Radio Power Bulletin

COMPILED FOR RADIO ENGINEERS, SERVICE MEN AND RADIO EXPERIMENTERS BY THE ENGINEERING STAFF OF THE

Raytheon Manufacturing Company

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Raytheon, Type BH, 125 milliamperes

The Heavy Duty, Long Life, Rectifying Tube

GENERAL DESCRIPTION. Raytheon BH is a higher power full-wave gaseous rectifying tube which fills a distinct need not met by other rectifiers. It is especially intended for use in (1) B-power units, (2) power amplifiers using the 171A power tube, and (3) complete A-B-C power units for full A-C operation of special radio receivers using the type 199 tubes.

Raytheon BH is of rugged construction, comprising a glass bulb, containing a mixture of inert gases and internal elements consisting of a patented hollow cap or cathode and two rod electrodes or anodes protruding into the hollow cap, and properly insulated by the patented short-path method of construction. The ionization of the gas, which is the basis of the rectifying action of the Raytheon, takes place inside the cap of the tube and is therefore concealed from view. The only sign of the tube's operation is in the heating of the glass bulb.

Overloading the tube, either with excessive input voltage through the use of the wrong transformer or through an excessive output load due to short-circuited filter condensers or other overload, will materially shorten the useful life of the Raytheon BH.

RATING: Raytheon BH has an output rating of 125 milliamperes with a maximum allowable input voltage of 350 per anode.

Raytheon BH in normal operation should become no warmer than the usual electric light bulb. It is best, however, to provide some measure of cooling such as ventilating openings in the case.

RAYTHEON TYPE BH

MOUNTING: Raytheon BH is provided with the UX or long-prong type of base, and may be used in the Navy standard socket or in the UX or universal socket. As for base connections, the usual two filament prongs are the anodes, and they connect with the outside terminals of the transformer, while the usual plate prong is the cathode and it acts as positive terminal for the direct-current circuit. The negative side of the direct-current circuit is obtained by a center tap on the transformer

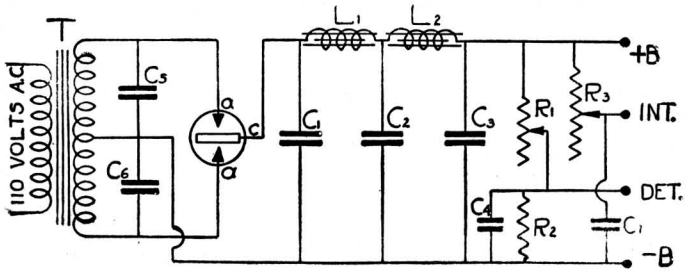
CIRCUIT: Raytheon BH is employed as a full-wave rectifier in the standard Raytheon B-power circuit, as shown in Fig. 1.

It is advisable to ground the metal cases of transformers, chokes, and condenser blocks to the—B terminal, thru a .5 mfd. condenser

TRANSFORMER: For the proper operation of Raytheon BH a transformer with secondary of approximately 300 for each anode is required. The secondary voltage per anode may even be as high as 350, but this should not be exceeded. This transformer should be of good quality, properly balanced for resistance of both halves of the center tapped secondary and with electrostatic shielding between primary and secondary windings so as to keep line noises and outside interference out of the B-power circuit and the radio receiver.

CHOKE COILS: The proper filter for the Raytheon BH consists of two sections as shown in Fig. 1. For the BH circuit, the choke coils should be 20 henry chokes at 85 milliamperes. Chokes of smaller inductance will cause excessive hum at higher current loads. The d. c. resistance of the chokes should be as low as possible, with a maximum of 350 ohms per choke. The use of chokes of higher resistance will lower the output voltage considerably.

CONDENSERS: The minimum capacities for the condensers of the Raytheon BH B-power circuit are 2-2-8 mfd., for the first, second and third condensers, respectively. Filtering may be improved by increasing the capacity of the filter condensers, particularly the first and second units. The first condenser affects the regulation or voltage-sustaining characteristic of the circuit and also the hum, thus providing slightly higher voltage at the heavy loads. There is no decided advantage in raising the capacity of the first condenser beyond 6 mfd. The second condenser affects the hum or ripple. There is no marked advantage in using a condenser larger than 6 mfd. for this second unit.



T is a specially designed transformer with tapped secondary for full-wave rectification.

a, a the anodes of the tube will be connected to the "Filament" terminals in the standard 201-A socket.

c the cathode will be connected to the "Plate" terminal of the same socket. (The grid terminal on the socket is not used.)

C1 and C2 are high voltage filter circuit condensers of 2 microfarads each.

C3 is a high voltage condenser of 8 microfarads.

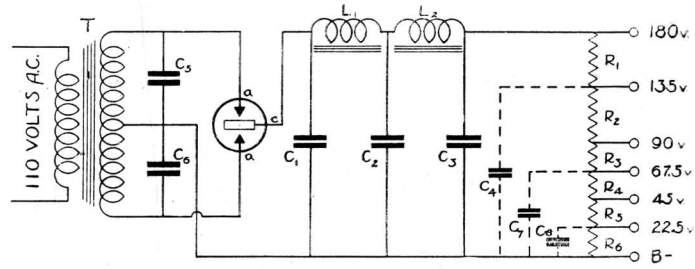
C4, C7 and C8 are by-pass condensers of 1 microfarad each.

C5 and C6 are high voltage condensers of 0.1 microfarad each connected from each anode to the center tap of the transformer.

L1 and L2 are specially designed high inductance choke coils whose resistance should be approximately 350 ohms or less.

R1 is a variable resistance of from 10,000 to 100,000 ohms. It is used to adjust the voltage on the detector tube only. R2 is a fixed resistance of 10,000 ohms, current capacity 15 millamperes or more. The voltage that will be obtained at the intermediate tap is obviously dependent upon the current drawn. Hence it will vary with the number of tubes using this tap. A variable resistance R3 of from 1,000 to 10,000 ohms is recommended so as to take care of all possible combinations of tubes. A variable resistance is unnecessary at R3, however, if the proper value of fixed resistance is known. From 2,000 to 10,000 ohms will probably be found satisfactory for average use.

Resistance banks suitable for use in the power unit of Fig. 2 are available from a number of radio manufacturers. The various resistance values should be as follows: R1 is 1200 ohms with 50 m.a. capacity; R2 is 2000 ohms with 40 m.a. capacity; R3 is 1800 ohms with 20 m.a. capacity; R4 is 2400 ohms with 15 m.a. capacity; R5 is 2900 ohms with 10 m.a. capacity, and R6 is 4300 ohms with 10 m.a. capacity. The condensers indicated by the dotted lines are necessary across the taps used.



NOTE: These transformers and chokes are made by the Acme Apparatus Co., Dongan Electric Mfg. Co., Ford Radio & Mica Co., and the Thordason Electric Mfg. Co.

Quality of reproduction, when employing the highest type of audio amplifier capable of reproducing the bass notes can be improved by increasing the capacity of the third condenser, resulting in a deeper and more accurate loud-speaker rendition. However, there is no noticeable gain in quality when the capacity is increased beyond 8 mfd., and this increased capacity can be added externally to the —B and +B terminals with the same result.

All condensers should be of the best possible quality, and with sufficient voltage rating to withstand surges and meet the high potentials impressed on them when there is no load on the unit. In the Raytheon BH circuit, all filter condensers should have a d. c. working voltage rating of 400 volts (usually 3 paper). The .1 mfd. buffer condensers across the secondary terminals of the transformer should be extra high voltage rating (usually 4 paper). The by-pass condensers across the various voltage taps may be of lower voltage rating (usually 2 paper).

RESISTANCE BANK: Whether to employ fixed or variable resistors in the output is a matter of choice. It is not always possible to obtain a fixed resistor with a sufficient number of taps to provide the correct voltages for some types of receivers. The standard tapped fixed wire wound resistors made just for such use by several of the well known resistor manufacturers will, in most cases, however, provide the necessary voltage outputs. Variable resistors, which may be readily set for any value are often very desirable with some types of receiving sets. In Fig. 1 are shown two variable resistors providing the variable intermediate and the variable detector voltages, while a fixed resistor of 10,000 ohms completes the resistance bank. A by-pass condenser of at least 1 mfd. should be used between each of these taps and the —B side.

The better makes of variable resistors will provide sufficiently dependable and noiseless operation to make their use entirely satisfactory. If a fixed resistor is employed as in Fig. 2, for the entire resistance bank, it should be provided with taps at about the values indicated on the diagram.

TESTING: To prevent the possibility of broken down condensers and short-circuited resistors, these parts should be tested before assembly. The test may be made with a telephone receiver and dry cell, connected in series, with the two free leads touched to condenser or resistor terminals. A good condenser will give a fairly loud click the first few times the test terminals are applied after which the click will grow fainter. In the smaller capacities, the click is soon rendered inaudible. Short-circuited condensers will be detected by a loud click each time the test terminals are applied. Short-circuited resistors will provide an excessively loud click, which may be as loud as when the test terminals are touched together. In the case of a shorted variable resistor, the click will remain excessively loud at all settings.

CAUTION: The Raytheon BH, in conjunction with its associated equipment, is capable of delivering a high voltage, with enough power to give a disagreeable shock. Therefore, when working on the B-power unit or the radio receiver to which it is connected, the 110-volt current should first be disconnected. It is also good practice to discharge the condensers by shorting the terminals of the B-power unit after the 110-volt supply has been disconnected. In this way there is no danger of shock.

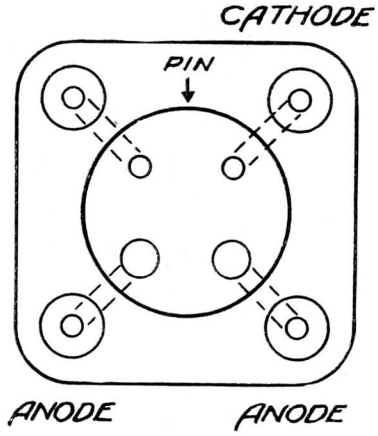
Do not overload the Raytheon BH. An excessive transformer voltage or a short-circuited resistor or condenser will materially shorten the life by imposing the wear and tear of months upon the tube in as many minutes. There is little danger of applying an excessive output load under normal operating conditions, since Raytheon BH will safely operate a radio receiver with as many as twelve tubes, including a large power tube, provided the proper C-battery grid bias is employed. Or again, the BH tube will operate as many as eight tubes of the 199 type, with their filaments connected in series, supplying A, B and C power, as well as B and C power for a larger power tube.

OPERATING: Always light the filaments of the receiver before turning on the B-power, and turn off the B-power before turning off the filaments. It is only when the receiver tube filaments are turned on that the energy, from the B-power unit is safely dissipated. Otherwise, added strain is thrown on the B-power unit as well as on the receiver tubes, resulting in shortening the life of the equipment, and often causing serious breakdown. An automatic relay switch may be used for shutting off B-power supply and filament current in a safe manner.

TROUBLE SHOOTING: There are few elements to cause trouble in the Raytheon-approved radio power unit. More often the trouble is to be found in the associated receiver. However, when genuine trouble does develop, it may be readily located and remedied.

INOPERATIVE RECEIVER: If the cause, through a process of elimination, is found to be in the radio power unit, then the following suggestions may be considered. However, as often as not the trouble is primarily in the receiver itself, or in the wiring between receiver and B-power supply. Sometimes when a B-power unit is connected to a receiver where the grids of the amplifying tubes are not biased with a C-battery the high voltage may soon paralyze the tubes. This may be remedied by inserting proper values of C-battery for each tube.

NO VOLTAGE AT GIVEN TAP: The logical place to begin the hunt for trouble in a radio power unit is at the resistor bank, and then work backwards through the filter rectifier tube and finally the transformer. It is assumed, of course, that the 110-volt alternating current is known to be flowing through the transformer, and that the rectifier tube is not visibly damaged in any way.



An open-circuited or burnt-out resistor will result in no voltage from the tap it controls. If the 10,000-ohm fixed resistor becomes open, in the case of the B-power unit, the detector voltage will immediately increase so that in the tuned radio-frequency receiver the signal strength will be greatly diminished, while in the regenerative receiver there will be constant oscillation.

The simplest method to locate a defective resistor is by means of a high-resistance voltmeter, connected to each tap in turn. In fact, this device is essential in adjusting B-power voltages to any receiver, in place of the cut-and-try method. In the absence of this device, a 15-watt, 220 volt incandescent lamp may be employed. It should glow a dull red on the full output and on the intermediate of the B-power unit. If it lights equally bright on the detector tap, it is an indication of an open or defective 10,000 ohm fixed resistor.

If the tap voltages are found to be satisfactory, and the receiver still does not operate well, the trouble may be due to an open or an omitted by-pass condenser. A short-circuited by-pass condenser will act the same as a short-circuited resistor.

NO VOLTAGE AT ALL TERMINALS: This condition can be caused by an open circuit in the wiring, transformer, choke coils or by a broken-down filter condenser.

With power disconnected from the B-power unit and the Raytheon tube removed, a click should be heard in the testing telephone when connected in series with battery between plate terminal of rectifier socket and the +B of the B-power unit. A click should also be heard between either filament terminal of the rectifier socket and the —B of the B-power unit. These clicks should be of equal strength. If one filament terminal gives a much louder click than the other, it generally indicates a defective buffer condenser. If no click is heard on either filament terminal, then the transformer secondary is open-circuited, or the center tap of the transformer does not connect to the —B side as it should.

The circuit continuity of the transformer itself may be tested by the click between the two filament terminals of the rectifier socket, with tube removed. If the transformer secondary tests O. K. on the foregoing procedure, there must of necessity be an open circuit in the —B lead.

A short-circuit in the secondary of the transformer can be most easily checked by connecting a 25-watt, 110-volt lamp in series with the primary. The current is now turned on in the usual way, but with the rectifier or Raytheon tube removed from the socket. The incandescent lamp should glow dull, if at all. If it glows bright either the transformer secondary or one of the .1 mfd. condensers is broken down. With the lamp still in the primary, the rectifier tube is inserted in its socket. If the secondary connections are O.K., and the Raytheon is operative, the lamp will increase in brilliancy.

If the Raytheon becomes warm when the B-power unit is in operation, it is sufficient indication that the rectifier tube is operating. If there is any doubt about the proper functioning of the Raytheon, the simplest check is to replace it with a new Raytheon and note the results with the radio receiver left unchanged for a fair comparison.

EXCESSIVE HUM: This condition may be caused by an incorrect connection in the filter circuit, such as a condenser by-passing a choke coil. The hum should increase when either choke coil is short-circuited, in turn. If the hum does not increase, the circuit connections to that choke coil should be checked, and if found correct, then the choke coil should be replaced by another of similar characteristics. Make sure that one side of the A-battery is grounded.

IMPORTANCE OF HIGH-RESISTANCE VOLTMETER: Those desirous of operating a B-power unit or a Raytheon A-B-C radio power unit, as the case may be, should have a voltmeter whose resistance is at least 100,000 ohms, with a full-scale deflection of 200 or 250 volts. Such a meter will permit of adjusting the resistances for the proper output voltages when connected with a given radio receiver. Not only is this of great advantage when the initial installation is made, but it will later be of use in making adjustments to take care of line voltage fluctuations, etc.

Correct readings are impossible with the inexpensive, low-resistance type of voltmeter. A meter of this kind requires considerable current for its operation, and in a B-power unit, the considerable drain imposed by an inefficient voltmeter causes a drop in voltage, so that it is quite impossible to secure an accurate voltage reading.

MOTOR BOATING: Certain types of audio amplifiers when employed with a B-power unit develop troublesome audio oscillations which cause a fluttering in the loud speaker quite suggestive of a motor-boat engine, hence the term motor-boating in this connection.

Although this trouble is often thought to be due to poor filtering in the B-power unit such is not the case. B-bat-

teries will cause the same phenomenon on some amplifiers, particularly if a high impedance is in series with the battery. In general, this trouble can be remedied by an adjustment of the amplifying circuit. The manufacturer of the audio amplifier is usually in the best position to specify for the motor-boating.

Of the dozens of methods that have been used in the Raytheon Laboratory to eliminate this disturbance the three that have widest application are shown here. The "Change of Resistance Method" and the "Grid Impedance Method" are applicable only to resistance coupled amplifiers, while the "Filter Method" may be used on any amplifier.

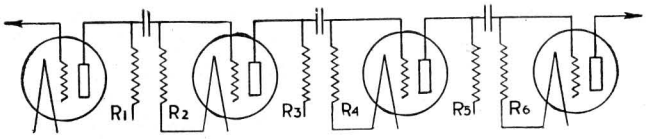


FIG. 2

CHANGE OF RESISTANCE METHOD: In the amplifier shown on the diagram (Fig. 2) first replace R_4 with a resistor of about 0.1 megohm. If this does not stop the motor-boating replace R_5 with a resistance of about twice its original value. Then try increasing the resistance of R_1 to as high as 1 megohm. This method will slightly decrease the volume.

GRID IMPEDANCE METHOD: Substitute a high impedance (the secondary of an old audio transformer does very well) for R_4. If this does not work replace R_4, and try the impedance in place of R_2. Then leave the impedance in place of R_2 and try a similar impedance in R_6.

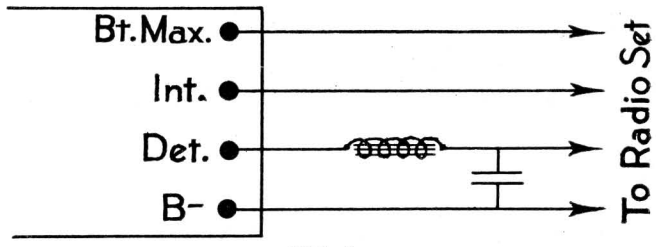


FIG. 3

FILTER METHOD: Put a small audio filter section in the detector lead from the power unit as indicated on the diagram, Fig. 3. If this is inadequate put a similar filter in the +B lead. In cases where the intermediate voltage tap is used for the audio amplifier it may be necessary to put a filter in this lead also. The choke coil should be of fairly low resistance (about 600 ohms or less) and of about 20 to 30 henries. The condenser should be of from 2 to 4 microfarads.