted on Function switch S3. Break the wiring to R27 and R29 and insert them in series. R105 is inserted from R30 to S3, deck E. Break wiring to R30 and put in series. Be sure to ground the wire which went to pin 3 on the V2 (6SN7) socket and decks D and E on the Function switch.

Theory of Operation

Capacitors C100 and C102 bypass the battery power supply. Diodes CR102 and CR103 prevent an overvoltage condition if you are probing a large voltage while the meter is switched to a low-voltage range. They limit voltage on U100, pin 3 to ±9.0 volts dc. Resistor R100 limits current into CR102 and CR103 and forms part of the protective circuitry. Capacitor C101 keeps any ac out of U100's input. Its value is not critical except increasing its value will increase the measuring time. Potentiometer R101 is the new Zero Adjust pot.

Diodes CR100 and CR101 replace the original 6H6 diode circuit. They should be at least 600-piv, 1-Amp types. CR100 clips the negative half of the cycle to ground after coupling through capacitor C3. CR101, R104, and R103 "steer" the positive half of the cycle to the Function switch and Range switch circuit as dc input does. C4 bypasses any stray ac to ground.

Calibration

With unit power off and the S101 1.5-V Battery Test switch set to Dc Read, adjust the mechanical zero screw on the meter until the needle points to zero. Turn the S100 meter power switch on and adjust the Zero Adjust control (R101) until little or no change occurs when the Function switch goes from +dc to −dc with no probe input. Probe a known dc voltage and adjust the Dc Cal control for the correct meter reading. Position the 1.5-V Battery Test switch to read the ohmmeter battery on the 5-V scale. You should read about 1.5 volts on a new battery. Position it back to Dc Read. Next, switch the Function switch to the Ohms position and set the Ohms Adjust control on the front panel so the meter reads infinity resistance (on left side of scale) with the resistance probe open-circuited (not shorted to the ground probe). Touching these probes together will bring the needle to read zero Ohms on the right side of the meter scale.

Never leave the meter in the Ohms position or S101 in the 1.5-V Battery Test position as the latter disables the meter from reading dc and the first is normal procedure. The battery could drain over a few months. Finally, put the Function switch in the Ac position and adjust the Ac Cal pot until a known ac voltage reads correctly on the meter. Caution: Do not use the ac line to calibrate this meter as one side of the line will always be on the panel and chassis and a serious shock could result. A suggested method is to use a 6.3-V-ac transformer and calibrate the meter on the 10-V-ac range, comparing the reading with a known good meter.

Always turn this meter off when not using it, as the LM-310H draws about 4 mA and will consume the batteries in a period of time. An LED Power On indicator would consume 20 mA from the power supply, so it was not part of this conversion.

Another useful application in ham radio for this conversion is to use an rf probe into the ac input and measure relative power output and antenna field strength. A short piece of wire or a clip lead on the end of an rf probe will pick up enough rf energy to give a good reading. Eico had a model PRF-25 probe available for this VTVM, or a simple probe may be made with a 1N48 diode, a 0.02-μF, 600-V capacitor, and a 20-megohm, 1/2-Watt resistor in a shielded tube or enclosure. See Fig. 2.

If you still need a milliammeter, the basic movement here is 0-1 mA dc full scale. Mount a DPDT switch on the front panel and wire the meter terminals to the common contacts. Wire two banana jacks to the normally-closed contacts and connect the two original meter wires to the normally-open contacts (see Fig. 3). The banana jacks could be mounted on the back of the cabinet. Of course, the main on-off switch stays off to use the 1-mA function. By experimenting with resistor shunts across the banana jacks, this 1-mA range can be extended to several Amps. Start with about 90 Ohms and go as low as 0.1 Ohms and compare the reading with another milliammeter in series with this meter between a dc power source and a load. With the proper shunt, this meter should track the known meter. ■