CQ Reviews: The Heathkit SB-200 Linear Amplifier

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THE Heathkit SB-200 Linear Amplifier has been around for quite a few years; nevertheless many requests are still being received for information on this piece of gear.

In view of this situation and inasmuch as *CQ* has never reviewed this table-top kilowatt job (mainly due to the fact that its forerunner, the Model HA-14 "KW Kompact" mobile version had already been covered[1]), we shall at this time discuss the SB-200.

This model is rated at 1200 watts p.e.p. input on s.s.b. and 1000 watts on c.w. which is available with 100 watts r.f. drive such as that obtained from the Heath SB-400/401 transmitter, the Heath SB-100/101 and HW-100 transceivers or other exciters in the same power class. This does not preclude its use with lower- or higher-power drivers as we will see later.

The SB-200 is a completely self-contained unit with a built-in power supply for operation from 120/240 v.a.c., 50/60 c.p.s. It is quite well compacted in a 6⅝" × 14⅞" × 13⅜" (H.W.D.) wrap-around cabinet with attractive styling to match the Heath SB-series of gear and thus makes a neat-looking job requiring relatively little desk space. It weighs 35 lbs.

Full coverage is obtained on the 3.5-30 mc amateur bands using bandswitched input and output circuits. The input impedance is nominally 52 ohms with broad-band pre-tuned-input circuits that need no tuning adjustment during operation.

The output is designed to work into 50/72-ohm impedances that present an s.w.r. within 2:1. This is realized with a Pi-network furnished with a variable loading control. A built-in reflectometer provides s.w.r. readings up to 3:1.

Details

Referring to the schematic diagram at fig. 1, the amplifier is an essentially grounded-grid affair and is operated in Class B using a pair of 572-B or T-160-L graphite-anode triodes connected in parallel.

R.f. drive is applied to the tube cathodes (filaments) through individual matching networks (pi or L types) tuned for each band. Use of such tuned circuits here ensures better efficiency with less distortion than with a passive input. RFC_1 is a bifilar-wound choke that maintains the tube filaments above r.f. ground and prevents the r.f.-drive power from being bypassed to ground through the filament-supply windings of the power transformer.

The Pi-network is made up using two inductors, L_1 and L_2. L_1 is tapped and is used alone for the 10- and 15-meter bands. L_2 is added for the other bands for which it is appropriately tapped. C_5 and C_6 are switched in only for 80-meter band operation.

The reflectometer is an in-line trough-line type. The panel meter can be switched to read the relative forward power (for which there is a sensitivity control) or the reflected power for which the meter is calibrated in terms of s.w.r. up to 3:1. The meter also can be switched to read 0-100 ma grid-current, 0-1000 ma plate current or 1500-3000 v. plate potential.

A.L.C.

The a.l.c. setup is a departure from the usual in that its operation is based on an *r.f.*

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[1] *CQ* Reviews: The Heathkit HA-14 "KW Kompact" Linear Amplifier, *CQ*, February 1966, page 52.

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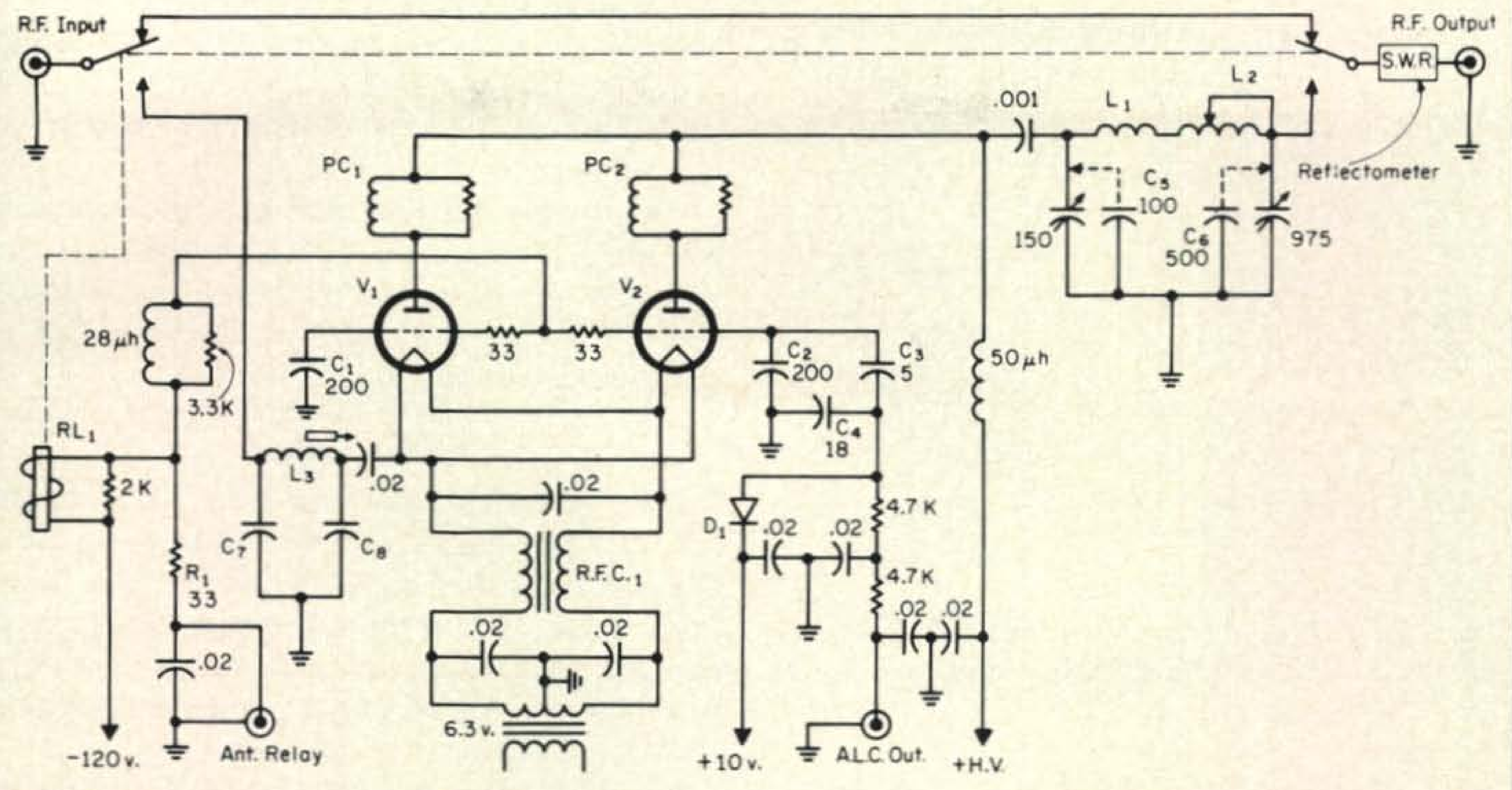


Fig. 1—Schematic for the SB-200 amplifier (power-supply and metering circuits not shown). The bandswitch alters L_3, C_7 and C_8 to form impedance-matching Pi or L input networks for the various bands. Other details are in the text.

voltage, rather than on an *a.f.* voltage that is developed during modulation when an amplifier starts to overload or draw grid current.

As shown at the schematic, the tube grids are not heavily bypassed to ground (by C_1-C_2 and some r.f. voltage thus appears at the grids. C_3 and C_4 comprise a voltage divider across the grid of V_2 from which a sample voltage is derived and rectified by D_1. The resulting d.c. voltage provides the automatic bias for reducing the gain of the a.l.c.-controlled stage in the exciter.

D_1 is reverse-biased into non-conduction by an a.l.c. *threshold* potential of +10 volts applied to its cathode from a tap on the plate-supply bleeder. When the r.f. voltage applied to D_1's anode exceeds 10 volts, the diode conducts and rectifies the r.f. to supply the necessary d.c. voltage for the a.l.c.

The threshold has been set for a.l.c. operation at the instant the r.f. voltage at the tube grids reaches the point just below that which occurs when the tubes are overdriven.

The advantage of this arrangement, over the conventional system, is that a.l.c. operation is not dependent on *some* overdrive before it takes hold, thus allowing it to be effective prior to the occurrence of *any* flat-topping or overdrive.

Since the a.l.c. is not dependent on an a.f. component during modulation, the a.l.c. voltage can be produced even with steady-state or c.w. drive.

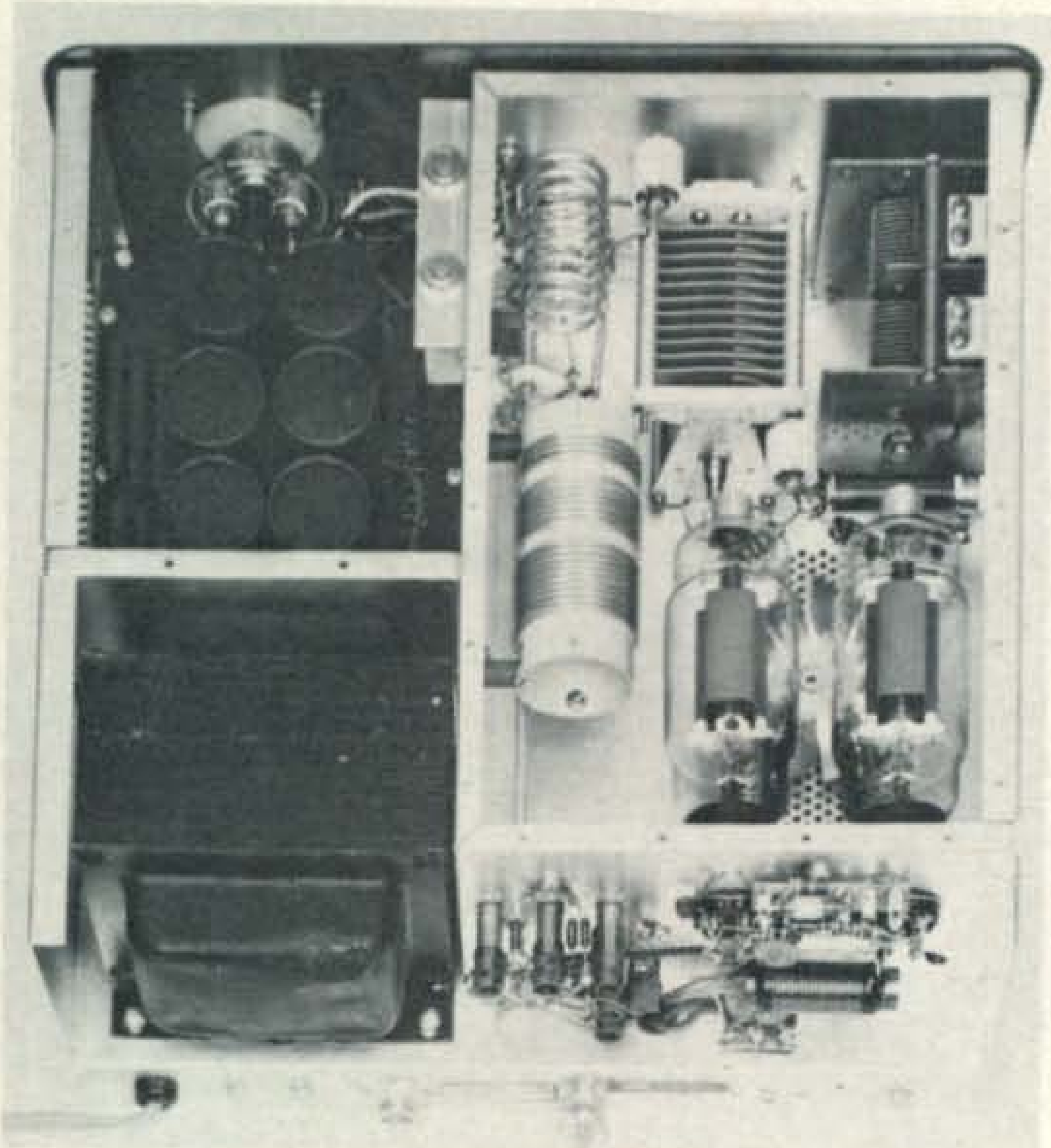
Transfer Circuits

The r.f. circuits are switched with a d.p.d.t. antenna-changeover relay which is operated by the v.o.x. relay in the exciter. Operation is as follows: During receive, a bias of −120 volts is applied to the tube grids through the relay coil. The bias cuts off the plate current, eliminating the possibility of the generation of hash within the tube that might be heard in the receiver.

During this time the relay is not energized, because the exciter-relay contacts are not closed, nor do the tube grids draw current through the relay coil. Under this condition, the antenna is connected, through the normally-closed relay contacts, to the antenna terminal of the exciter if it is a transceiver; or to the antenna-connector of a separate transfer relay that would normally be used with a receiver-transmitter setup. This allows signals to be received.

On transmit, the contacts on the exciter v.o.x. relay ground the top end of the amplifier-relay coil through R_1, energizing the relay from the −120-volt bias source. The normally open contacts then close, connecting the exciter-setup output to the r.f. input of the linear and transferring the antenna to the linear's output.

At the same time, the resistance of the



Top view of the SB-200. Enclosure for power-supply components is at upper left with circuit-breakers on its right wall. The amplifier enclosure is at the right. The input networks are in the center foreground with the bifilar filament choke below the tube sockets at the right. A perforated cover fits over the enclosures.

relay coil and R_1 form a voltage divider so proportioned that the current drawn through the circuit produces a drop of 2 volts across R_1. This appears as a negative voltage at the tube grids and thus provides operating bias for the amplifier tubes.

When the power switch on the SB-200 is turned off, there is no bias voltage to operate the changeover relay, so the antenna remains connected directed to the exciter setup for normal low-power operation without the linear.

The amplifier tubes have instantaneous-heating filaments, so along with the use of solid-state rectifiers in the power supply which also are instantaneously-performing devices, linear-amplifier operation may be had as soon as the power switch is turned on, making it possible to instantaneously switch back and forth between low power from the exciter alone or high power from the amplifier.

Power Supply

Operating power is obtained from a single transformer that has three secondary windings; one for 6.3-volt filament power, one for a −120-volt bias source and one for a plate supply of 2500 volts. A full-wave voltage doubler, consisting of eight silicon diodes in each leg, is used for the latter along with 21 mf of filter capacitance provided by six 125 mfd, 450 v., electrolytic capacitors connected in series. Voltage-equalizing resistors are installed across the capacitors. They also serve as a bleeder.

The power transformer has two primary windings that are connected in parallel for 120-volt operation, or in series for 240-volt operation. An 8-ampere circuit breaker is installed in one leg of each winding.

Construction

The SB-200 is assembled on a chassis on top of which are two shielded compartments. One encloses the amplifier proper, the tubes for which are mounted horizontally in a manner that eliminates the possibility of a grid-filament short due to filament sagging that could occur after long use.

A small motor-driven fan is located beneath the tubes and provides cooling by blowing air upwards against the portion of each tube envelope opposite the tube plate. Perforations on the chassis deck and in the enclosure cover and the amplifier cabinet provide an air-flow path for cool-air intake and warm-air exhaust. The fan goes on or off when the power switch is operated.

The variable capacitors for the pi-output circuit are ceramic-insulated. The one for loading is a two-gang job somewhat huskier than the usual t.r.f. receiving type. The plate-tuning capacitor is a wide-spaced high-voltage type. L_1 is a self-supporting inductor wound with #10 wire, L_2 is wound with #14 wire on a fiberglass form.

The tuned circuits for the cathode input are installed on the rear of the amplifier compartment on which the tube sockets also are located. Slug-tuned inductors are used along with mica fixed capacitors.

The bifilar filament choke is wound with #14 wire on a ferrite core, the use of which cuts down the number of turns otherwise required, raising the Q and holding down the wire resistance for a minimum filament voltage drop.

The bandswitch employs ceramic-insulated sections. Those for the output tank have dual contacts for adequately handling the r.f. current at the high power levels involved.

Except for the transformer, the power-supply components are located in a second enclosure and are assembled on a printed-circuit board. The circuit breakers are mounted on one wall of this enclosure in a way that allows them to be handily reset

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through access holes when the hinged cover of the cabinet is raised.

The reflectometer is located beneath the chassis and on the inside of the rear apron. It is built in a U-shaped metal trough with the transmission line conductor and the pick-up wires held in place by nylon spacers. One side of the trough is open which, together with the fact that the antenna relay also is exposed under the chassis (as is a long unshielded lead below the chassis between the bandswitch and the loading capacitor), might allow sufficient r.f. to be induced into power leads to cause TVI, even through the external leads are bypassed. The job otherwise is pretty well boxed in with shielding to minimize the possibility of TVI difficulties.

Assembly

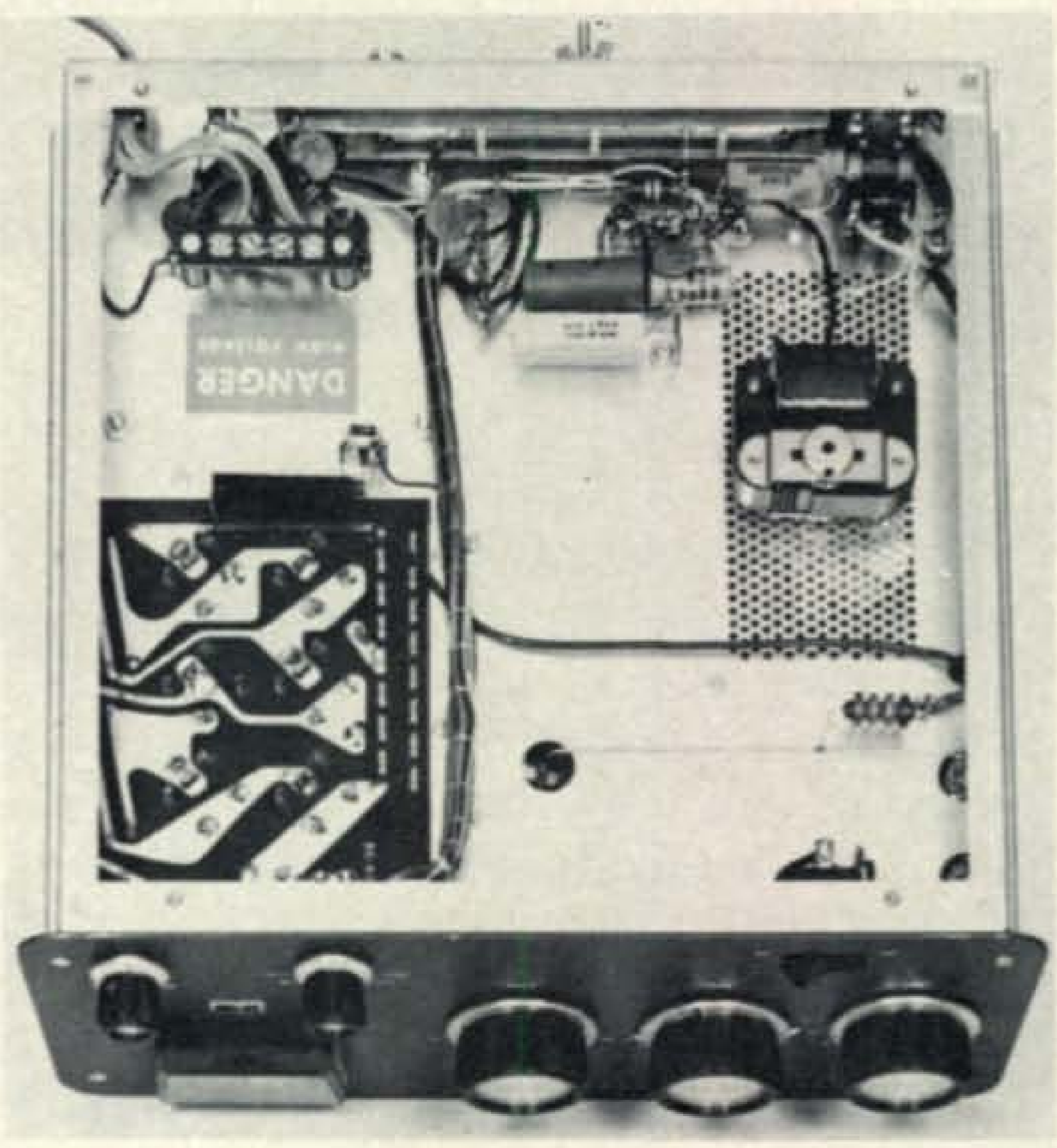
No problems were encountered with the assembly work, thanks to Heath's standardized easy-to-follow instructions and procedures. Upon its completion, the amplifier functioned properly in all respects "right off the bat." A total of 12 hours was required to do the job; however, for a less experienced builder, 15 hours or so may be needed.

Operation

Tuneup is a simple procedure during which time you don't have to hurry the adjustments or worry about burning up the tube grids as sometimes is the case with high-power rigs. Furthermore, the range of the tuning controls is so proportioned that the adjustments are rather broad, thus making them noncritical.

With the linear turned off, the exciter is tuned up for maximum output in the normal manner. With such drive applied, you then close the amplifier's power switch and adjust its plate and loading controls for maximum r.f. output as indicated by the meter which is first set for relative-power readings. You're now ready to go with high- or low-power transmissions available simply by flipping the SB-200 power switch on or off (this switch is a rocker type).

During initial tuneup with the exciter alone, it is best to check the s.w.r. of the load before turning on the linear, to make sure the load presented to the amplifier will fall within the 2:1 matching range of the linear amplifier. This is especially important for proper loading as described later. If needed, the s.w.r., as *seen by the amplifier,* often can be brought down by altering the length of the transmission line accordingly.



Bottom view of the SB-200. The printed-circuit board for power-supply parts it at the lower left. The reflectometer trough is at the center of the rear apron. The blower motor is near right center.

It also may be found that the tuning of the exciter may be slightly off when the amplifier is turned on, because the s.w.r. (or reflected impedance) seen by the exciter will vary btween 1:1 and 3:1 due to the fact that there is a variation in the nominal input impedance of the amplifier, depending on the band, and the portion of the band used. The reflected impedance also will change with various line lengths between the two units. In some cases, slightly retouching the exciter tuning may be needed.

Performance

With a monitored 100 watts of steady-state drive and with a power-line potential of 120 or 240 volts, measured under load, the plate-power input of the SB-200 at full tune-up amounted to 1150 watts with an r.f. output of 775 watts. This was essentially the same on all bands. With 100 watts of s.s.b. p.e.p. drive, the power input and r.f. output were 10% higher, thus adequately fulfilling the rating of 1200 watts p.e.p. input.

Under these conditions an oscilloscope trapezoid display indicated excellent linearity; while observations on a spectrum analyzer showed the 3rd-order distortion products to be within Heath's specification of −30 db relative to 1000 watts p.e.p. input. Actually, this was a limitation imposed by the exciter used at the time. The 5th-order product was −45 db.

With 200 watts drive, the amplifier could be pushed to 1500 watts input with 1000 watts output. With s.s.b. peak power at these levels, flattopping was not evidenced, except for only a slight tendency to round off the peak of a trapezoid display. At the same time, a spectrum analysis showed the 5th-order product to rise to near the 3rd-order level which itself did not change significantly.

At these higher-power levels, no evidence of excessive tube heating or deterioration was found after periods of on-the-air operation with s.s.b. or during rigid bench tests; nevertheless, it must be kept in mind that such operation exceeds Heath's specifications and recommended power levels, as well as the tube ratings. In this respect, Heath's specifications call for a maximum p.e.p. input of 1200 watts (with 100 watts drive) using continuous voice modulation on s.s.b.; while for c.w. the input is rated at 1000 watts with a 50-percent duty cycle (key-down time not to exceed 5 minutes).

With low-drive levels of 45-50 watts, such as obtainable from the Heath HW-16 c.w. transceiver, the amplifier will put out 450-500 watts. From the power levels given herein, it may be noted that the apparent gain in power output decreases with drive levels (from 10 db with low drive to 7 db with high drive). This is primarily due to feedthrough of the r.f.-drive power which bears a smaller ratio to the power produced by the amplifier itself at high drive levels than with lower drive.

In order to maintain good linearity, particularly with high-power drive levels, during tuneup the amplifier must be loaded to beyond the maximum-output point; that is, past this spot to where the output starts to drop off. This also will be indicated by a very broad or hardly noticeable plate-current dip at resonance. The plate current under these conditions may be higher than recommended in the manual; however, the tubes will take it, at least during s.s.b. operation.

Insufficient loading can result in flattopping or other deteriorating effects with high peak levels, especially on the 40-, 20- and 10-meter bands where the tank impedance for high peak levels apparently is not quite as favorable as on 80 and 15. As a matter of fact, it was found that with proper loading as just described, use of the a.l.c. was not required, since no flattopping or other bad effects show up, especially at the recommended power levels.

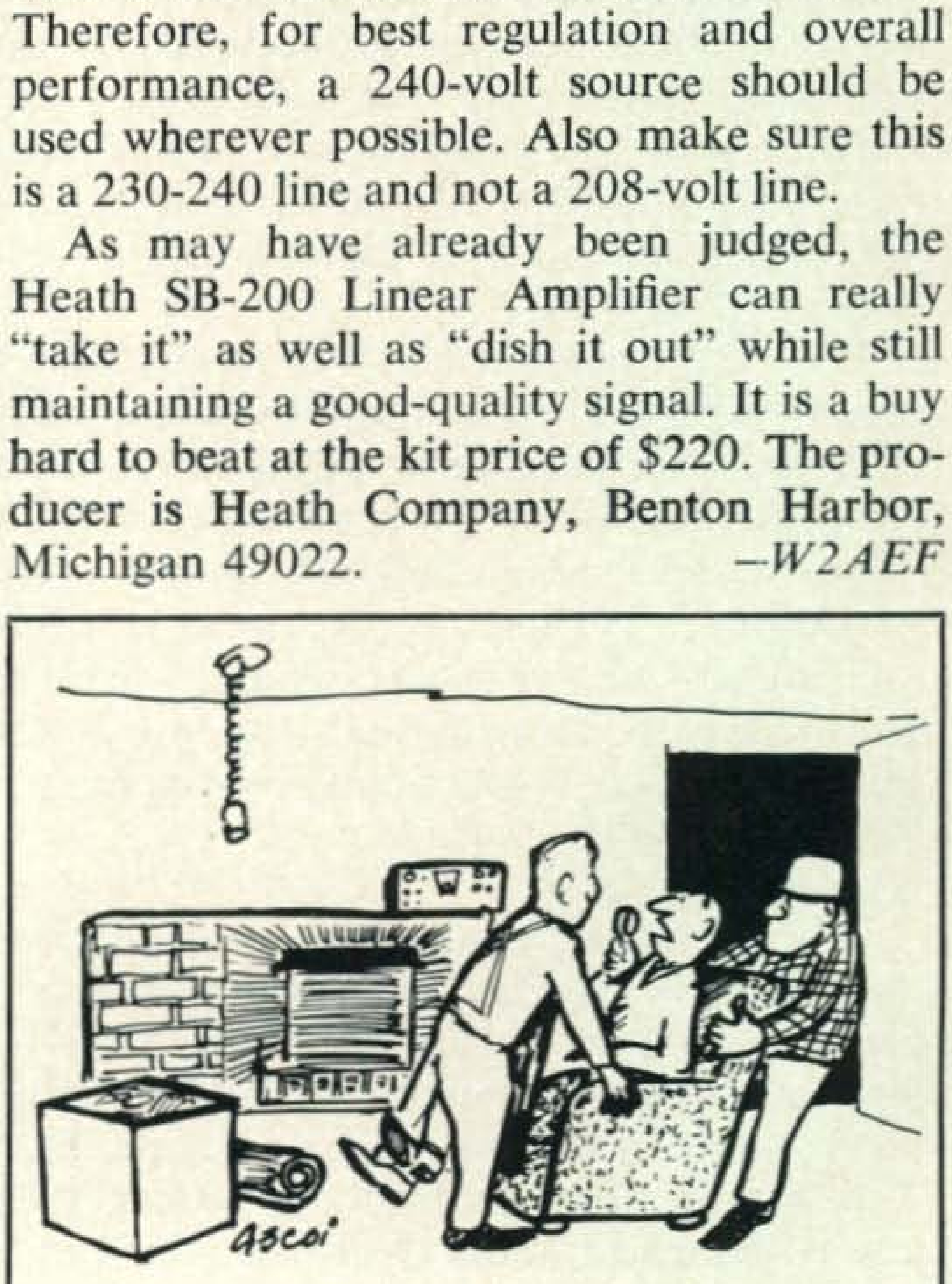
On the other hand, where the exciter delivers more than 150-200 watts, the use of a.l.c. would be desirable to limit the drive. Such exciters usually will require a higher a.l.c. voltage than that normally provided by the SB-200. This may be realized by reducing the a.l.c. threshold which can be done by connecting the cathode of D_1 to ground, instead of to the 10-volt tap on the power-supply bleeder.

Adjustments both for optimum loading and a.l.c. operation are best made while observing a trapezoid display on an oscilloscope (such as the Heath HO-10 or SB-610 Monitor-scopes) by sampling both the r.f. input and output of the amplifier. Either a two-tone test signal may be used or speaking into the microphone will suffice.

Observations thereby can be much more accurately and easily made than with an r.f.-envelope display. Furthermore, with the trapezoid display obtained as described, you're looking at only the amplifier performance towards its proper adjustment, thus eliminating possible confusion with the exciter preformance as could otherwise be the case with an r.f.-envelope display.

One final admonition–with a 120-volt supply line the amplifier draws up to 16 a.; while with a 240-volt source the current is 8 a. Therefore, for best regulation and overall performance, a 240-volt source should be used wherever possible. Also make sure this is a 230-240 line and not a 208-volt line.

As may have already been judged, the Heath SB-200 Linear Amplifier can really "take it" as well as "dish it out" while still maintaining a good-quality signal. It is a buy hard to beat at the kit price of $220. The producer is Heath Company, Benton Harbor, Michigan 49022. *–W2AEF*



"Actually you'll be the last QSO from this QTH..."

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