



CQ Reviews:

The Henry 2K

Linear Amplifier

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HAVING heard a lot about the Henry 2K-2 Linear Amplifier, we made a special effort to get hold of one to find out about it first hand. Happily, we were not disappointed, inasmuch as here is not only a solidly-built and efficient powerhouse with a good 2 kw p.e.p. input, but it also is one with excellent linearity and comparatively low intermodulation distortion. This is all realized through the use of two 3-400Z zero-bias triodes operating in parallel in a grounded-grid circuit with a tuned input for the cathodes.

The 2K-2 is a floor-console model in which the amplifier is installed at the top of the cabinet which houses a really husky power supply. Operation may be had throughout the 3.5-28 mc amateur bands using s.s.b., a.m.

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c.w. or RTTY. It also may be set up for use on frequencies outside of the ham bands.

Other features include: full-time plate meter and a separate multimeter for other readings; built-in s.w.r. bridge indicating forward and reflected relative power; instant operation (no delay required for warmup); immediate transfer between linear-amplifier operation or direct feedthrough from exciter alone; electrical and mechanical interlocks for safety of operating personnel; equipment protection with circuit breakers, fuses or overload relay; Pi-L output network adjustable with plate-tuning and loading controls equipped with illuminated dials, squirrel-cage type air blower; silicon rectifiers; choke-input filter with high-capacitance output; excellent dynamic voltage regulation; operation from 115 or 230 v.a.c., 50-60 c.p.s.; oversize com-

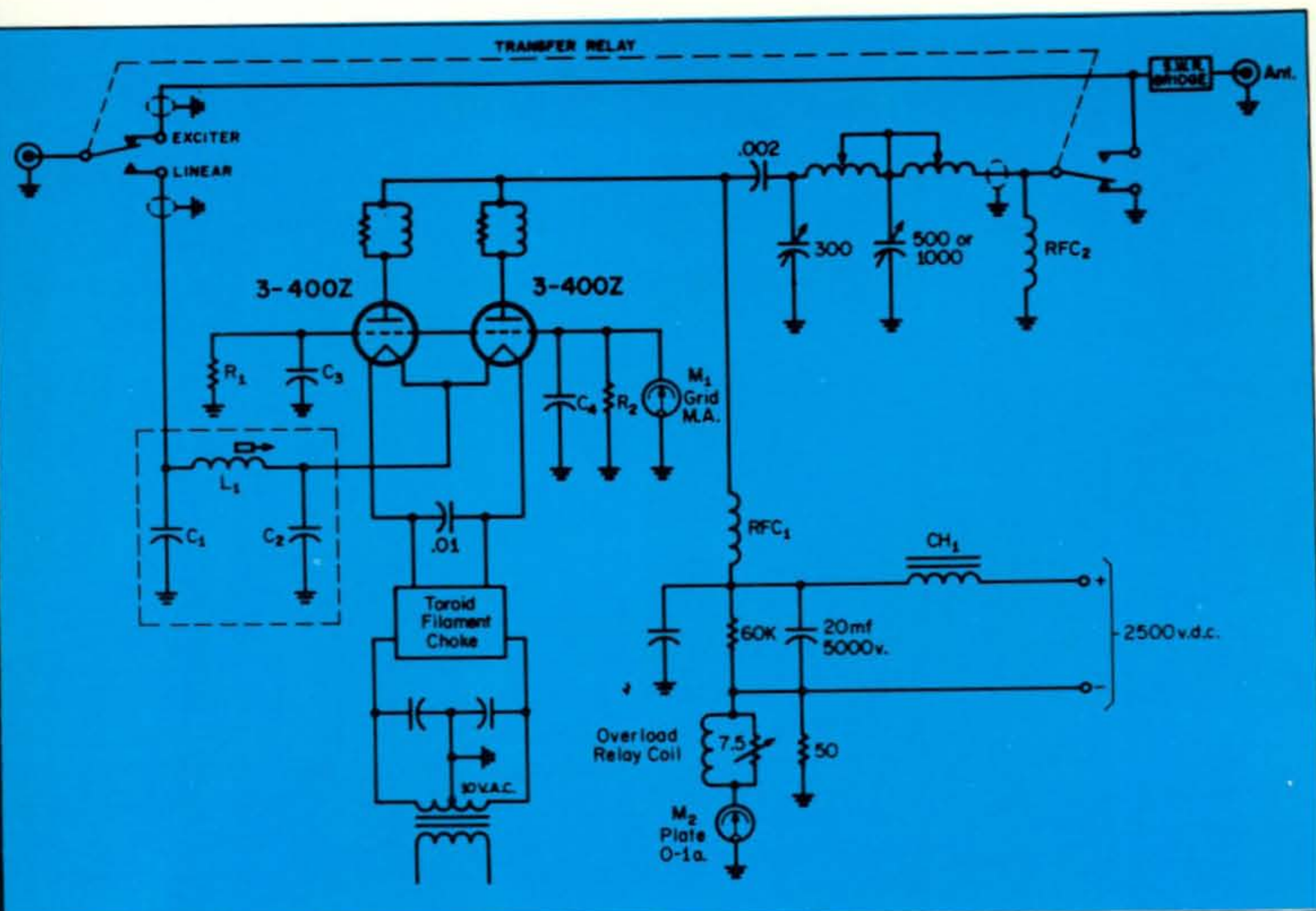


Fig. 1—Basic circuitry for the 2K-2 amplifier. Different modules for the various bands are switched in for the input Pi-section L_1 , C_1 - C_2 . The r.f. excitation is applied to the mid point of the series-connected filaments. C_3 - C_4 are .027 mf and R_1 - R_2 are about 1.7 ohms (see text). Multimeter, M_1 , is shown connected for grid current only.

ponents; rugged commercial-type construction.

Circuit Details

Referring to fig. 1, excitation is applied to the cathodes (filament) of the tubes through a fixed-tuned Pi-network that has a 50-ohm input impedance. Separate networks are used for each band and are sufficiently broadbanded to cover each range without retuning. They are contained in individual shielded nodules. The advantages of the tuned-cathode input over an untuned affair is that the amplifier is easier to drive and the distortion products can be held to a lower level.¹

The tube cathodes are maintained above r.f. ground by a bifilar toroid-wound choke in each leg of the filament supply. The power requirements for the filament of each tube are 10 volts @ 15 amperes; however, the filaments for the two tubes are connected in series across a 10-volt supply, so the total current is maintained at 15 amperes, rather than 30

amperes as would the case with a parallel connection for 5 volts. The lower current requirement thus eliminates the need for extra-large connecting leads, reduces heating in conductors or at certain connections and places less stringent requirements electrically and physically on the toroid filament choke and the power transformer.

In order to provide a means for reading grid current while maintaining freedom from instability that might be caused by parasitics, the grids are maintained at r.f. ground through a minimum amount of reactance using two 10-ohm composition resistors at each of the three grid terminals for each tube and with three .003 mf bypasses at the same points.¹ There are 12 resistors all told and since they are in parallel, the total resistance is about 0.8 ohms, the voltage drop across which, as a result of grid-current flow, is indicated by the meter calibrated in terms of current. Stability is further enhanced with a parasitic suppressor at each tube plate.

The Pi-L output tank facilitates an optimum impedance match to the tubes and im-

¹ Orr, Rinaudo, Sutherland, "The Grounded-Grid Linear Amplifier," *QST*, Aug. '61, page 16.

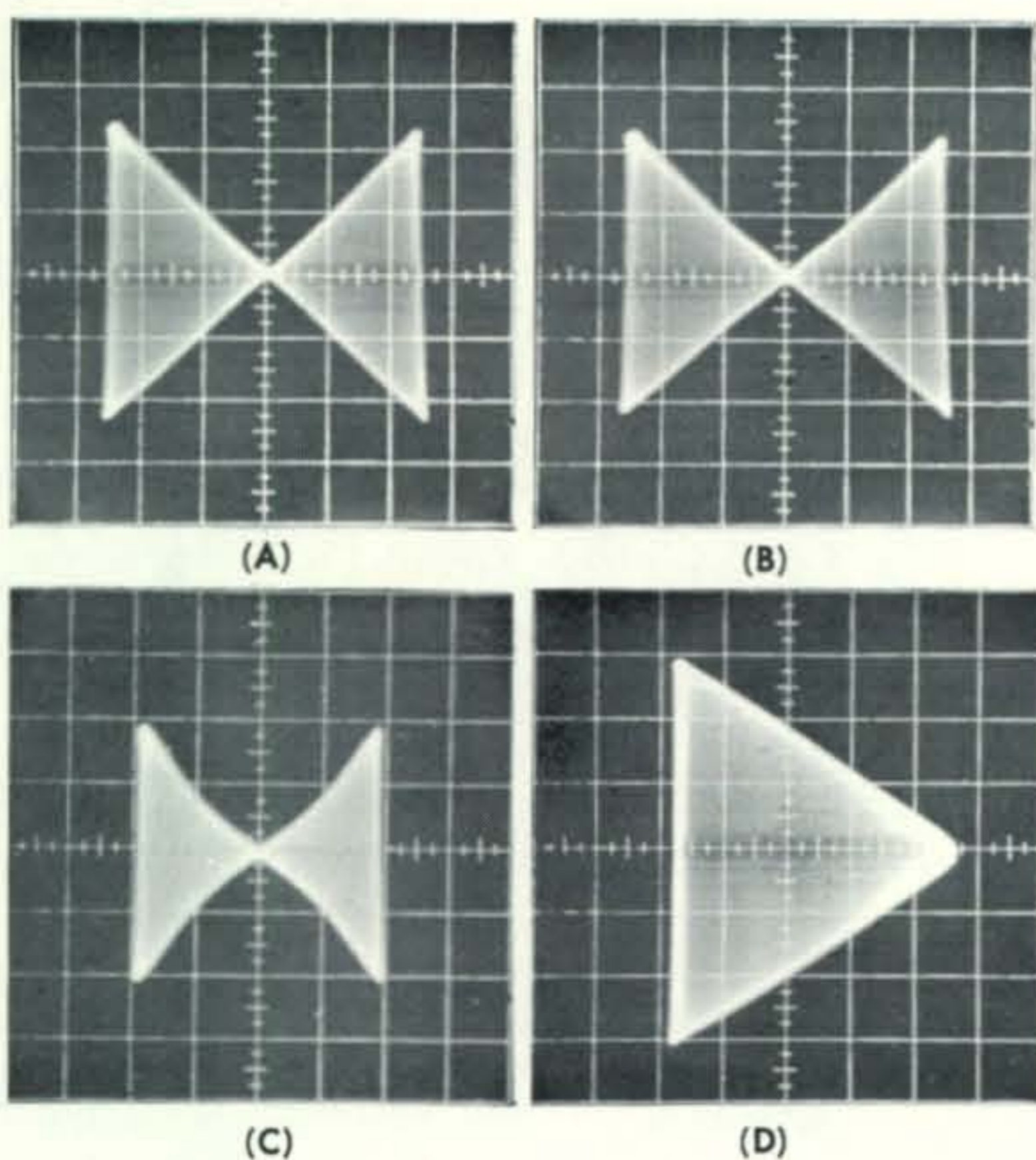


Fig. 2—Oscilloscope displays for linearity. A—Bow-tie pattern of exciter alone. B—Bow-tie pattern of exciter plus the 2K-2 amplifier with 2 kw p.e.p. input. C—Same exciter with another popular "linear" of the same rating as the 2K-2. D—Trapezoid display of the 2K-2 alone. Note the good linearity indicated by the straight slopes as compared to the non-linearity indicated by the curvature at C.

proves harmonic attenuation. The inductors are tapped for the various bands. Included are two separate taps for the 3.5 mc band to optimize operation in either the 75 or 80 meter region. For the latter section, an additional loading capacitor is switched in. All the network capacitors are heavy-duty variables with large plate spacing. Inductors and r.f. connecting straps are silver-plated.

Power Supply

Plate power is obtained from a 2500 v.d.c. supply which employs four silicon diodes in a full-wave bridge circuit. High dynamic voltage regulation is maintained by a choke-input filter with a 20 mf output capacitor which is a husky 5000-volt job in contrast to a string of series-connected 1.v. electrolytic capacitors often employed as an inexpensive expedient. Likewise, a comparatively low-resistance (high-wattage) bleeder is used in place of a high value, thus permitting the filter capacitor to discharge relatively fast when power is removed.

Filament voltage is obtained from a second winding on the transformer which has two

individual primaries that can be parallel or series connected for operation from 115 or 230 v.a.c. respectively.

A separate transformer provides 12 v.d.c. through a full-wave center-tapped silicon rectifier, for relay operation. Voltage for the indicating lamps also is taken from this transformer. Power for the air blower is obtained from across one of the 115-volt primaries of the main transformer.

Protective Circuits

Equipment protection is provided by a 15 ampere circuit breaker for each primary winding on the large transformer, separate fuses for the blower and for the relay supply and an overload relay in the p.a. cathode d.c. return. Personnel protection is furnished with two electrical interlocks which open the solenoid circuit of the power-on relay when either the power-supply door or the amplifier cover is opened. Similarly located mechanical switches at the same time short-circuit the h.v. line to ground.

Metering

The plate meter, which operates full time is located in the negative return, for the h.v. supply. Should a short to ground occur across the h.v. line, either by one of the grounding switches or some other cause, the meter therefore could be damaged, but to avoid the possibility, it is protected with a 1½ ampere fuse.

A second meter functions as a "multimeter" that can be switched to read plate voltage, grid current and forward or reflected relative power from the s.w.r. bridge which the conventional trough-type reflectometer

Transfer Circuits

When de-energized, the transfer relay connects the r.f. input jack directly to the antenna through normally-closed contacts for operation with the exciter alone. This relay is arranged to be controlled by auxiliary contacts (open on receive, grounded on transmit) of the exciter relay, but it will not be energized until the linear's line power has been applied to furnish the necessary relay voltage. When this is done, the tube filaments also go on as well as the plate voltage and the energized relay transfers the r.f. input to the linear input and the antenna to the linear output.

Switching the amplifier power on or off

thus transfers operation between the linear or exciter alone, respectively, whenever the exciter itself is activated. Since the 3-400Z's have instant-heating filaments and since silicon rectifiers are used in the power supply, no warmup time is needed and transfer to either type operation can be made immediately.

Operation

The normal procedure for tuneup is to first adjust the exciter for proper operation while the linear is turned off, also making sure the s.w.r. of the load is under 2.5:1 as indicated by the s.w.r. bridge.

The linear is then turned on and with low drive from the exciter² is quickly adjusted with the plate tuning control for a minimum plate-current dip as the loading is simultaneously adjusted for a 400 ma reading at this point. After this has been achieved, full drive is momentarily applied to check for a plate current of 800 ma. If a lower current is indicated, the drive must again be reduced to the amount specified for tuneup and the loading increased for slightly above 400 ma, with a check again made at full drive.

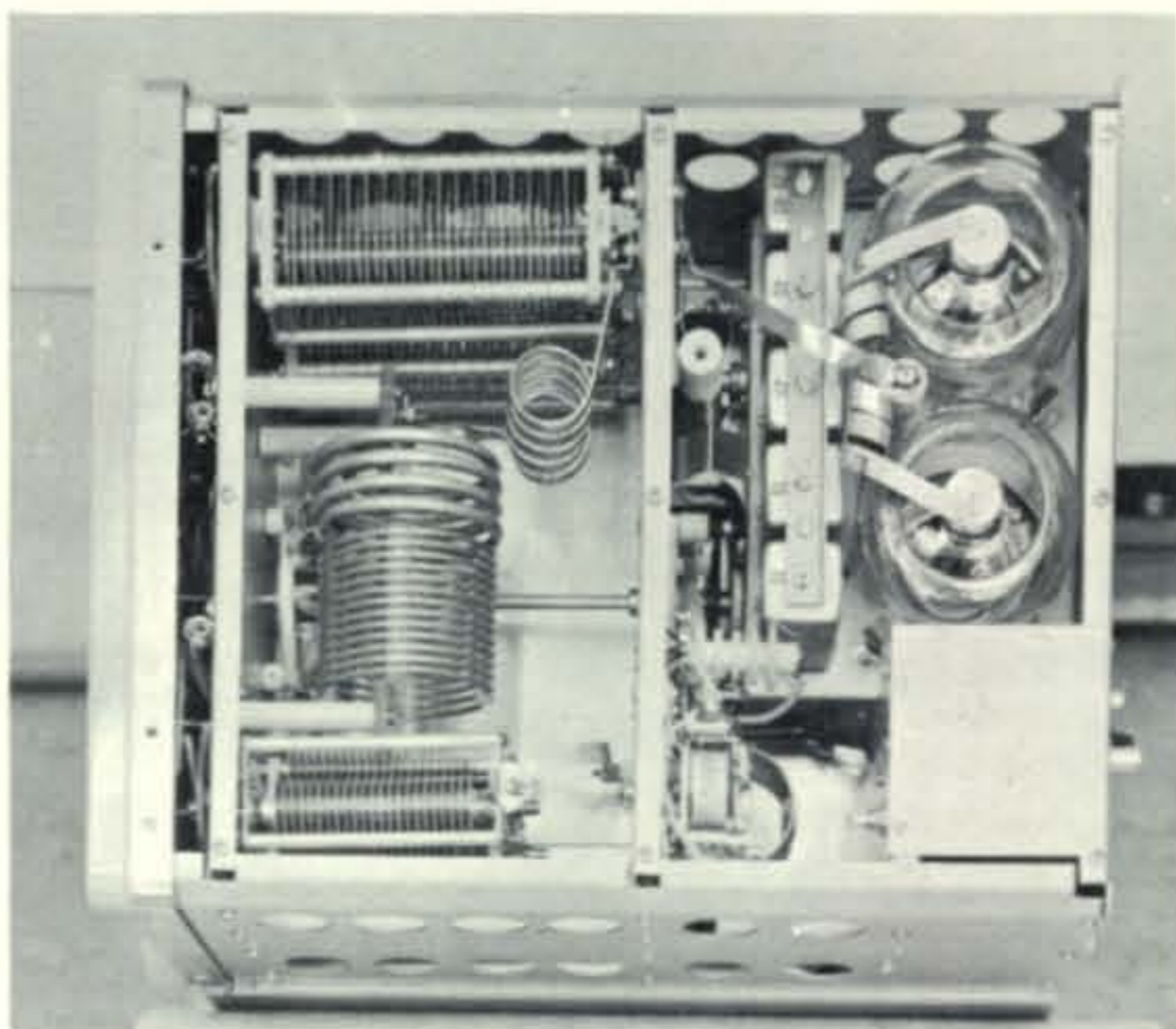
In order to avoid tube damage during the process, resonance must be *quickly* established as indicated by the plate-current dip. Also, the initial tuneup should *always* be done with low drive. Under this condition, the plate dip may be somewhat broad or sluggish near the proper loading point and may necessitate a slight reduction in loading, before the dip is clearly defined.

Another point to keep in mind is that the progression of the dial calibrations for the loading control is backwards as far as minimum and maximum loading goes. Minimum loading is at the *high*-numbered end, maximum loading at the *low*-numbered end.

From our experience with the unit, it was found quicker and safer to set the drive as specified and quickly switch to the forward-power meter and tune for maximum output with the rated tuneup plate current, following which the check can similarly be made with full drive.

Another procedure, particularly desirable for determining optimum loading, is to apply two-tone a.f. signal to the exciter, tune up with low drive and then with full drive, *gradually* make final adjustments for maximum

² For 100-125 ma linear grid current. Exciter output usually may be varied by a carrier, exciter-grid or carrier-balance controls.



Interior view of the 2K-2's amplifier. Heavy straps are used for the parasitic chokes at the tube plates. The five cans alongside the tubes are the Pi-input modules. The box next to the tubes contains the s.w.r. bridge and resistors for the meter circuits. The r.f. transfer relay is next to the pi-wound choke (RFC₂), below it is the L-output inductor. The 10-meter Pi-inductor is wound with 3/8" strap and 1/4" tubing is used for the sections added for 15 and 20 meters. Large-spaced variable capacitors are used in the output circuit. A perforated shield fits on top of the unit which is then enclosed in a wrap-around cover.

peak output with best linearity and without flattopping as indicated by an envelope or trapezoid display with an oscilloscope at the linear output. As a matter of fact, this is a preferred method of tuning up *any* linear amplifier for proper operation.

In any event, it cannot be stressed too strongly that during tuneup, the plate should first be quickly resonated and maintained as near as possible thereat while the loading is simultaneously adjusted. In addition, correct loading is a *must* for proper operation with maximum p.e.p. Although both procedures require meticulous care, it is well worth it for the high-quality performance that is possible.

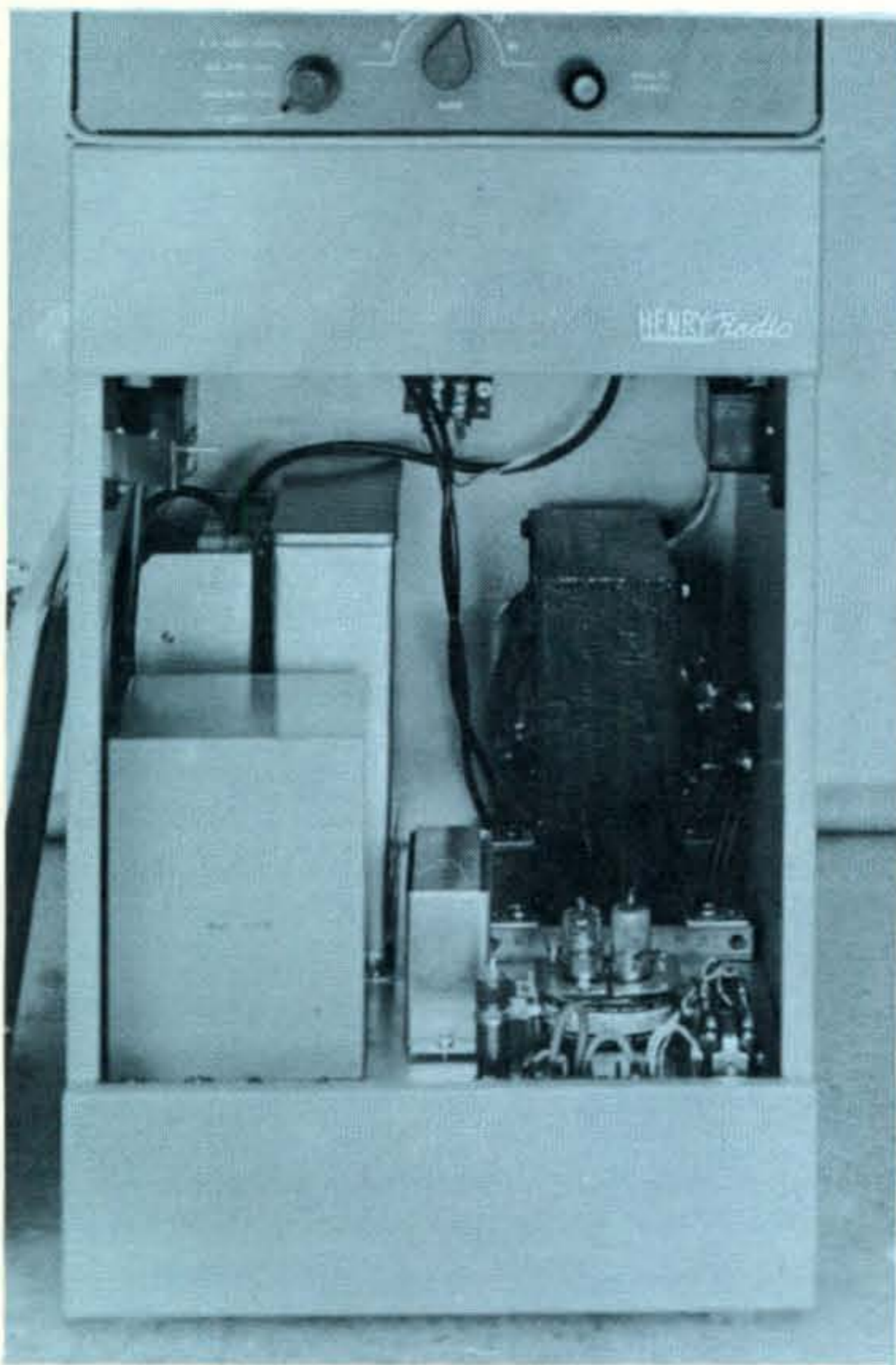
Performance

It was found that with a line potential of 230 volts under load, the d.c. input with 110 watts drive was 2000 watts, while the r.f. output was 1400 watts. P.e.p. with voice modulation ran up to 2.2 kw input with 1530 watts output.^{3,4}

³ About 5% less on 10 and 15 meters. Output includes drive power.

⁴ With other line voltages, power will vary by a percentage equal to about twice the percentage of line-voltage difference from 230 volts.

⁵ Not taking into consideration the drive power.



The Henry 2K-2 Linear Amplifier Floor Console. Interior view of the 2K-2 power-supply section. The power transformer is at the right rear in front of which may be seen the glass envelopes for the mercury contacts of the power relay. The filter choke is encased at the left foreground. The filter capacitor is at the rear. The mechanical grounding switch for the h.v. is at the upper left corner.

Under these conditions it was noted that the plate meter does not kick up to 400 ma as would be indicative of the maximum legal 1 kw⁵ (400 ma × 2500 v.) meter reading with modulation. Due to this slow meter action, peaks of 400 ma usually are not possible with normal voice operation and for this reason the 2K-2 has an erroneous and unfortunate reputation of requiring a great deal of drive; however, the maximum p.e.p., as noted above, is possible with plate meter peaks of 300 ma. Operation above this point not only may exceed the legal average input but also may overdrive the amplifier as is best determined with oscilloscope observations.

As for distortion products, the 3rd order ones averaged -35 db with 2 kw p.e.p. input on all bands, with higher-order products proportionately lower. The excellent linearity is

demonstrated by the oscilloscope displays at fig. 2.

The addition of the L-section to the Pi network and the extensive shielding and bypassing contributes much to the reduction of r.f. harmonic production, as was evident by the relatively little TVI experienced on a nearby TV set with the linear in operation.

Although special care must be exercised during tuneup, once this is properly executed, the tubes run within their dissipation rating, even at full d.c. input, as may be evidenced by the color of the tantalum plates in the tubes which remain below the bright orange range that is indicative of maximum dissipation. With modulation the tubes just load along.

The 2K-2 can be operated at 2 kw input with c.w. or RTTY, but to remain within the legal limit, the input power must be reduced as explained in the manual, in which case the output is approximately 600 watts. Conventional a.m. operation (d.s.b. with carrier) also must be held within the legal carrier input, in which mode the carrier output is near 350 watts with 1400 watts p.e.p. output at 100 per cent modulation.

There are no provisions for a.l.c., so when an exciter is capable of delivering more than 100 watts p.e.p., the possibility of overdriving the amplifier must be minimized by proper monitoring with the plate meter or an oscilloscope.

It is interesting to note that the line of Henry Radio gear, such as the 2K-2 along with higher-power versions, is fast finding its way into the commercial and military field which speaks well for its performance, quality construction and dependability.

The size of the Henry 2K-2 is 29½" × 14" × 17½" (H.W.D.) and it weighs 12 pounds. The price tag is \$675. Another model, the 2K-3 which was announced after this review was prepared, is identical, except for the use of two 3-500Z tubes for 200 watt greater plate dissipation and corresponding higher-power capabilities (about 1 db worth). Price is \$745. The manufacturer is Henry Radio, 11240 W. Olympic Blvd., Los Angeles 64, California.—W2AEF

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