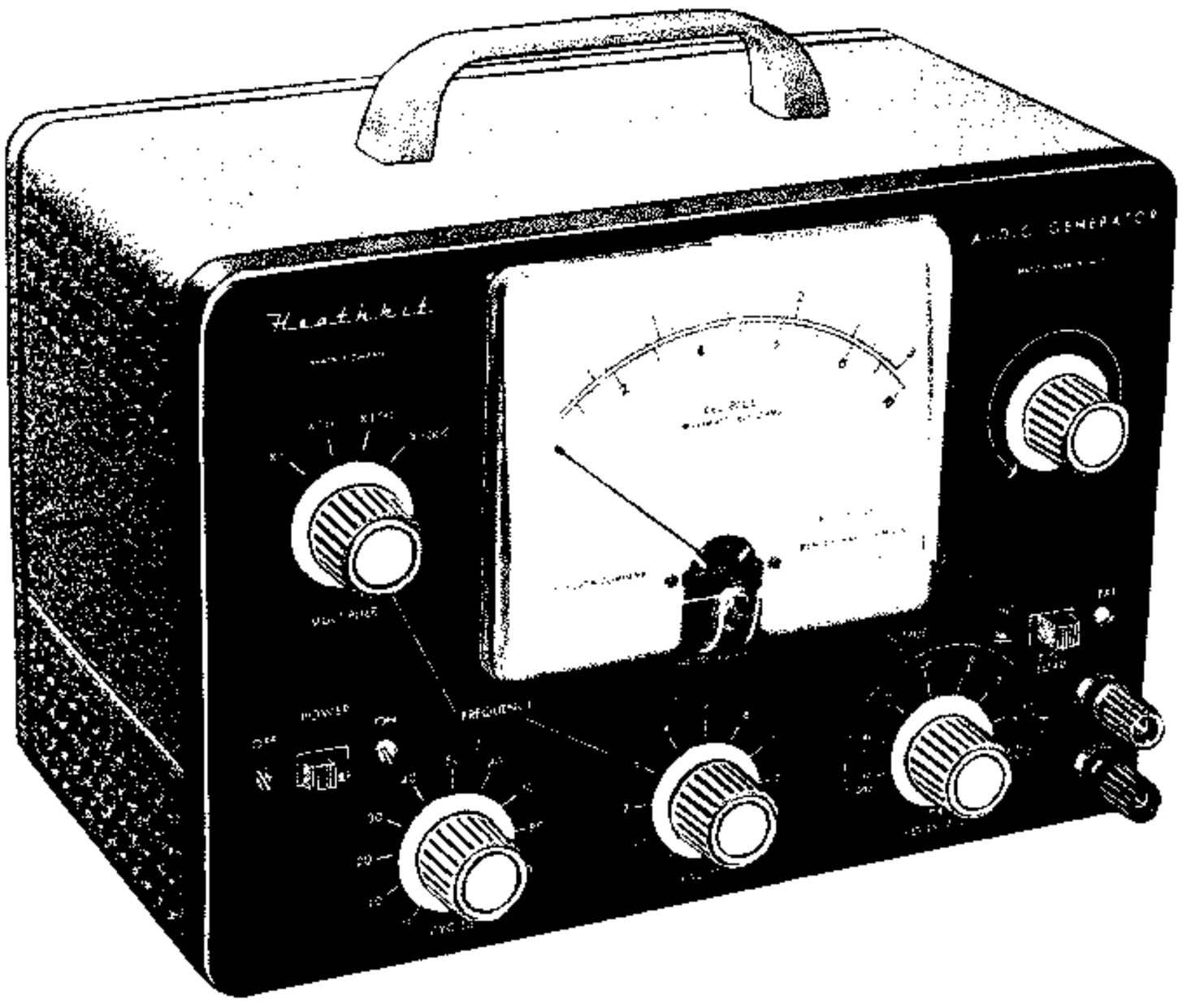
# HEATHKIT AUDIO GENERATOR

## MODEL AG-9A






### SPECIFICATIONS

| | |
|---|---|
| Frequency Range: | 10 cycles - 100 kc |
| Tuning Method: | Switch-selected, 2 significant figures and multiplier. |
| Frequency Accuracy: | ±5% |
| Output Voltage Ranges: | 0-10 volts into Hi-Z (10 KΩ min.) |
| | 0-3 volts into Hi-Z (10 KΩ min.) |
| | 0-1 volts<br>0-.3 volts<br>0-.1 volts<br>0-.03 volts<br>0-.01 volts<br>0-.003 volts — Into external load of approximately 600 Ω or with internal load into external Hi-Z. |
| Source Impedance: | 0-10 volt range - varies between 0 and 1000 Ω. |
| | 0-3 volt range - varies between 800 and 1000 Ω. |
| | 0-1 volt range and below - 600 Ω (External Load) 290 Ω (Internal Load) |
| DB Ranges: | -60 db to +22 db (-10 to +2 on meter, -50 to +20 on attenuator in 10 db steps). |
| DBM Ranges (600 Ω Ext. Load): | -60 dbm to +2 dbm (0 dbm = 1 mw-600 Ω) |
| Output Indication: | Voltage and db scales on meter. |
| Output Meter Accuracy: | ±5% of full scale when properly terminated. |
| Distortion: | Less than 0.1% from 20-20,000 cycles. |
| Tube Complement: | 6X4, 6AU6 and 6CL6 |
| Power Requirements: | 105-125 volts, 50-60 cycles, 40 watts |
| Dimensions: | 9 1/2" wide x 6 1/2" high x 5" deep |
| Shipping Weight: | 8 lbs. |

8/3/59

## INTRODUCTION

The Heathkit model AG-9A Audio Generator is a simple, yet versatile instrument. While simple in layout and easy to construct, the carefully assembled instrument provides ease of operation in a multitude of test setups encountered in audio laboratories. The wide range of repeatable frequencies and the metered low distortion output voltages covering nearly all values encountered in audio work contained in the conveniently small cabinet will entitle this instrument to a preferred spot in the laboratory.

The excellent performance of which this design is capable will not be realized in the finished instrument, UNLESS the assembler uses the best workmanship of which he is capable. Poor soldering technique, corrosive fluxes (acid core, so-called non-corrosive pastes), hurried and careless construction and failure to follow procedures outlined in this manual are the most prevalent causes for unsatisfactory operation. Protect your investment in time and money and reap the reward of personal satisfaction that money cannot buy, by doing a first class job of constructing this kit.

## CIRCUIT DESCRIPTION

The circuit of this instrument may be divided into four parts: the power supply, the oscillator, the attenuator and the metering circuit.

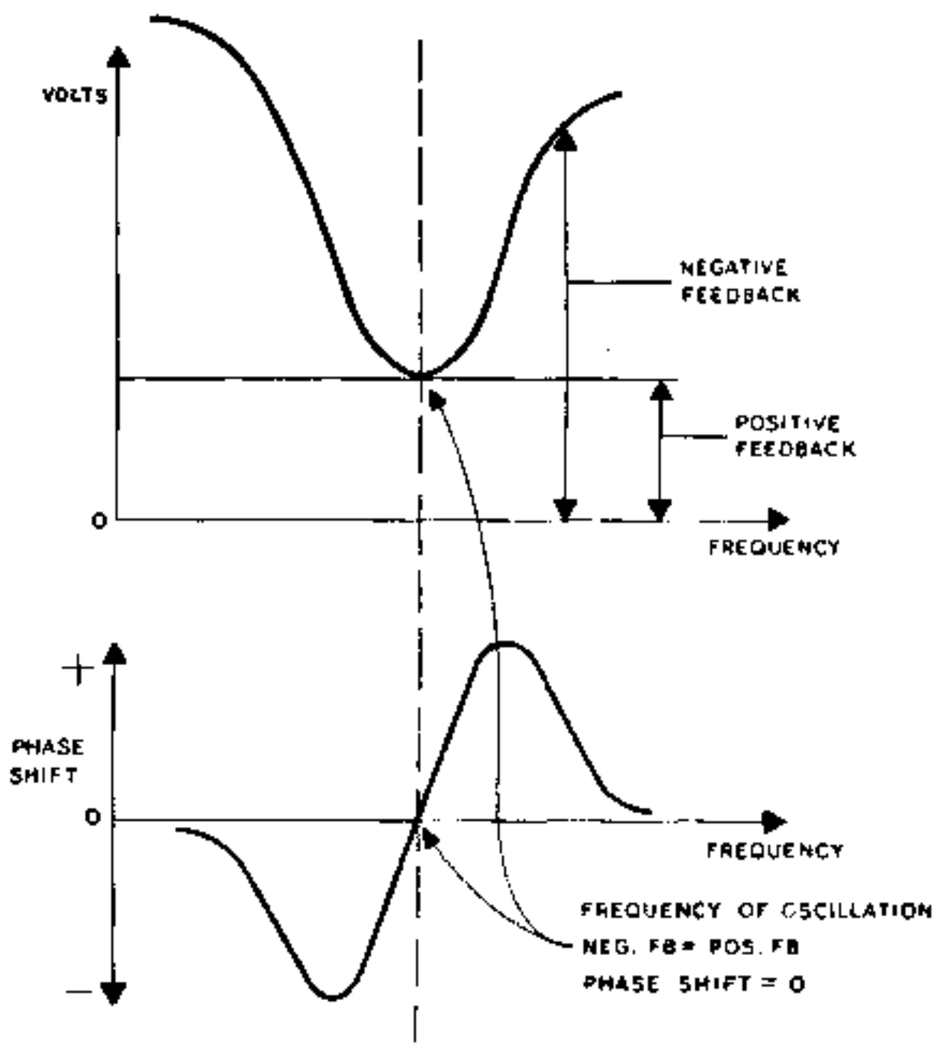
The power supply uses the conventional power transformer full wave rectifier circuit feeding a ripple filter consisting of two condensers and a choke.

The oscillator uses a 6AU6 pentode voltage amplifier and a 6CL6 triode-connected cathode follower. Regenerative feedback from the 6CL6 to the 6AU6 cathode is applied through the tungsten filament candelabra based lamp.

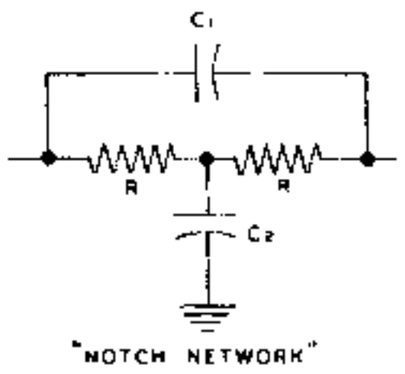
Degenerative feedback is applied from the 6CL6 through a "notch" network to the grid of the 6AU6. The resultant oscillation occurs at the "notch" frequency, where degeneration is minimum and phase shift is zero.

The "notch" network is a capacitor-shunted bridged-T type. The "notch" occurs at a frequency: $F = \frac{1}{2 \pi RC}$

where $C = \sqrt{C_1 C_2}$




The amplitude of oscillation is maintained at a nearly constant value by the tungsten lamp. The regenerative feedback is applied through a voltage divider consisting of the lamp and the "oscillator" control. An increase in output signal increases the lamp current, the lamp temperature and the lamp resistance. This reduces the amount of feedback applied to the 6AU6 cathode and the resultant output. A balanced condition is thus obtained. The "oscillator" control is used to set the nominal output level.




The "notch" network consists basically of two resistances and two condensers. From the relationship shown it is evident that a decrease in capacities by a factor of 10 will increase the frequency by a factor of 10. As the values of $C_1$ and $C_2$ were chosen with a 10:1 ratio, five condensers can do the job of four pair or eight, in achieving four decade ranges.

For frequency variation within the steps of 10 times provided by the multiplier switch, the value of R is changed. For a multiplier switch setting of X1 a resistance (R) of 100 KΩ will produce a frequency of 10 cycles. As F and R are inversely proportional, 20 cycles or twice the frequency, requires half the resistance, or 50 KΩ. Likewise, 30 cycles or three times the frequency requires 1/3 the resistance or 33.3 KΩ. The 0-100 "cycle" switch uses two decks, each deck switching four resistors as follows: 100 KΩ, 50 KΩ, 33.3 KΩ, 25 KΩ. 100 K // 25 K = 20 K; 50 K // 25 K = 16.7 K; 33.3 K // 25 K = 14.3 K; 100 K // 33.3 K // 25 K = 12.5 K; 50 K // 33.3 K // 25 K = 11.1 K; 100 K // 50 K // 33.3 K // 25 K = 10 K. These resistance values produce frequencies of 10 to 100 cycles in steps of 10 cycles. (// means "in parallel with.")

Frequency variations within a 10 cycle span are produced by the 0-10 "cycle" switch. Here the same reasoning and circuitry are used as above but the actual resistance values are substantially ten times larger. These resistance values are connected in parallel with the first switch and produce one cycle increments.

The attenuator reduces the output voltage from the 6CL6 cathode-follower through a continuously variable 5 KΩ "output" control, and then through a step attenuator. The attenuator system is designed for 600 Ω output up through 1 volt and high impedance output at the 3 and 10 volt positions. The 600 Ω positions may be terminated by an internal load for high impedance work or this load may be disconnected when an external 600 Ω load is used. In the 3 and 10 volt positions, the internal load is automatically disconnected. The attenuator operates in steps of 10 db.

The metering circuit measures the voltage at the arm of the "output" control. A portion of this voltage, determined by the "meter" control, is rectified by a half-bridge using crystal diodes. Non-linearity of the diodes at low signal level is compensated by a third diode across the meter. The meter carries three scales: 0-10 volt, 0-3 volt, and -10 to +2 db. When the instrument is operated with the proper termination, the meter and attenuator will indicate the output level at the binding posts.

## STEP-BY-STEP ASSEMBLY INSTRUCTIONS

A kit of parts can be assembled into the finished product in a variety of ways; from pictorials, photographs or from circuit diagram alone. However, even experienced and skilled professional persons have discovered that a combination of pictorials and step-by-step written instructions provide the fastest, most convenient way. This also guards against the disappointment of failure to operate after construction is completed, due to a single minor hard-to-find omission.

The written assembly instructions in this manual are divided into small operations or steps. Each step is a complete operation. Read the entire step through, then do that operation and check it off as completed. After an interruption, it is easy to find where you left off by the check marks. Read over the last checked step and you are all ready to continue.

The major pictorials in this manual are reproduced on large separate sheets. Fasten the appropriate pictorial on the wall above your work space. This will save you paging back and forth in the manual.

In the mechanical assembly, use lockwashers under all 6-32 nuts and between all controls or switches and the mounting surface.

In the wiring (S) means solder this connection and (NS) means do not solder yet, as more wires will be connected to this point. If more than one wire is to be soldered at a connection point, the instructions will appear as follows (S) (3) which means solder this connection which should have three wires connected to it. This will provide a running check of multiple connections.

## PROPER SOLDERING PROCEDURE

Only a small percentage of Heathkit purchasers find it necessary to return an instrument for factory service. Of these, by far the largest proportion function improperly because of poor or improper soldering.

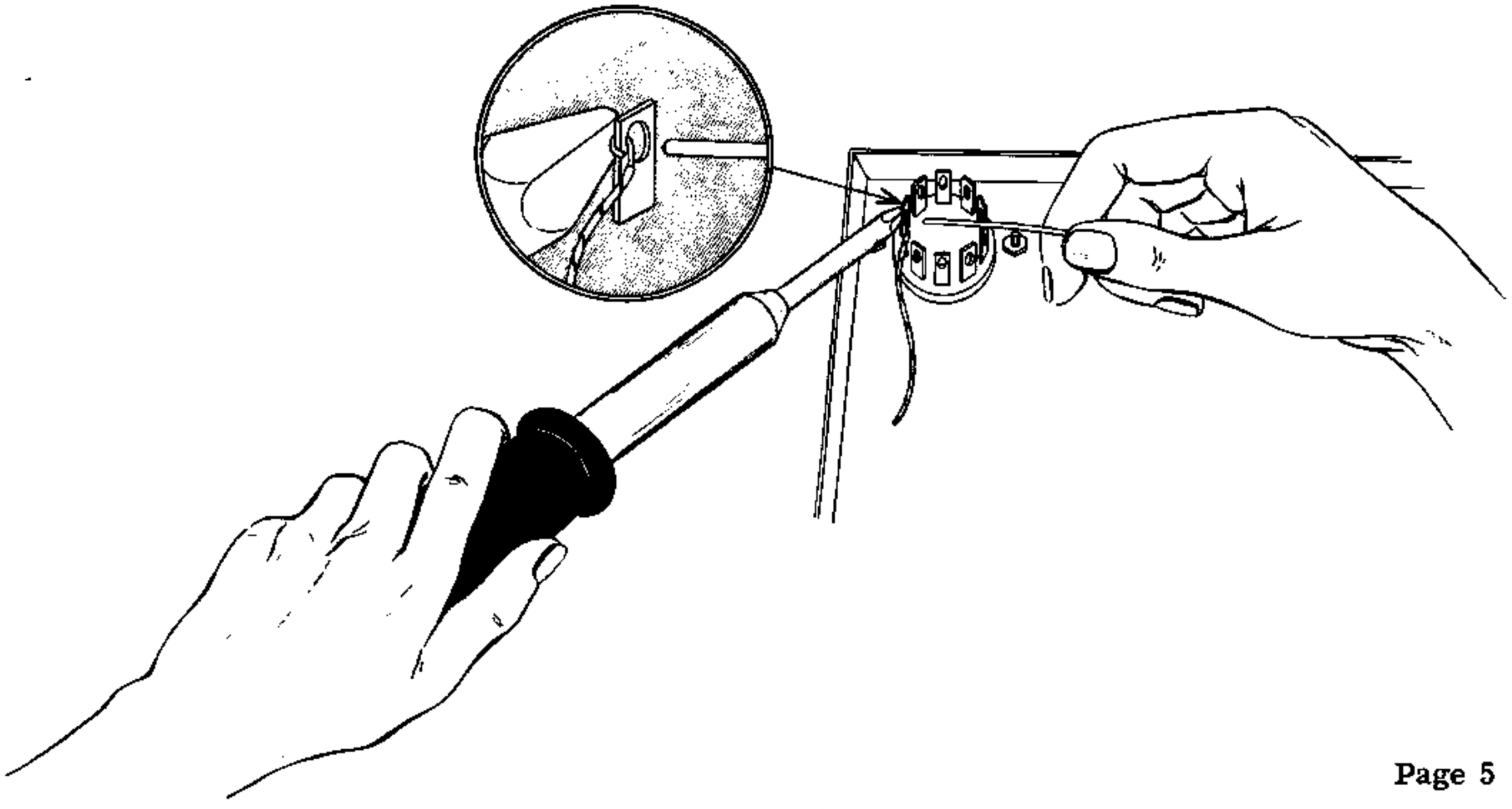
Correct soldering technique is extremely important. Good solder joints are essential if the performance engineered into the kit is to be fully realized. If you are a beginner with no experience in soldering, a half-hour's practice with odd lengths of wire and a tube socket will be a worthwhile investment.

High quality solder of the proper grade is most important. There are several different brands of solder on the market, each clearly marked "Rosin Core Radio Solder." Such solders consist of an alloy of tin and lead, usually in the proportion 50:50. Minor variations exist in the mixture such as 40:60, 45:55, etc. with the first figure indicating the tin content. Radio solders are formed with one or more tubular holes through the center. These holes are filled with a rosin compound which acts as a flux or cleaning agent during the soldering operation.

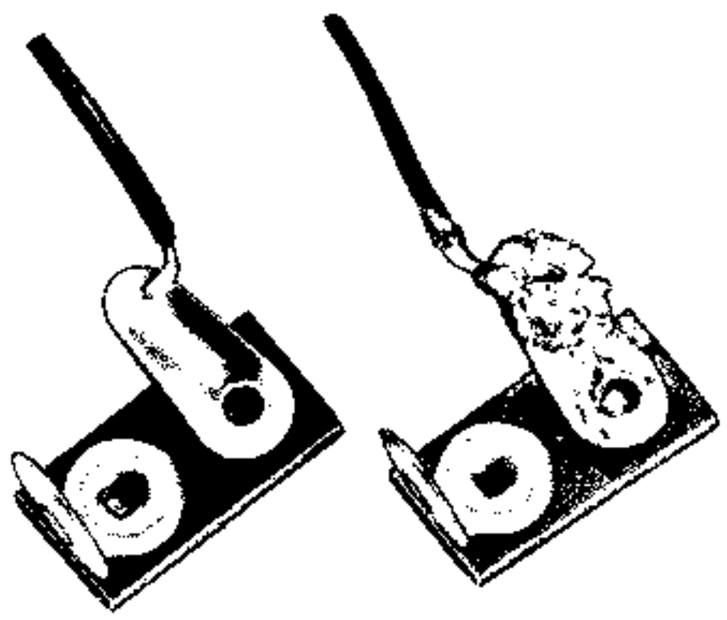
NO SEPARATE FLUX OR PASTE OF ANY KIND SHOULD BE USED. We specifically caution against the use of so-called "non-corrosive" pastes. Such compounds, although not corrosive at room temperatures, will form residues when heated. The residue is deposited on surrounding surfaces and attracts moisture. The resulting compound is not only corrosive but actually destroys the insulation value of non-conductors. Dust and dirt will tend to accumulate on these "bridges" and eventually will create erratic or degraded performance of the instrument.

NOTE: ALL GUARANTEES ARE VOIDED AND WE WILL NOT REPAIR OR SERVICE INSTRUMENTS IN WHICH ACID CORE SOLDER OR PASTE FLUXES HAVE BEEN USED. WHEN IN DOUBT ABOUT SOLDER, IT IS RECOMMENDED THAT A NEW ROLL PLAINLY MARKED "ROSIN CORE RADIO SOLDER" BE PURCHASED.

If terminals are bright and clean and wires free of wax, frayed insulation and other foreign substances, no difficulty will be experienced in soldering. Crimp or otherwise secure the wire (or wires) to the terminal, so that a good joint is made without relying on solder for physical strength. To make a good solder joint, the clean tip of the soldering iron should be placed against the joint to be soldered so that the terminal is heated sufficiently to melt solder. The solder is then placed against both the terminal and the tip of the iron and will immediately flow out over the joint. Refer to the sketch below. Use only enough solder to cover wires at the junction; it is not necessary to fill the entire hole in the terminal with solder. Excess solder may flow into tube socket contacts, ruining the socket, or it may creep into switch contacts and destroy their spring action. Position the work so that gravity tends to keep the solder where you want it.

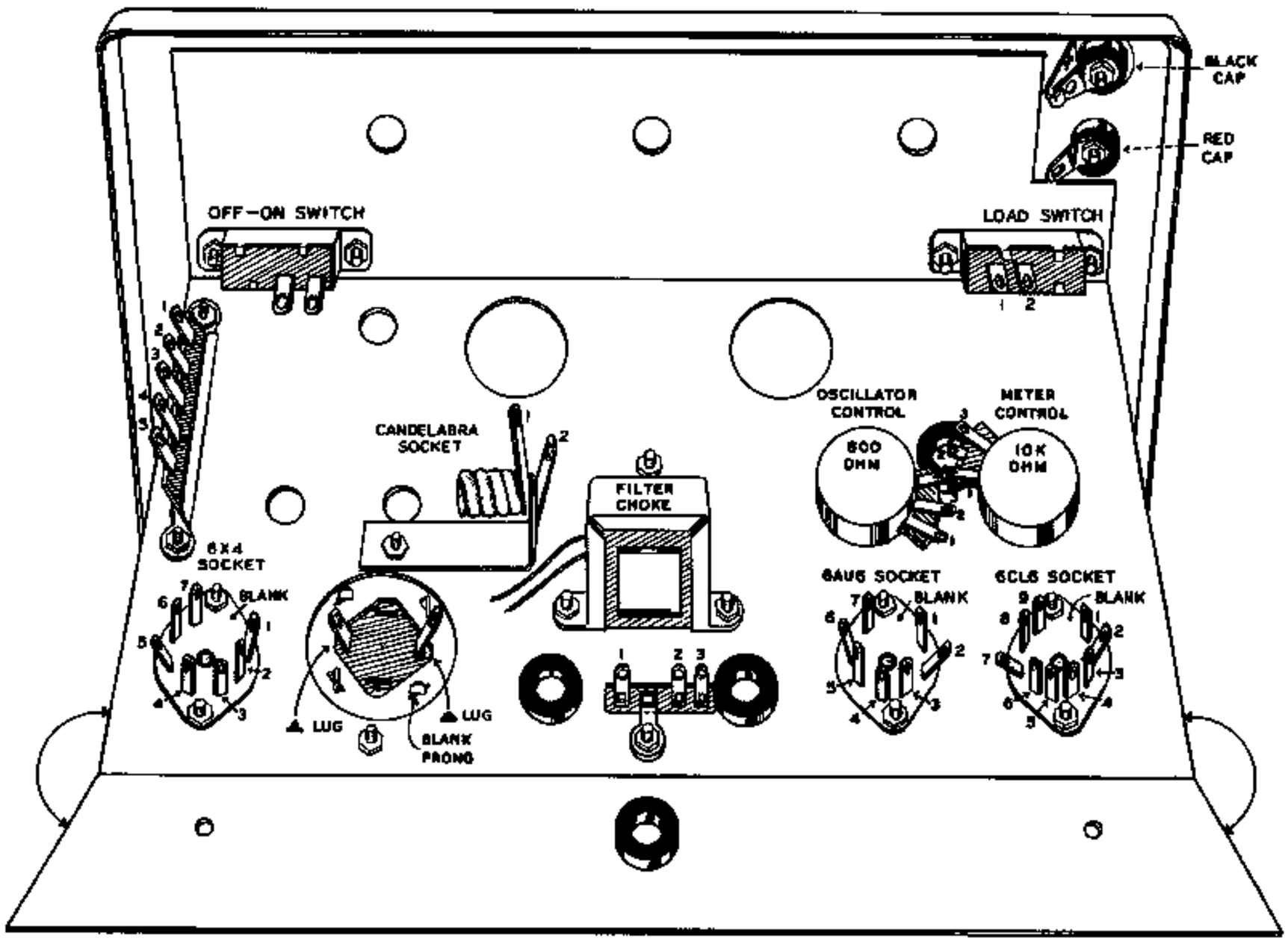


A poor solder joint will usually be indicated by its appearance. The solder will stand up in a blob on top of the connection, with no evidence of flowing out caused by actual "wetting" of the contact. A crystalline or grainy texture on the solder surface, caused by movement of the joint before it solidified is another evidence of a "cold" connection. In either event, reheat the joint until the solder flows smoothly over the entire junction, cooling to a smooth bright appearance. Photographs in the adjoining picture clearly indicate these two characteristics.

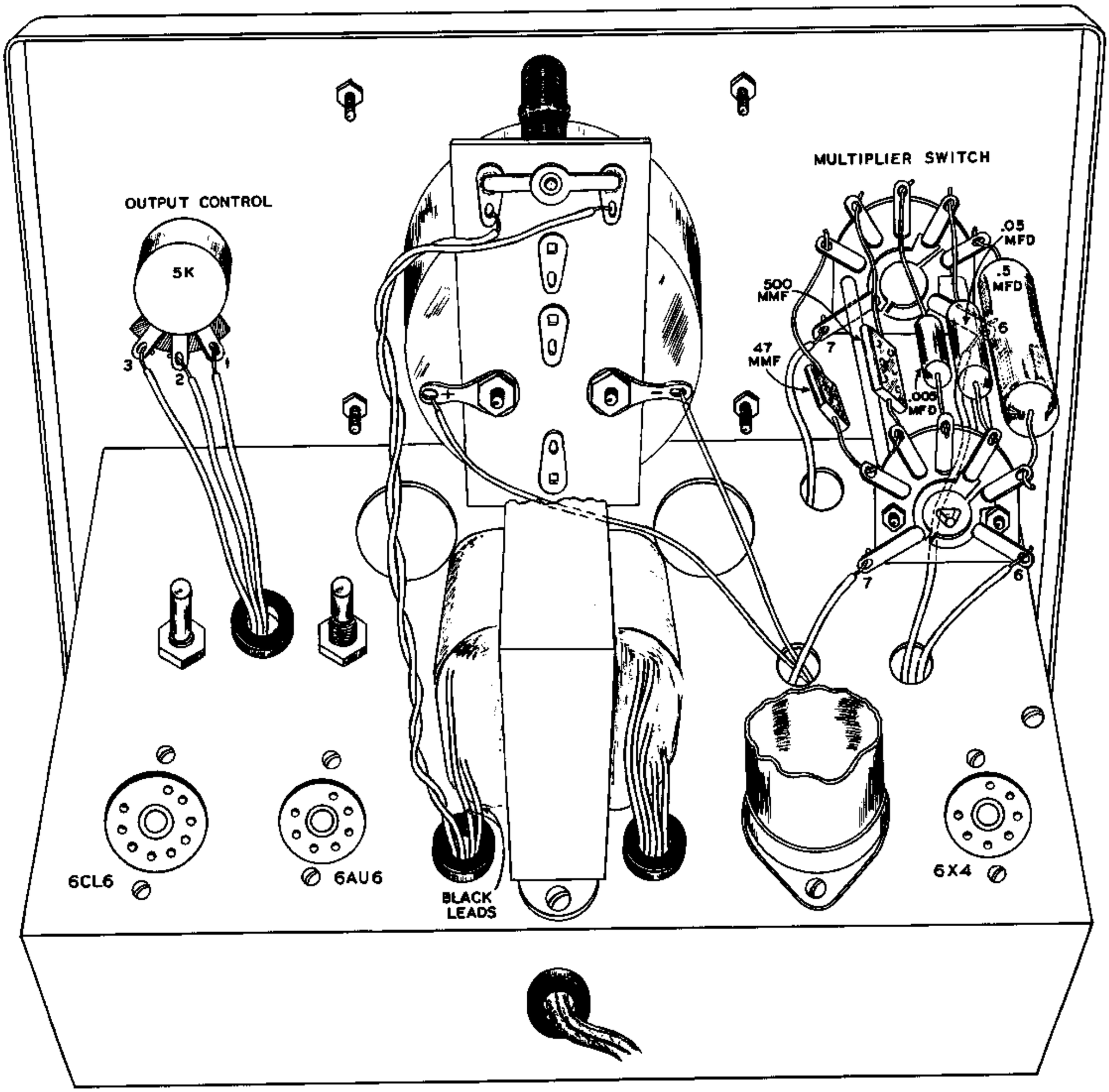


A good, clean, well-tinned soldering iron is also important to obtain consistently perfect connections. For most wiring, a 60 or 100 watt iron, or the equivalent in a soldering gun, is very satisfactory. Smaller irons generally will not heat the connections enough to flow the solder smoothly over the joint and are recommended only for light work, such as on etched circuit boards, etc. Keep the iron tip clean and bright. A pad of steel wool may be used to wipe the tip occasionally during use.

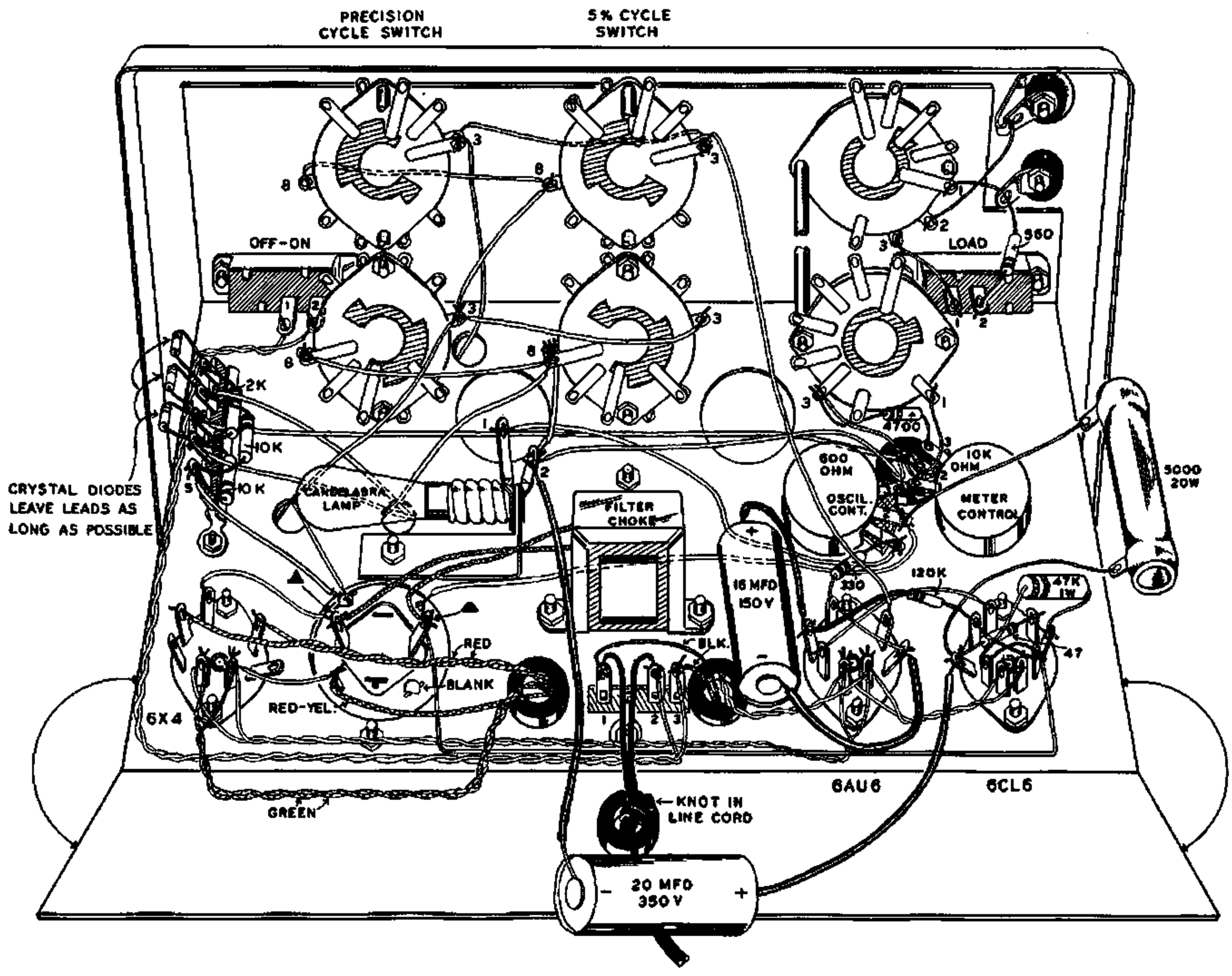
Take this precaution and use reasonable care during the assembly of the kit. This will insure the wonderful satisfaction of having the instrument operate perfectly the first time it is turned on.




PICTORIAL 1


OUTPUT CONTROL
5K
3
2
1
MULTIPLIER SWITCH
.05 MFD
.5 MFD
500 MMF
47 MMF
.005 MFD
7
6
6CL6
6AU6
BLACK LEADS
6X4

PICTORIAL 2


PRECISION CYCLE SWITCH
5% CYCLE SWITCH
OFF-ON
LOAD
360
2K
10K
10 K
CRYSTAL DIODES LEAVE LEADS AS LONG AS POSSIBLE
CANDELABRA LAMP
FILTER CHOKE
600 OHM
OSCIL. CONT.
10K OHM
METER CONTROL
5000 20W
16 MFD 150 V
330
120K
47K 1W
47
RED
BLANK
RED-YEL.
BLK.
6X4
6AU6
6CL6
GREEN
KNOT IN LINE CORD
20 MFD 350 V

PICTORIAL 3

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Resistors** | | |
| 1-1 | 1 | 47 Ω |
| 1-4 | 1 | 330 Ω |
| 1-94 | 1 | 390 Ω |
| 1-95 | 1 | 560 Ω |
| 1-96 | 1 | 750 Ω |
| 1-97 | 5 | 1100 Ω |
| 1-98 | 5 | 1600 Ω |
| 1-90 | 1 | 2000 Ω |
| 1-89 | 1 | 2400 Ω |
| 1-16 | 1 | 4700 Ω |
| 1-20 | 2 | 10 KΩ |
| 1-99 | 2 | 240 KΩ |
| 1-87 | 2 | 330 KΩ |
| 1-100 | 2 | 510 KΩ |
| 1-101 | 2 | 1 megohm |
| 1-121 | 1 | 120 KΩ |
| 1-7A | 1 | 47 KΩ 1 watt |
| 3-2T | 1 | 5000 Ω 20 watt |
| 2-97 | 2 | 25 KΩ precision |
| 2-98 | 2 | 33.3 KΩ precision |
| 2-99 | 2 | 50 KΩ precision |
| 2-11 | 2 | 100 KΩ precision |
| **Condensers** | | |
| 20-1 | 1 | 47 μμf mica |
| 20-55 | 1 | 500 μμf mica |
| 23-67 | 1 | .005 μfd paper |
| 23-68 | 1 | .05 μfd paper |
| 23-69 | 1 | .5 μfd paper |
| 25-5 | 1 | 16 μfd 150 v electrolytic |
| 25-16 | 1 | 20 μfd 350 v electrolytic |
| 25-37 | 1 | 40-40 μfd 450 v electrolytic |
| **Controls-Switches** | | |
| 10-34 | 1 | 600 Ω control |
| 10-7 | 1 | 5000 Ω control |
| 10-8 | 1 | 10 KΩ control |
| 60-1 | 2 | SPST slide switch |
| 63-8 | 1 | 4-pos. switch MULTIPLIER |
| 63-107 | 1 | 8-pos. switch ATTENUATOR |
| 63-108 | 2 | 11-pos. switch CYCLE |
| **Tubes-Lamp-Sockets** | | |
| 411-11 | 1 | 6AU6 tube |
| 411-63 | 1 | 6CL6 tube |
| 411-64 | 1 | 6X4 tube |
| 412-2 | 1 | 115 v 3 watt lamp |
| 412-4 | 1 | #50 pilot lamp |
| 434-15 | 2 | 7-pin wafer socket |
| 434-16 | 1 | 9-pin wafer socket |
| 434-23 | 1 | Candelabra socket |
| 434-47 | 1 | Pilot lamp socket |

| PART No. | PARTS Per Kit | DESCRIPTION |
|---|---|---|
| **Binding Posts-Terminals-Knobs** | | |
| 75-17 | 4 | Insulator bushing |
| 100-M16B | 1 | Binding post cap, black |
| 100-M16R | 1 | Binding post cap, red |
| 427-2 | 2 | Binding post base |
| 431-3 | 1 | 3-lug terminal strip |
| 431-19 | 1 | 5-lug terminal strip |
| 431-23 | 1 | Terminal board |
| 462-19 | 5 | Knob w/skirt |
| **Choke-Transformer-Diode-Meter** | | |
| 46-3 | 1 | Filter choke |
| 54-57 | 1 | Power transformer |
| 56-4 | 3 | Crystal diode |
| 407-8A | 1 | Meter |
| **Hardware** | | |
| 250-2 | 6 | 3-48 screw |
| 250-8 | 2 | #6 sheet metal screw |
| 250-9 | 12 | 6-32 screw |
| 250-83 | 2 | #10 x 1/2 handle screw |
| 252-1 | 6 | 3-48 nut |
| 252-3 | 14 | 6-32 nut |
| 252-7 | 7 | Control nut |
| 253-10 | 5 | Nickel control washer |
| 254-1 | 12 | #6 lockwasher |
| 254-4 | 7 | Control lockwasher |
| 259-1 | 2 | #6 solder lug |
| 259-10 | 1 | Control solder lug |
| **Sheet Metal Parts** | | |
| 90-60 | 1 | Cabinet |
| 200-M123 | 1 | Chassis |
| 203-80F158 | 1 | Panel |
| **Wire-Sleeving** | | |
| 89-1 | 1 | Line cord |
| 340-2 | 1 | length Bare wire |
| 344-1 | 1 | length Hookup wire |
| 346-1 | 1 | length Sleeving |
| 346-6 | 1 | length 3/8 sleeving |
| **Miscellaneous** | | |
| 73-1 | 4 | Rubber grommet |
| 211-4 | 1 | Handle |
| 261-1 | 4 | Rubber feet |
| 481-3 | 1 | Condenser mounting wafer |
| 595-165 | 1 | Instruction manual |

## INITIAL TEST AND ADJUSTMENT

Plug the line cord into a 105-125 volt 50-60 cycle outlet. Do not plug into an outlet of higher voltage or lower frequency, or a DC outlet, as an incorrect power source will damage the transformer.

Turn power switch on and observe tubes and pilot lamp as they light up. If they do not light, turn power off and investigate filament circuit wiring. Set OSCILLATOR and METER controls about midway. Set precision (0-100) CYCLE switch to 10 or more and advance OUTPUT control. This should show a reading on the meter.

Calibrate the meter. NOTE: If in the following test the OUTPUT control is left off or fully counterclockwise, it will be severly damaged. Proceed as follows: Turn both CYCLE switches to 0. Turn the OUTPUT control to maximum clockwise. Turn the ATTENUATOR to maximum clockwise (10 volt or +20 db). Connect a wire between the red output binding post and one of the pilot light terminals on the meter terminal board. Use the terminal that gives a meter indication. Turn the METER control to produce a meter reading of 6.3 volts on the 0-10 scale (a little over half-way up the scale). Now remove the wire.

If an accurate AC voltmeter of adequate sensitivity (at least 500 Ω per volt on the 10 volt range for instance) is available, it should be used in preference to the above procedure. In that case: select a suitable frequency (between 50 and 3000 cycles, depending on the AC meter used) with the CYCLE and MULTIPLIER switches and connect the meter to the output of the generator. Adjust the METER control to produce equal readings on the two meters.

Adjust the OSCILLATOR control as follows: No connections to the output terminals. OUTPUT control at maximum. CYCLE switches and MULTIPLIER to 10 cycles or more. Turn OSCILLATOR control to give just over full scale reading on the meter. Select various frequencies between 10 cycles and 100 kc and if the output drops below full scale, readjust OSCILLATOR control for full scale. Do not adjust OSCILLATOR control higher than necessary as higher than nominal distortion will result.

This completes the adjustment of the rument. Install the generator in the cabinet and fasten with the two #6 sheet metal screws th h the rear of the cabinet into the chassis.

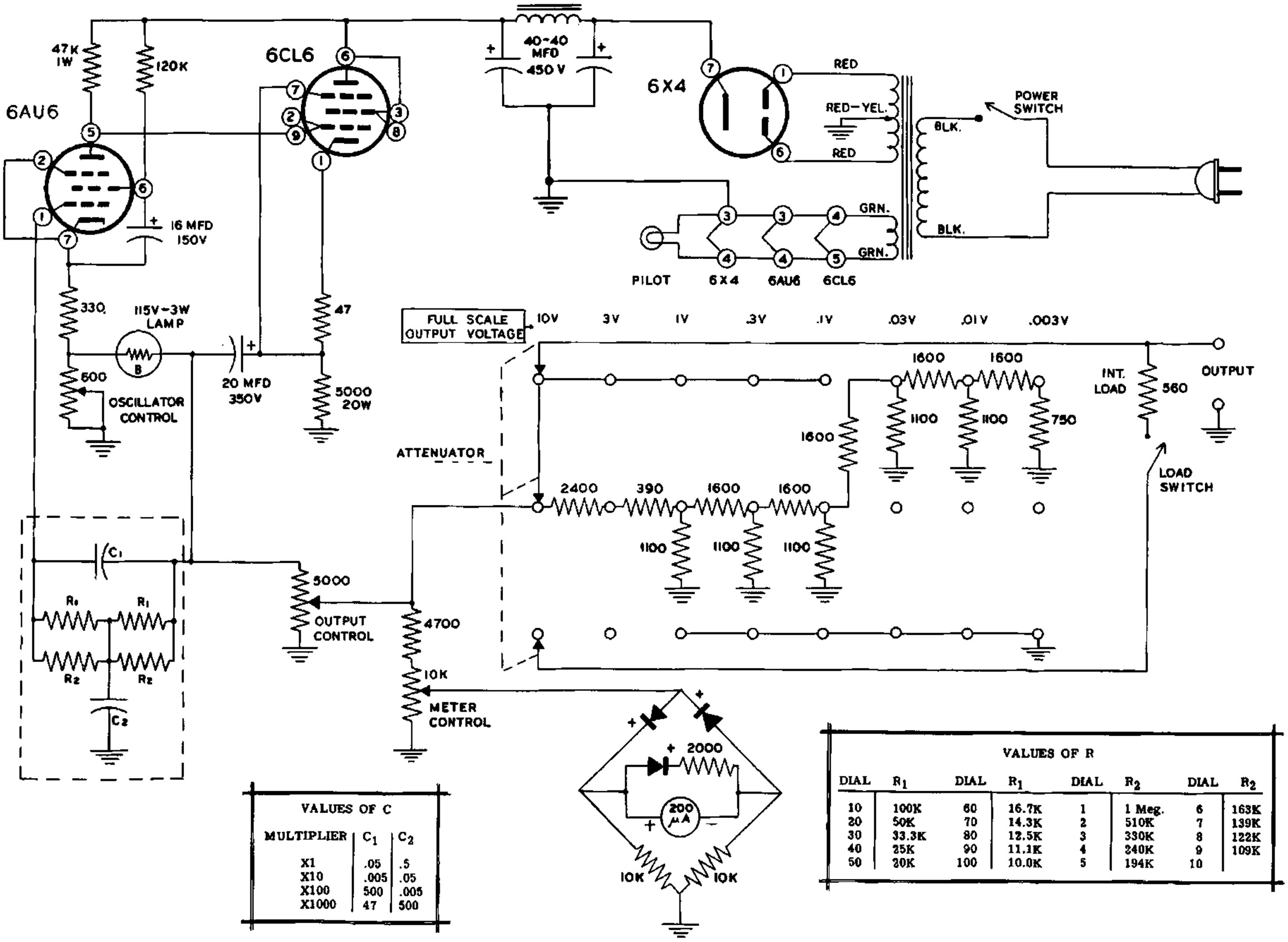
## IN E OF DIFFICULTY

If upon completion of careful construct the instrument fails to operate as specified, proceed as follows:

1. Check the wiring carefully step-by-step. Often having a friend check for you will locate an error consistently overlooked.
2. Inspect visually for malfunctioning, such as tubes lighting, discoloring of resistors through overheating, etc.
3. Inspect electrically with a voltmeter. The nominal voltages between tube socket pins and chassis are tabulated below. Nominal voltages were measured with a VTVM with 11 megohm input resistance. Lower resistance meters may give lower readings in some instances (particularly pin 6 on the 6AU6). Normal deviations due to line voltage and component variation may reach ±20%.

| TUBE | Pin 1 | Pin 2 | Pin 3 | Pin 4 | Pin 5 | Pin 6 | Pin 7 | Pin 8 | Pin 9 |
|---|---|---|---|---|---|---|---|---|---|
| 6X4 | 320AC | NC | X | X | NC | 320AC | 420 | | |
| 6AU6 | 1.5 | 4 | X | X | 200 | 140 | 4 | | |
| 6CL6 | 210 | 200 | 410 | X | X | 410 | 210 | 410 | 200 |

NC - no connection. X - heater voltage (one pin 0 volts, other pin 6.3 volts AC.)
Generator frequency set to 10 cycles or higher.




VALUES OF C

| MULTIPLIER | $C_1$ | $C_2$ |
|---|---|---|
| X1 | .05 | .5 |
| X10 | .005 | .05 |
| X100 | 500 | .005 |
| X1000 | 47 | 500 |

VALUES OF R

| DIAL | $R_1$ | DIAL | $R_1$ | DIAL | $R_2$ | DIAL | $R_2$ |
|---|---|---|---|---|---|---|---|
| 10 | 100K | 60 | 16.7K | 1 | 1 Meg. | 6 | 163K |
| 20 | 50K | 70 | 14.3K | 2 | 510K | 7 | 139K |
| 30 | 33.3K | 80 | 12.5K | 3 | 330K | 8 | 122K |
| 40 | 25K | 90 | 11.1K | 4 | 240K | 9 | 109K |
| 50 | 20K | 100 | 10.0K | 5 | 194K | 10 | |

## HEATHKIT AUDIO GENERATOR MODEL AG-9A

Met dank aan Jan van de Vijver