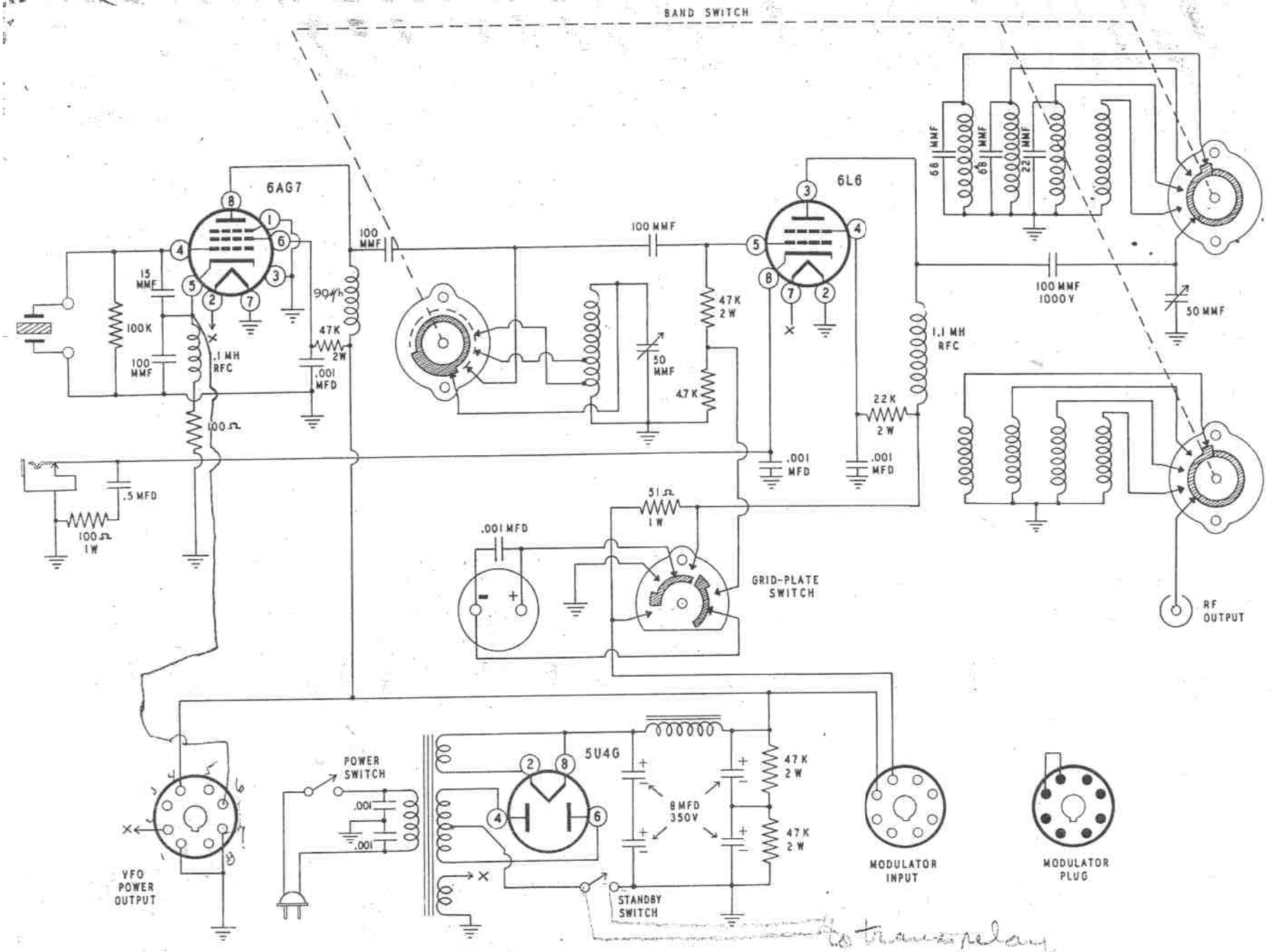
ASSEMBLY AND OPERATION OF THE HEATHKIT AMATEUR TRANSMITTER

MODEL AT-1

SPECIFICATIONS

RF Amplifier Power Input	25-30 Watts
Output Connection	52 Ohm Coaxial Cable
Oscillator Operation	Crystal, can be operated by a VFO
Amplifier Operation	CW, can be modulated for phone
Band Coverage	80, 40, 20, 15, 11, 10 Meters
Tube Complement	
5U4G	Rectifier
6AG7	Oscillator - Multiplier
6L6	Amplifier - Doubler
Power Requirements	105-125 50/60 Cycle, 100 Watts
Cabinet Size	8 1/8" high x 13 1/8" wide x 7" deep
Net Weight	13 lbs.



HEATHKIT AMATEUR TRANSMITTER

MODEL AT-1

INTRODUCTION

The Heathkit Model AT-1 Transmitter was designed to provide both the beginning and experienced amateur with a simply constructed yet versatile kit form transmitter at modest cost. Consideration was also given to the probable enlarging of the operator's station. Rather than become obsolete, the AT-1 can be operated with crystal or VFO control and used as an all-band exciter for a high power final. It has provision for modulation as a low power phone transmitter and can be used directly as such or used to drive a linear amplifier in a high power phone station. For the "old timer," it makes an excellent standby transmitter while the big "rig" is being overhauled.

The transmitter incorporates the maximum permissible shielding to minimize TVI from harmonics radiated directly by the transmitter. The amplifier stage operates as a doubler on the higher frequencies to eliminate the possibility of parasitic oscillations.

Although primarily designed for crystal operation, it will perform equally well when driven by a VFO and is equipped to supply the VFO with both plate and filament power from an octal socket on the rear of the transmitter chassis. The band switching knob on the panel switches both the oscillator and amplifier coils simultaneously. This not only increases the convenience of operation but also lessens the possibility of operation on the wrong crystal or VFO harmonic. A three position meter switch provides for measurement of the amplifier grid current, amplifier plate current, and has an "off" position for use when the transmitter is being keyed.

The transmitter incorporates tried and proven tube types and circuitry, careful layout, and quality components. It will give long and reliable service when properly constructed.

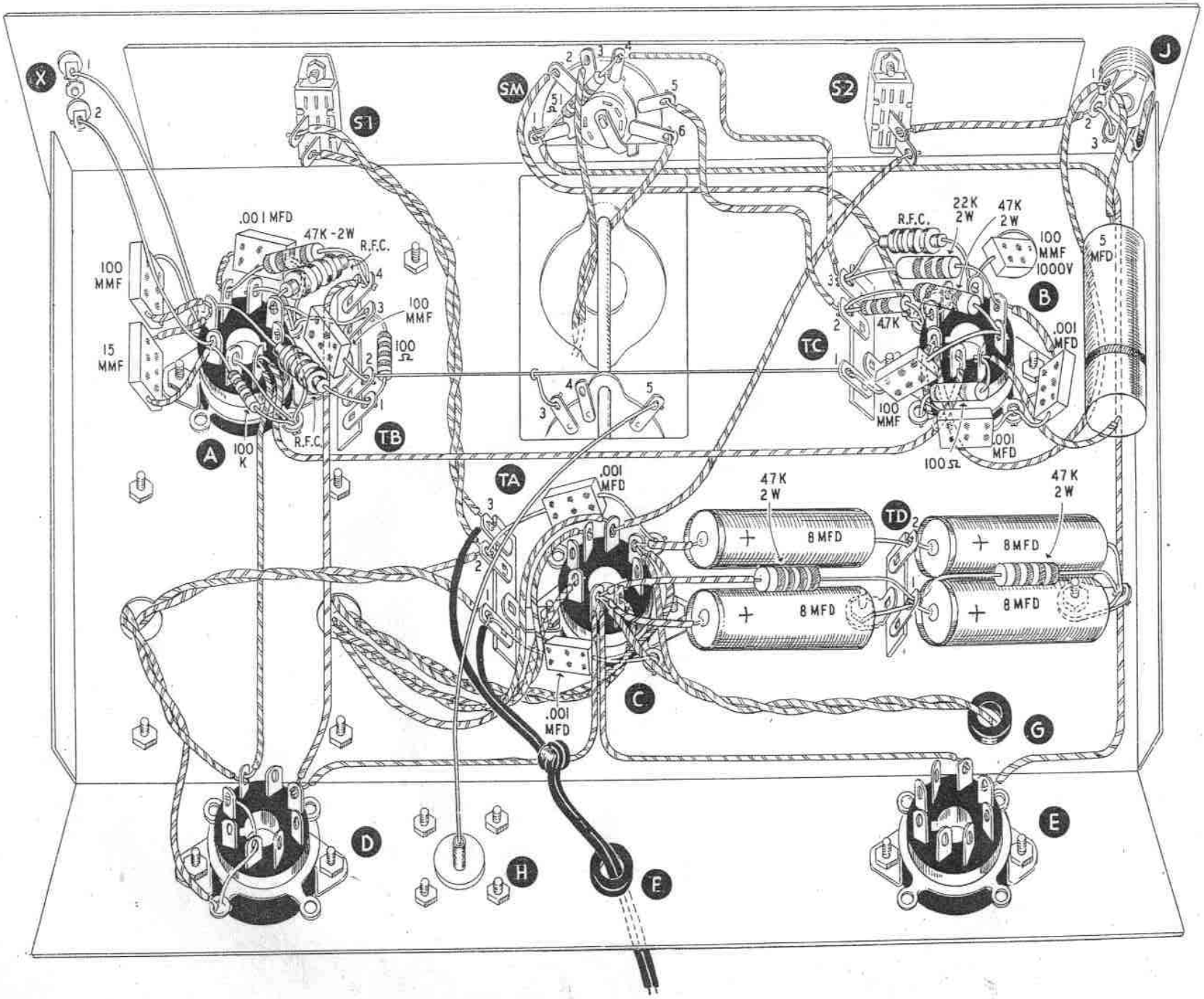
CIRCUIT DESCRIPTION

The power supply is conventional. A transformer steps up the AC line voltage to approximately 400 volts, which is then converted to direct current by the action of a 5U4G full-wave rectifier tube. Ripple component present in the output of the rectifier is removed by a "brute force" filter consisting of four electrolytic condensers and a filter choke. A switch in the AC line turns the transmitter ON and OFF. Another switch in the negative return shuts off the DC power when in the STANDBY position, leaving the filaments on.

The crystal oscillator consists of a 6AG7 tube operated in a tuned or untuned Colpitts circuit. The plate circuit of the oscillator is untuned when the transmitter is operated on the 80 meter band. This prevents coupling between oscillator and amplifier coils when both are at the same frequency. On all other bands the oscillator is operated as a tuned plate amplifier or doubler stage. One set of contacts on the band switch inserts the proper oscillator coil for each band. Grid bias for the 6AG7 is obtained mainly from a grid leak resistor and partially from resistance in the cathode circuit.

The output stage consists of a 6L6 amplifier-doubler which may be operated up to approximately 30 watts input on CW or Phone. Four coils each having preadjusted antenna coupling loops are connected in turn to the 6L6 plate circuit by the action of the band switch. These coils cover the frequency range from 3.5 to 30 mc. Bias for this stage is derived from the grid current flowing through the grid resistor and is only present when the stage is being excited by the oscillator. The Grid-plate meter has its full scale sensitivity automatically changed from 10 to 100 milliamperes when switched from the grid to plate position.

Two octal sockets on the rear of the chassis provide connections for audio input and VFO power output. A coaxial jack, when used with 52 ohm coax cable, provides a shielded RF output to the antenna coupler. A .5 μfd condenser and a 100 Ω resistor across the key jack provide an effective key click filter.


X
S1
SM
S2
J
.001 MFD
47K -2W
R.F.C.
100 MMF
15 MMF
100 MMF
100 Ω
R.F.C.
A
100 K
TB
TA
.001 MFD
.001 MFD
22K 2W
47K 2W
R.F.C.
100 MMF 1000V
5 MFD
B
TC
47K
.001 MFD
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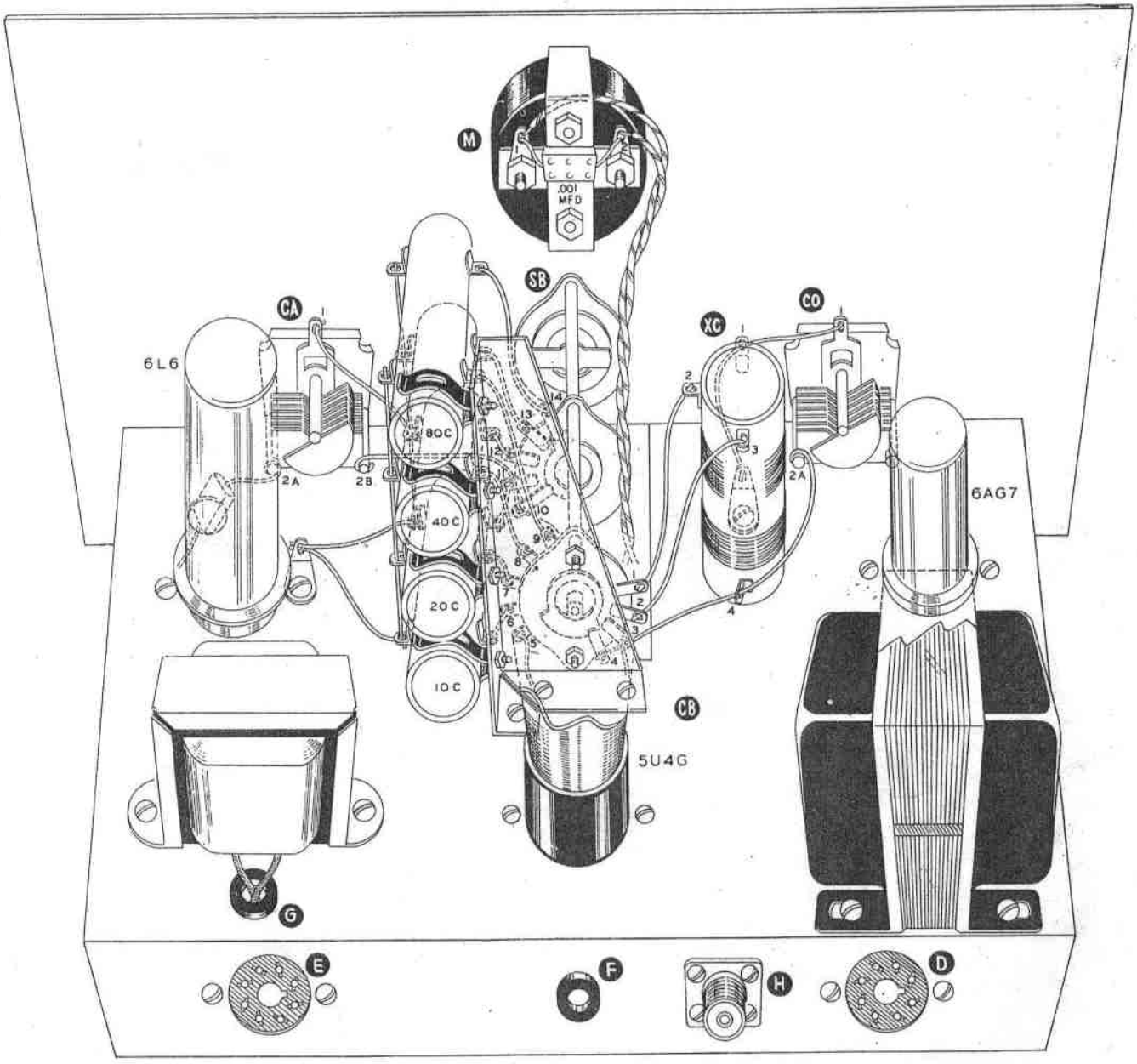
PICTORIAL 1


M
.001
MFD
SB
CA
6L6
80C
40C
20C
10C
2A
2B
XC
CO
2A
6AG7
CB
5U4G
G
E
F
H
D

PICTORIAL 2

AT-1 OPERATION ADJUSTMENTS

The AT-1 transmitter may be operated on the amateur bands of 80, 40, 20, 15, 11, and 10 meters using crystal or VFO control. Before attempting operation in any particular band, the operator should ascertain the frequency range of the desired band and the type of emission permissible in any portion of that band. After the desired frequency of operation has been arrived at, the crystal frequency necessary may be found by dividing the desired frequency by the harmonic relation to the crystal fundamental.

It is possible to operate the 10 meter band from an 80 meter crystal operating on its 8th harmonic but it is advisable to use 40 meter crystals for operation in the bands from 20 to 10 meters

A VFO may be used to control the transmitter by plugging the output of the VFO into the crystal socket. If a VFO is used, care should be taken to ascertain that the VFO output is within the band, particularly on the higher frequencies where the error will be multiplied.

80 METER OPERATION

NOTE: All adjustments should be made quickly as the tubes draw excessive current when their associated circuits are not in resonance.

It is assumed that the proper antenna and coupler is attached to the transmitter in the following paragraphs and that a key is plugged in.

Plug in a crystal with a frequency between 3,500 and 4,000 kc. Turn on power switch and allow transmitter to warm up for a short time. Leave STANDBY switch in STANDBY position. Turn the meter switch to the PLATE position. Turn on STANDBY switch, depress key and quickly tune OUTPUT control for a dip. It is not necessary to adjust the DRIVER control on this band.

While holding key depressed, tune antenna coupler for a rise in plate current. As the antenna is tuned for increased current, continuously adjust OUTPUT control for resonance as indicated by a dip in current. A point should be reached where the meter will still show a dip when tuned through resonance, but at a considerably increased current.

The final current reading with the antenna and transmitter both tuned to resonance should be about 60 to 80 milliamperes. If it is much lower than this, the antenna coupling should be increased. If a point is reached where it is no longer possible to dip the plate current, the antenna is over-coupled and the coupling should be reduced.

40 METER OPERATION

Plug in a crystal in the frequency range between 3,500 and 3,650 kc and turn meter switch to GRID position. Turn STANDBY switch to on, depress key and quickly tune DRIVER control for maximum meter reading. Release key. Turn meter switch to PLATE position, depress key and tune for dip. Tune antenna as outlined under 80 meter operation.

20, 15, 11 AND 10 METER OPERATION

The method of tuning for these bands is exactly the same method as for the 40 meter band, except for the choice of crystal frequencies. The 15 meter and 11 meter bands are operated on the 10 meter position of the band switch. Below is a chart of crystal frequencies necessary for operation in any of the amateur bands.

WARNING: The frequencies listed cover the entire band limits. It is not advisable to operate near the band edge. When operating in the 15 meter band with a crystal frequency near 5250 kc, it is possible to tune to the 6th harmonic. As the 6th harmonic of that crystal is outside of any of the amateur bands it should be avoided. In any case, where two dips are noted when tuning the OUTPUT control, the one giving the most pronounced dip is the correct tuning.

80 METERS	40 METERS	20 METERS
3500 to 4000 kc Crystal	7000 to 7300 kc Crystal	14000 to 14350 Crystal
3500 to 4000 kc	3500 to 3650 kc	3500 to 3587.5 kc 7000 to 7175 kc
15 METERS	**11 METERS**	**10 METERS**
21000 to 21450 kc Crystal	26960 to 27230 kc Crystal	28000 to 29700 kc Crystal
5250 to 5362.5 kc	6740 to 6807.5 kc	3500 to 3712.5 kc 7000 to 7425 kc 14000 to 14850 kc

Crystals operating between any of the figures listed above can be used for operating the AT-1 in the band they are listed under.

RADIO TELEPHONE OPERATION

NOTE: Phone operation is limited to certain parts of the amateur bands only. It is also restricted to certain grades of amateur licenses. This must be taken into consideration before operating the AT-1 as a phone transmitter.

Modulation of a transmitter involves several factors not present in CW operation. For example, the load presented by the radio frequency amplifier must match the output impedance of the modulator. The modulator must have an impedance matching device, such as a transformer with the proper ratio to match the load resistance of the modulator tubes to the radio frequency load. The modulator must be capable of an audio output equal to 1/2 the power input to the radio frequency amplifier for 100% modulation. Some form of microphone and speech amplifier is necessary and the modulator for amateur use should reject audio frequencies above 3,000 cycles per second.

Frequencies above 3 kc are not necessary for the transmission of intelligent speech. Therefore, any frequencies above this figure not only waste usuable power but cause interference to other stations by increasing the band width of the transmitted signal.

MODULATOR DESIGN

The method of calculating the load impedance presented by the radio frequency amplifier when plate modulated is given by the formula:

$$Z_m = \frac{E_b \times 1000}{I_p}$$

where E_b is the amplifier plate voltage and I_p is the amplifier plate current in milliamperes. In the case of a screen grid tube, such as the 6L6 used in the AT-1, both plate and screen are modulated, so I_p used in the formula represents the total current for both plate and screen grid.
EXAMPLE: AT-1 transmitter operating with 400 volts on the plate and 80 MA total plate and screen grid current:

$$Z_m = \frac{400 \times 1000}{80} = 5000\ \Omega \text{ Load Impedance}$$

Power input to the amplifier is expressed by the formula:

Power In Watts - $E_b I_p$

E_b is the amplifier plate voltage and I_p is the amplifier plate current in amperes.

As we require half the audio power output that we have RF power input, the audio requirements under the operating conditions stated above will be:

Audio output in watts - .5 x 400 x .080 or 16 watts

From the tube table it is found that push-pull 6L6's operating class AB_1 with 250 plate volts will give an output of 18 watts. The plate to plate load resistance of the tubes is found to be 5,000 ohms. Therefore, an output transformer having a 5,000 ohm primary and a ratio of total primary to secondary turns of 1 to 1 will match the modulator to the transmitter.

NOTE: This example only applies to one set of conditions, a change in the antenna loading will cause a change in RF amplifier plate current with a subsequent change in load impedance and wattage input. A different choice of modulator tubes would affect the output transformer necessary. However, from the formula given above, the modulator for any set of operating conditions may be calculated.

The reader is again referred to the amateur radio handbooks for more detailed information on the subject of phone operation.

MODULATION CONNECTIONS TO THE AT-1

In order to modulate the AT-1 transmitter, it is merely necessary to remove the jumper from pins 3 and 4 on the male octal plug, and connect the proper impedance output from the modulator transformer across these two pins. As the output of the modulator is AC, either terminal of the modulation transformer may be connected to either pin on the octal plug.

As the output impedance of the modulation transformer is more or less fixed, it is usually customary to adjust the transmitter by loading the antenna to a lesser or greater degree in order to present the proper RF load impedance to match the modulator.

VFO OPERATION

When using a VFO with the AT-1, it will be necessary to short out the cathode of the RF choke and resistor on the 6AG7. If a wire is connected from A5 to D6, an octal plug having a jumper between pins 6 and 7 may be inserted in socket D for VFO operation. If the VFO receives its power from the AT-1, its plug can be wired in the same manner.

IN CASE OF DIFFICULTY

The greatest single cause of trouble is due to wiring mistakes. First, check very carefully the transmitter wiring. Due to the large amount of bare wire used in this kit, there is a good chance that a short circuit will occur. All bare wire should be kept away from the chassis and other components.

The meter may be used to some degree in trouble shooting. In the GRID position, it indicates whether the oscillator is operating correctly and, in the PLATE position, it does the same for the amplifier stage. No deflection of the meter in either position usually indicates the trouble is in the power supply.

A voltage chart is often a good means of locating trouble. The chart below gives the voltages to be expected under normal operating conditions. All readings are DC, except where indicated. These voltages were measured with an 11 megohm input vacuum tube voltmeter. A normal variation of ±15% is to be expected. With regular voltmeters, reading may be somewhat lower.

SOCKET VOLTAGE CHART

TUBE	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
5U4G	0	450	440	430AC	0	430AC	0	450
6AG7	0	6.3AC	0	-95	3.5	220	0	430
6L6	0	0	420	250	-45	0	6.3AC	0

The trouble shooting chart included at this point may also be used to good advantage in case difficulty occurs.

TROUBLE	SYMPTOMS	POSSIBLE CAUSE
Transmitter inoperative	Meter reads high current in PLATE position. No indication in GRID position.	Oscillator not oscillating due to: 1. Defective or dirty crystal. 2. Defective 6AG7 tube. 3. No voltage on oscillator plate or screen grid. (Pins 6 and 8 on voltage chart.) 4. Shorted or open circuit on oscillator coil or terminals SB1 through 4 on the band switch. 5. DRIVER control not tuned properly.
Transmitter inoperative	Meter reads in GRID position. Does not read in PLATE position.	Amplifier not drawing current due to: 1. Modulator plug not inserted in socket. 2. Modulator plug does not have jumper between terminals 3 and 4. 3. Defective 6L6 tube. 4. No voltage on plate and screen grids. (Pins 3 and 4 on the voltage chart.) 5. Cathode circuit to ground open. (Check key jack.) 6. Plate voltage supply open at meter switch. (Terminals 1 and 4 on meter switch.)
Transmitter inoperative	Meter reads in both GRID and PLATE positions. OUTPUT tuning will not dip meter current.	Amplifier will not resonate due to: 1. 100 $\mu\mu$f 1,000 volt condenser circuit open between B3 and CO2A. 2. "Tank" circuit open between CA2B and SB10. 3. Amplifier coil connections shorted. 4. Switch positions SB10 through 14 open or shorted. 5. Antenna overcoupled.
Transmitter inoperative	Meter does not read in either position.	No voltages on tubes due to: 1. Open circuit at switches S1 or S2. 2. Defective 5U4G tube. 3. Short in high voltage circuit. 4. Open circuit at SM3 or 6 on the meter switch.

Transmitter will not load when connected to an antenna.	No increase in plate current with antenna connected.	1. Short or open connections on #4 amplifier coil terminals. 2. Shorted or open connections on terminals SB5 through 9 on the band switch. 3. Antenna coupler not tuned to band being operated. 4. Inefficient antenna.

TELEVISION INTERFERENCE (TVI)

There is no single method of combating television interference that will apply to all circumstances. Each individual installation may require a different technique. However, a few hints are included here covering the usual methods of eliminating TVI.

LOW-PASS FILTER

A low-pass filter inserted in the coaxial line between the transmitter and the antenna coupler is very effective. The low-pass filter will eliminate any harmonic radiation above its cutoff frequency, usually 40 to 50 mc. The figure below describes one method of making a low-pass filter.

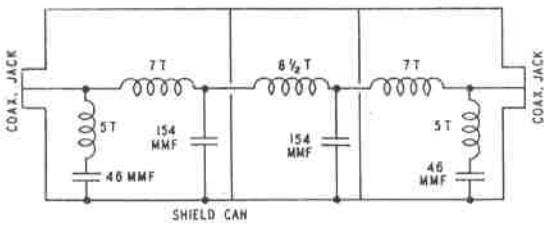


Fig. 14

Coils are wound of No. 12 or 14 wire 1/2" inside diameter, spacing 8 turns per inch.

HIGH-PASS FILTER

The high-pass filter is used where only one or two television sets are affected out of many. It must be inserted in the TV lead-in directly at the antenna terminals of the receiver. The figure below describes one method of making a high-pass filter.

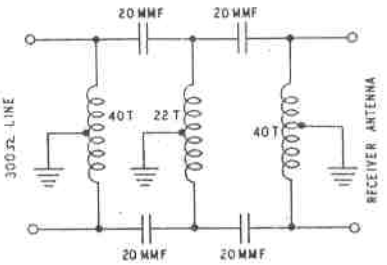


Fig. 15

Coils are wound of No. 30 wire on a 1/8" diameter form.

AC LINE FILTER

It is sometimes possible that the transmitter is feeding energy from the antenna into the house wiring. This energy in turn is fed directly into the receiver through its line cord. The figure below shows a method of constructing an AC line filter for the receiver.

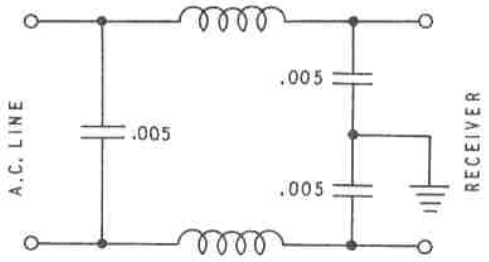


Fig. 16

The coils consist of a 2" length of close wound No. 18 wire on 1/2" diameter form.

There are numerous other methods which will help to eliminate TVI. In general, the transmitting antenna should be kept away from receiving antennas. All RF components should be shielded. Consequently, the AT-1 should be operated in the case at all times.

For further information on television and broadcast interference elimination, refer to the amateur handbooks.

REPLACEMENTS

Material supplied with Heathkits has been carefully selected to meet design requirements and ordinarily will fulfill its function without difficulty. Occasionally improper instrument operation can be traced to a faulty tube or component. Should inspection reveal the necessity for replacement, write to the Heath Company and supply all of the following information:

A. Thoroughly identify the part in question by using the part number and description found in the manual parts list.
B. Identify the type and model number of kit in which it is used.
C. Mention the order number and date of purchase.
D. Describe the nature of defect or reason for requesting replacement.

The Heath Company will promptly supply the necessary replacement. Please do not return the original component until specifically requested to do so. Do not dismantle the component in question as this will void the guarantee. If tubes are to be returned, pack them carefully to prevent breakage in shipment as broken tubes are not eligible for replacement. This replacement policy does not cover the free replacement of parts that may have been broken or damaged through carelessness on the part of the kit builder.

SERVICE

In event continued operational difficulties of the completed instrument are experienced, the facilities of the Heath Company Service Department are at your disposal. Your instrument may be returned for inspection and repair for a service charge of $5.00 plus the cost of any additional material that may be required. THIS SERVICE POLICY APPLIES ONLY TO COMPLETED INSTRUMENTS CONSTRUCTED IN ACCORDANCE WITH THE INSTRUCTIONS AS STATED IN THE MANUAL. Instruments that are not entirely completed or instruments that are modified in design will not be accepted for repair. Instruments showing evidence of acid core solder or paste fluxes will be returned not repaired.

The Heath Company is willing to offer its full cooperation to assist you in obtaining the proper operation of your instrument and therefore this factory repair service is available for a period of one year from the date of purchase.

PARTS LIST

HEATHKIT AMATEUR TRANSMITTER

MODEL AT-1

PART No.	PARTS Per Kit	DESCRIPTION
Resistors		
1-3	1	100 Ω 1/2 watt
1-16	1	4.7 KΩ 1/2 watt
1-26	1	100 KΩ 1/2 watt
1-43A	1	51 Ω 1 watt 5%
1-17A	1	100 Ω 1 watt
1-11B	1	22 KΩ 2 watt
1-10B	4	47 KΩ 2 watt
Condensers		
20-29	1	15 μμf 500 volt mica
20-30	1	22 μμf 1 kv silver mica
20-31	2	68 μμf 1 kv silver mica
20-11	3	100 μμf 500 volt mica
20-32	1	100 μμf 1 kv mica
20-33	7	.001 μfd 500 volt mica
23-15	1	.5 μfd 400 volt paper
26-[illegible]	2	50 μμf variable
25-22	4	8 μfd 350 volt electrolytic
Switches		
60-1	2	SPST slide switch
63-52	1	3 pole 3 position rotary
63-53	1	2 pole 3 position rotary
Transformers-Coils-Chokes		
54-21	1	Power transformer
46-7	1	Filter choke
45-4	2	1.1 MH RF choke
45-7	1	90 μh RF choke
40-32	1	Oscillator coil
40-33	1	80 M amplifier coil
40-34	1	40 M amplifier coil
40-35	1	20 M amplifier coil
40-36	1	10 M amplifier coil
Tubes-Meters		
407-21	1	10 MA meter
411-2	1	5U4G tube
411-8	1	6L6 tube
411-53	1	6AG7 tube
Sockets-Terminal Strips		
431-2	1	2 Lug terminal strip
431-3	2	3 Lug terminal strip
431-5	1	4 Lug terminal strip
434-38	1	Crystal socket
434-39	5	Octal tube socket
436-4	1	Phone jack
436-5	1	Coaxial jack
438-6	1	Octal plug
438-9	1	Coaxial plug

PART No.	PARTS Per Kit	DESCRIPTION
Hardware		
73-1	2	3/8" rubber grommet
208-2	4	Spring clip
250-8	10	#6 sheet metal screw
250-9	24	6-32 round head screw
250-7	4	6-32 x 3/16 screw
250-18	4	8-32 round head screw
250-34	5	4-40 round head screw
252-3	24	6-32 hex nut
252-4	4	8-32 hex nut
252-7	35	Control nut
252-15	5	4-40 hex nut
253-10	35	Control washer
254-1	25	#6 lockwasher
254-2	4	#8 lockwasher
254-4	24	Control lockwasher
259-1	3	#6 solder lug
250-22	2	Set screw
Miscellaneous		
89-1	1	Line cord
90-22	1	Cabinet
200-M49	1	Chassis
203-M45F58	1	Panel
204-M47	1	Coil bracket
261-1	4	Rubber feet
340-1	1	length #14 bare wire
340-2	1	length #20 bare wire
340-3	1	length #16 bare wire
344-1	1	roll Hookup wire
346-1	1	length Spaghetti
462-M11	2	Pointer knob
462-15	2	Round skirt knobs
595-64	1	Manual