1. Summary

R&H 1948 Williamson amp. Peter Stinson July 2023

R&H March 1948. Prices Radio Kit (R&H May 1949)
Possibly made and sold by Ted Huckell (Radio)

As originally transferred, with additional rectifier for preamp/etc supply.

PT RED LINE Stock No.13 (15403) 400-0-400V 150mA (102+108Ω). Com-200-230-240 (12Ω); Shield. 2.5V 5A heater not used. 5V 3A. 6V3 3A. Pri: 350M 1kVdc. Sec: 180M 1kVdc. 5V 240M 1kVdc
OPT RED LINE AF15 10k: 15 DCR=255+252
Choke RED LINE TYPE NO 201?1?. DCR=234. 90M 1kVdc. 9200
10Vac: 13.9H 51mAdc; 13.4H 79mAdc.
Choke Rola type 14/60 – replacement, 2 JUL 1959. DCR=520. 350M 1kVdc

807 Philips 874 on mica - loose base
807 Philips 974 on mica
6SN7GT RCA VT-231 H5E
6SN7GT KEN-RAD 8C961A
5U4G RCA 722

Morganite 488 LHNAR 25k. insulated 1kV IR (32k).
200R pot CRL USA (212R) – retrofit
250R large pot – Federal No.24 – wiper shaft live to wiper, with plastic tube cover

Ducon e-caps dated 110, 90, 46, 86
Mustards B4H, 091H, B4H, 091H
47nF mustard 400V couplings 091H.
47nF 630V mustard couplings 84N.

IRC DCF resistors 713S , 718S
IRC 101Ω 5W AB2% (103R) ; 5%AB (102R) – these appear to be retrofitted.
IRC 250R 3W 5%AA (268R)

Notes:
- first filter from 2x series 16uF 600VP with 1M 1W balances (not 8uF and 250k)
- then choke, then single 16uF 600VP to B+ OPT, then ROLA choke.
- 5 pin rear panel socket with no wiring, and nearby 16uF 600VP with 1M bleed.
- Rola choke appears to be a replacement.
- 8-pin octal socket on top panel with no wiring.
- 5k f/b to 500R cathode with 15 ohm config.
- OPT with separate anode leads/terminals for top caps and 100R to 500pF screen to gnds made from 2x 1nF 630V mustards in series (these identify the amp as R&H March 1948).
- R&H April 1948 “Using the new amplifier” shows a photo – the top-chassis OPT is original Ferguson OP25/15, and choke is Ferguson. Front panel controls etc layout has common elements. Price’s advert in May 1949 shows first choke in same rotation, and some front panel control changes. This amp has choke rotated.

Issues:
- Mains AC safety - no fuse, poor cable

- haphazard gnd bus connections
- 5V heater leaking to chassis – needed insulation.
- 6V3 heater not grounded.
- all 50nF coupling caps (not 250nF from driver to output stage).
- Output stage common cathode pot is 250R (not 100) and not wired for fail-safe, and some corrosion. Balance pot is 200R (not 100R) and scratchy.
- 1k grid stopper suspect.
- 5U4 ST glass almost touches choke bell-end. 5U4 voltage drop is significant.
- R2 of input stage was 330k, not 33k (likely a repair mistake).

Testing:
Mains 240Vac 0.086A idle, no valves, 6.47V heater.
GZ32 fitted – tested for on-voltage balance. B+ increases from 386V with 5U4, to 408V with GZ32 under same conditions. Bridged anode configuration of GZ32 (using ss diodes for steering) increased B+ to 420V.

Squarewave with 15k feedback R for 11.7dB feedback showed 166kHz ringing, and often unstable with 5k feedback R for 18.7dB feedback with input pot on max. Comp cap improved squarewave ringing, with max improvement about 143pF across 5k (230kHz corner), which provided stable operation for 16R and no load and up to 470pF, but 20R-10nF zobel needed for up to 47nF load, but then unstable.

No load can cause a very high frequency oscillation at many hundreds of kHz. Not helped by a 10R-C zobel on output.

A resonance near 180kHz starts up with C loading with primary 1k2-600pF zobels – still stable at 1nF but not much more. Without the primary zobels the next resonance at 420kHz starts to dominate – still stable at 1nF but not much more.

Added 2T inductor, and 2nd resonance at ~800kHz with 1nF load. Changed to 8T and same resonance and GP with 1nF, although GP and SqW with 16R load shows slow rolloff from 10kHz.

Disconnected 500pF screen bypasses and get ~1.2MHz low level oscillation with no load. A515 indicates a much lower oscillation frequency was observed without the bypass, but 500pF cleared up any oscillations.

Replace screen bypass with 1nF 1600Vdc 680Vac FKP and output now stable with up to 100nF. Lowered inductor to 4T and roll-off now better but unstable for 47nF. Adding 470pF from 807 screen to cathode slightly lowered gain out past 150kHz by a few dB. Similar GP change when 807 input grid stopper raised from 1k to 4k9. Increased input stopper to 16k tot, with some further attenuation above about 300kHz but otherwise no change.

Returned to 1k input stoppers on output stage, and shunted 470k grid leaks on driver stage with 410pF matched caps – small change above 200kHz, but resonance a titch lower and more severe at 180kHz. Increased shunt to 1nF – resonance more severe and lower at 140kHz and then quite chaotic through to 600kHz, although gain was lower but phase was sitting around 180deg. Then shorted 4T output inductor, and no noticeable change – and similar when 470pF screen-cathode bypass removed.

Added in first stage step 120pF-10k (corner frequencies 30kHz-162kHz) [47k//10k=8k2], rather than nominal 18kHz to 185kHz, so less attenuation than 8.4dB. Unstable with 10nF load. Same with 4T in circuit. Same with 1nF screen increased to 1n5. Better with no screen bypass as 180kHz not so pronounced, but still unstable with no inductor, or 4T or 8T. Removed driver grid leak bypasses.

Stable with 120pF-10k step, and 150pF comp, and 10T up to 100nF – all other comp removed. But not stable if step removed. Also stable at 6T, but not at 4T. Squarewave with 16R shows minor 60kHz damped ring. This was then the final setup for HF response and stability. The bypasses on driver grid leaks, and 807 screens, and any zobels, appeared to introduce local resonances.

LF peaking was significant (+9dB) between 0.25W and 1W into 16Ω, with peak frequency increasing from 4Hz (0.25W) and 5.2Hz (1W), and then peak magnitude falling as frequency increased with higher power levels. The peaking was related to the two C-R corners at around 7Hz and the OPT primary inductance changing with signal voltage (power). The PI to driver coupling caps were increased from 47nF to 500nF, and that lowered both the frequency and magnitude of the peak down to +2.5dB at 4Hz for 1W, as well as lowering the phase shift below 10Hz and removing any rapid change associated with the peak.

The distortion profile was flat down to below 20Hz for all power levels, however the frequency response has a quirky -3dB dip around 2.5kHz at 10W 16R, with a significant increase in distortion associated with the dip. A 10W 2.5kHz signal indicated that output stage cathode current level drops, and B+ rises. Output signal waveform shows a significant portion of sinewave becomes modified as per FR plot. Not influenced by coupling cap size. The modified portion of waveform causes a noticeable sympathetic deviation in C5 and C8 voltage signal (via the 100:1 dividers). The effect's onset occurs earlier with lower mains Vac. The effect relates to output stage entering clipping region, and larger magnitude swing level, which is not symmetrical due to 807 differences.

The input volume pot introduces a significant low-pass response as wiper is reduced from 100%, with about -3dB at 15kHz at 80%.

The ac signal balance pot had negligible influence, as did the humdinger.

Cathode bias set for about 50mA and 420V at 240Vac, so about 19W diss.

Testing to do:

- Insulation resistance of valve heater-cathodes,

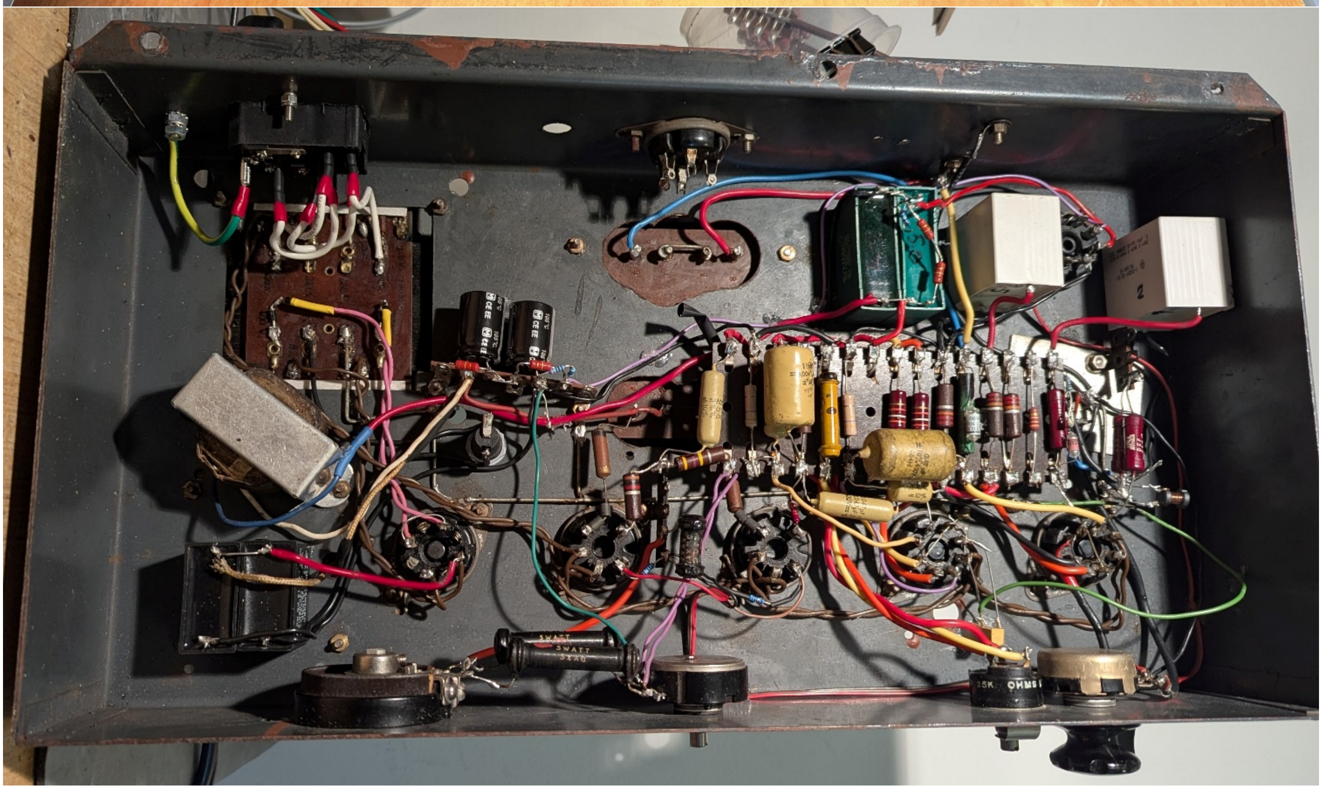
2. Modifications

Done:

- Added mains IEC fuse switch combo.
- Added sheet nomex protection for PT.
- Added 10R 0.25W cathode sense to each 807. Failsafe the 250R pot.
- Anode protection ss diodes for rectifier valve, and used bridged connection.
- Repaired OPT anode lead grommets.
- Relocated choke and 0V wiring. Replaced e-caps.
- Added tuned 200Ω humdinger trimpot to 6V3 heater.
- 8-pin top chassis socket re-purposed for monitoring,
- Increased coupling caps from 50nF to 500nF to driver stage.
- Added 120pF 10k step network to input stage.
- Added 6T inductor to feedback path, and added 150pF comp across 5k.
- Removed 500pF screen bypasses.
- Changed from 5U4 to GZ32 for higher B+, and slow turn-on.

To do:

- Elevated humdinger for heater.



As modified photos.

4. Design

The R&H 1948 amp had the following design changes from original 1947 Williamson (ie. no step network). Some changes were direct from the A515, but some were from R&H:

- Power supply for B+ used series e-caps with balancing Rs for 4uF then 16uF, and larger 20H choke (rather than 8uF, 10H, 8uF).
- Output stage 500pF screen to gnd bypass.
- Output stage grid-leaks 500k for 807's, as per A515 (rather than 100k for KT66's).
- Driver to output stage 50nF coupling caps, as per A515 (rather than 250nF).
    - A nominal 7Hz corner was retained as the 807 grid stopper was 500kΩ.
- Heater was grounded on one side (rather than winding CT).

A full-wave centre-tapped rectifier with 400-0-400V windings provides a no-load voltage of circa 560V.

The effective source resistance is comprised of the reflected power transformer primary resistance = 12Ω x $(400/240)^2$ = 33Ω; plus the secondary resistance = 102Ω min; which sums to 135Ω.

Idle (and max signal) loading is about 140mA, based on 60mA per 807, and 20mA downstream. PSUD2 indicates rectifier needs ~1.1A hot peak, and 0.5A cont. pk.

- Default 5U4G rectifier is fine, although it is directly heated and so initial B+ will be circa 550V.
- A 5V4G, GZ32 or GZ34 are ok for Vac and Iap ratings, but may give higher B+ if needed, and a delayed turn-on.
- A 5R4-GY is likely ok, but turn-on Iappk is marginal.

Voltage rating of filter and coupling caps (modified updated version):

- 400Vac poly for C9. 350Vac poly for C5. 320Vac poly for C1, C2.
- 2x series 350Vdc caps used for C8 with 110k PRO2 balancing resistor across each.
- C6, C7 are 47nF 630V mustards
- C3, C4 are 47nF 400V mustards.

The main choke drops about 23Vdc at 140mA.

PSUD2 indicates no resonance response for step dynamic load change.

Bleed resistance is 220k//220k (~3.6mA). Bleed on C8 and C5 (either side of choke), and incorporates B+/100 remote monitoring.

The continuous fuse current in the CT link is about 240mA nominal, which may be too close to 250mA. For a hot turn-on with 140mA load, the continuous load following data indicates a 0.315A F 5x20 is ok. 500mA T 3AG fitted.

Simulate period in PSUD2	**10ms**	**20ms**	**50ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current		0.48A		0.43A	0.3A	0.24A
Multiplier (for 0.315A fuse rating)		1.5		1.4	0.95	0.76
IEC 60127-2 **T** min limit multiplier		10		4.0	2.75	1

Simulate period in PSUD2	**10ms**	**20ms**	**50ms**	**150ms**	**600ms**	**continuous**
Simulated RMS current	0.4A		0.58A			0.24A
Multiplier (for 0.315A fuse rating)	1.3		1.9			0.76
IEC 60127-2 **F** min limit multiplier	4		2.75			1

Monitoring via 8-pin octal socket for 8x meter module. Common cathode voltage is nominally 125mA x (150//150 +250) = 40V, so use 8x meter module with 300VFS common cathode and 4k7 0.6W protection. 10R current sense per cathode. 110k+110k+2k2+68 for 100:1 monitoring of 450V rail to output stage, and 400V rail to driver/input stages.

TRIODE-CONNECTED 807 AMPLIFIER

The amplifier is built on a standard 2JU modulator chassis. Input arrangements may be via terminals or jack, as you please. The vacant socket hole will eventually house a pre-amplifier stage.

This amplifier is so good that more than once we began double-checking results to make sure we weren't mistaken. Its frequency response is so flat up to 35 kc that it can only be represented by a straight line. Its total harmonic distortion is below .1 per cent. at 11 watts and very little more at 17 watts. Its gain is sufficient for use with medium to high output pickups, and almost any type of radio tuner. Truly, an amplifier to end amplifiers!

YOU will remember that in our January issue, we were able to publish an article reprinted from "Radiotronics" describing an amplifier very similar to that described here.

This amplifier was based on a design first published in the English journal "Wireless World," well known for its sponsorship of many fine and original developments in radio.

The design attracted a great deal of attention, and our own interest in it was apparently shared by many other people, including the engineers of the A. W. Valve Co.

AUSTRALIAN VALVES

The original amplifier, of course, was designed for use with European type valves, not easily obtainable here, but for which we possess almost duplicate types.

The Radiotronics circuit was evolved in an attempt to use the original ideas as applied to valves which you can buy, allowing of course for the inevitable temporary shortages from time to time!

By reference to Radiotronics article, you will see that the results were unbelievably good, and substantially the same as those obtained by Wireless World.

It is not hard today to build amplifiers which have very flat frequency characteristics. What makes this job so much better is its low percentage of harmonic distortion—so low that we can consider it for our purposes as being non-existent.

ANY of the tuners described to date may be used with this amplifier, providing a suitable dropping resistor is used to reduce the tuner high tension to 250 volts. A spare filament winding is specified. We will be describing other tuners soon.

It is far and away superior to comparable characteristics which can be quoted in reference to pick-ups and loudspeakers with which it will be used.

The advantages of such an amplifier are obvious. It means that when assessing performance, we can virtually eliminate the amplifier from our calculations, as it is near perfection as a device to faithfully amplify any audio voltages we are likely to feed into it.

In actual practice, it sounds just that way. It has a clean, crisp character about it which can only be obtained by providing adequate reserve output without distortion of any kind.

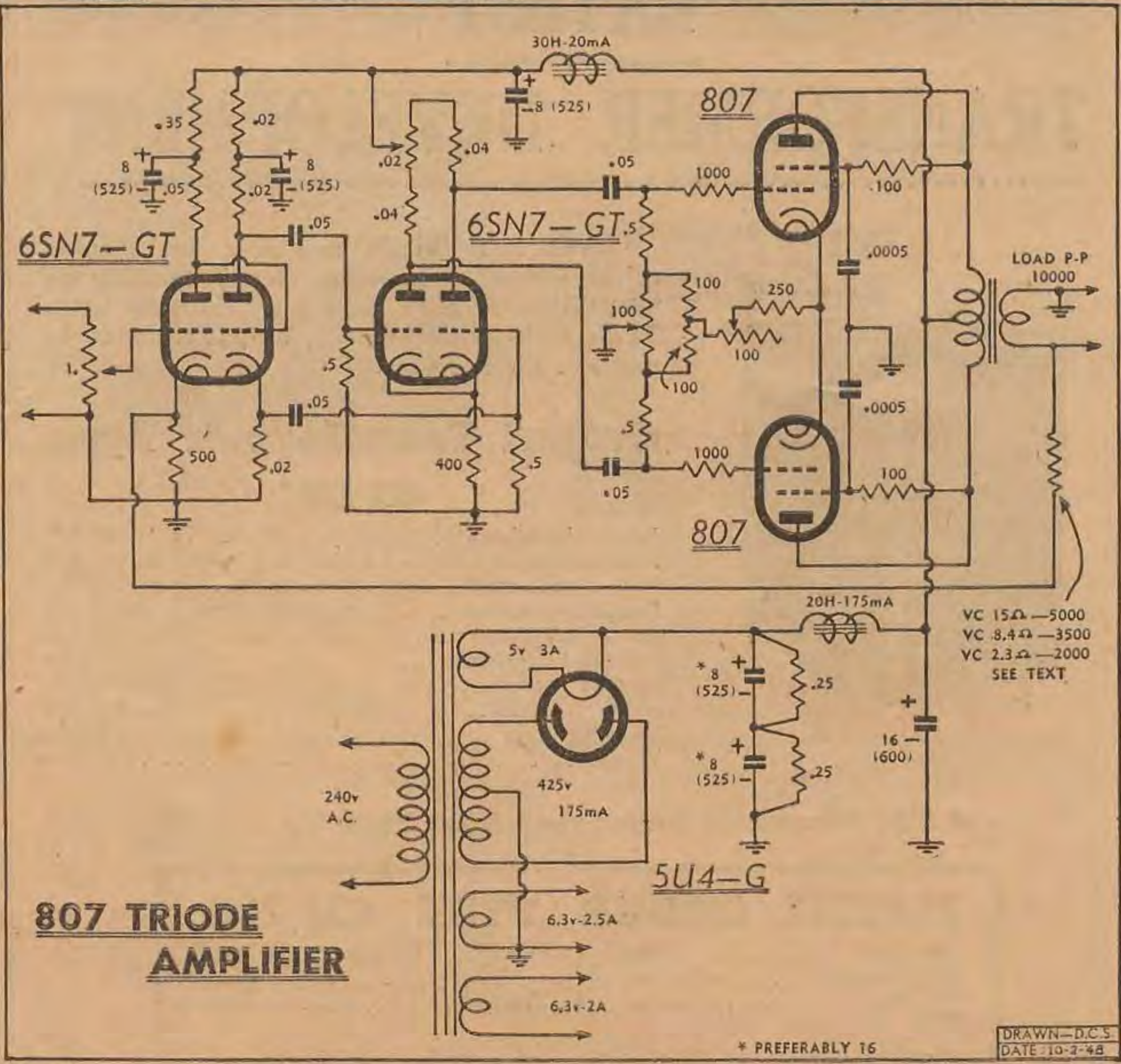
How does it compare with the amplifiers using 807 "pentodes" with feedback, we have been describing of late? That is a question many of our readers have already asked.

A "BEST" AMPLIFIER

Volume for volume, it is definitely better. The better your input and output arrangements are, the better it will sound. But if you use the average type of pickup and speaker, we don't suggest you scrap many hours of work put into one of our previous amplifiers expecting to be stunned by the improvement. Because it will be the limitations of pickups and speakers which will in effect limit your results with any of our recent jobs.

At the same time, if you intend to build a new amplifier from the ground up, would do well to consider this new design. If a maximum output of about 15 watts will suit you, and generally it will, your results will be better than with previous types. It will not have such a high over-all gain, and a pre-amplifier will be needed for pickups having a low output. We intend to do

CIRCUIT DIAGRAM OF THE 807 TRIODE AMPLIFIER



The circuit is particularly simple, consisting merely of a resistor condenser network. The feedback resistor valve is not highly critical, and results are nearly as good with no feedback at all.

some work along these lines with the idea of bumping up the gain without affecting present performance. But for the average crystal and magnetic pick-up, and the average 12 inch speaker, you will have enough gain to get plenty of sound.

Having more or less put the amplifier in its place in the scheme of things, we can proceed to tell you more about it.

Briefly, it consists of an output stage using a pair of 807's wired as class A triodes. In this connection, the plates and screen of each valve are connected together, a screen suppressor of 100 ohms being included, and a voltage of 400 used.

The valve manufacturers are carrying out life tests to see whether there are any undesirable effects due to operating the screen at this higher-than-usual voltage. There do not appear to be any, however, and no dissipation ratings are exceeded.

Ahead of the output stage is a pair of push-pull drivers, in the shape of a 6SN7 dual-triode, resistance coupled to the 807's.

INPUT STAGE

The input stage is another 6SN7, the first section being a voltage amplifier direct coupled to the second, which is a normal phase-splitter to drive the push-pull driver stage.

Degeneration is freely used throughout the amplifier. None of the bias resistors is bypassed, a practice which, although lowering the overall gain, reduces the harmonic distortion to a very low level.

A further feedback provision is made by bringing back into the cathode circuit of the first stage suitably phased voltage from the loudspeaker voice coil.

With an amplifier of this quality, the effectiveness of this feedback loop depends largely on the quality of the output transformer, as pointed out last month. For this reason, several manufacturers have made special transformers for the circuit. Two we have tested so far are the Ferguson; and the Swales and Swann, both of which are of exceedingly high quality.

Don't think that the circuit will not operate at all using ordinary output transformers. It will, but the extreme freedom from distortion which characterises the circuit will

LATEST

TRANSFORMER DEVELOPMENT

We have made available for general release three components ideally suitable for the "High Fidelity Amplifier" in this issue. These include a Hi-Fidelity output transformer and two filter chokes.

Output Transformer Type OP25*

Primary Impedance	10,000 P.-P.
Secondary Impedance	8.4 ohms & 2.1 ohms, or any 4/1 ratio of secondary impedance e.g. 500 ohms & 125 ohms.
Frequency Response	± 0.5 db 20 c/s to 30,000 c/s.
Primary Inductance	110 henries at 5V A.C. 50 c/s.
Leakage Inductance	14 millihenries
Insertion Loss	0.3db. at 1000 c/s.
Finish	Grey Brocade
Mounting	Vertical
Weight	6½ lbs.

*** Add Secondary Impedance After Type No. : OP25—8.4/2.1**

FILTER CHOKE TYPE C12/200

Inductance	12 henries	Max. D.C. Current	200 ma's.
D.C. Resistance	150 ohms.	Finish	Grey Brocade
Mounting	Vertical	Weight	6 lbs.

FILTER CHOKE TYPE C30/25

Inductance	30 henries	Max. D.C. Current	25 ma's.
D.C. Resistance	1000 ohms.	Finish	Grey
Mounting	Bracket (Vertical)	Weight	1 lb.

LABORATORY SERVICE TO MANUFACTURERS

The Ferguson Laboratory is continually engaged in research for the improvement and advancement in the transformer and electronic field. This Laboratory together with its technical staff is available to assist manufacturers with their transformer problems.

FERGUSONS RADIO Pty. Ltd.

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not be attained to the same degree.

Inspection of our circuit will show that we have modified the Radiotronics version in a few minor details.

The first point to note is the lower transformer voltage we have specified. This is made possible by the use of condenser input instead of choke input. Choke input will allow slightly better regulation at the extreme limits of output, which, being about 17 watts, the average man isn't likely to require. As a result, our amplifier might have a maximum output slightly lower than this. A very small point, as few will ever use it over about 10 watts.

The absence of the second filter choke has no appreciable effect on hum level. Particularly if you use 16 mfds. filter condensers throughout, you will be hard put to it to notice any hum at all.

POWER SUPPLY

We have also included in our specifications an extra filament winding for use when and if a tuner is used. For the same reason, we have specified a secondary winding which will accommodate such a tuner. If you bring the necessary leads out to a socket at the rear of the chassis, you will have a handy point of connection. The voice coil leads are connected to a pair of terminals at some convenient spot.

The voltage from the power supply is much too high for a tuner. A series resistor must therefore be used to reduce it to approximately 250 volts. We found a suitable wire-wound resistor of 7000 ohms was OK for a three-valve tuner.

The circuit provides for adjustments to balance the drive to the 807's, and also the individual plate currents of these two valves. It would be possible to do without them, but their addition is such a simple matter that we strongly advise you to include them.

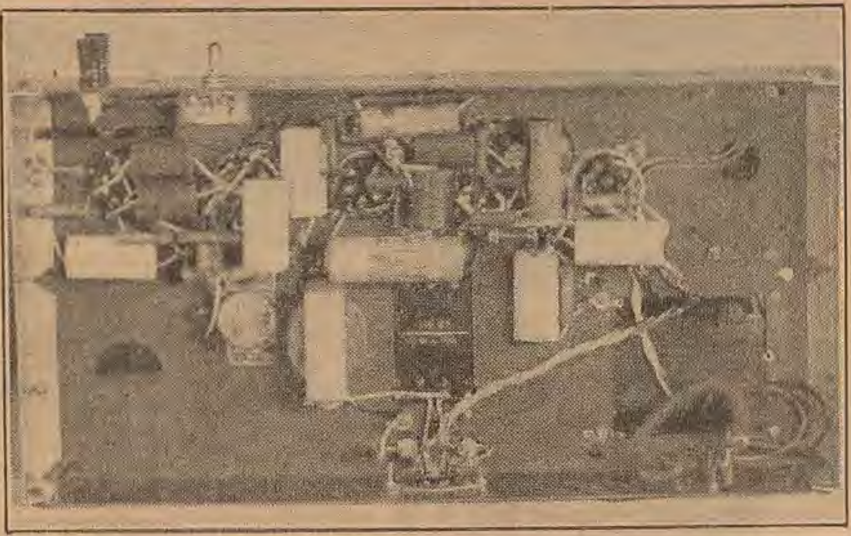
The adjustment of the 807 circuit is two-fold. There is a variable 100 ohm resistor, in series with one of 250 ohms, the function of which is to vary the grid bias until the plate current of the valves is 140 mills for the two.

807 BALANCE

The second resistor of 100 ohms allows the plate current of the 807's to be balanced, so that each draws 70 mills. Both these adjustments are made quite simply by the insertion of a DC milliameter of suitable range firstly in the common cathode circuit return, and secondly in the cathode return for each valve.

Balancing the input to each 807 isn't quite as simple, as the only obvious instruments likely to be satisfactory are the CRO or a VT voltmeter, with which to measure the grid voltages supplied to each output valve in turn. The degree of unbalance is likely to be about 10 per cent., or slightly more in extreme cases. This would show up only in a slight reduction in output without distortion, and if the amplifier is not required for high outputs, it may not be so important. However, this is something in the nature of a special amplifier, and to be even more exact, the method described in last month's article for balancing output voltages of the 807's instead of input voltages would be best of all. For practical purposes, balancing the grid circuit will be quite OK.

THE AMPLIFIER FROM BENEATH



The wiring is merely a matter of neat assembly and reasonably short leads.

OPTIONAL POT

The adjustment for bringing about this balance is the 20,000 ohms potentiometer in the plate circuits of the push-pull driver stage. There should be sufficient variation in this control to achieve balance in any normal 6SN7.

We mounted our potentiometer below the chassis on a bracket, immediately below a small hole, through which adjustment coud be made with a screwdriver. The shaft was a short one, fitted with a screw-driver slot.

If you cannot conveniently make this adjustment for the time being, by all means go ahead, omitting the potentiometer altogether. As we have said, in most cases, the difference in results will be very small.

As 6SN7 valves may not be as easy to obtain as one would wish, they can be replaced by a pair of 6J5 valves in each case, without alteration to the circuit or values. This necessity would affect layout, of course, but even if the chassis design were to vary considerably from the one we have used, results are unlikely to be prejudiced unless you do something very silly!

Building the amplifier should present no difficulties. We found that most of the components could be supported from the valve sockets themselves, with the aid of a few strategically placed insulated mounting lugs.

CONTROL POSITION

The place of the volume control and input terminals isn't symmetrical along the front of the chassis, but we don't like making leads to and from these things too long. If it is essential, the volume control can be placed centrally, with shielded connections, and an input jack can of course be used in place of input terminals.

PARTS LIST

AMPLIFIER—

1 2JU Modulator chassis.

1 Power Transformer, 425-0-425v at 175 mA, 6.3v, 2.5a, 6.3v, 2.5a, 5v 2a.

1 Special Output transformer, 10,000 ohm, CT to 2.1 or 8.4 ohm vc—see best.

1 Choke, 20 henries, 175 mA; 1 Choke 30 henries, 20 mA.

VALVES:

2 807's, 2 6SN7-GTs, 1 5U4-G.

CONDENSERS:

3 8 or 16 mfd, 600 PV, 1 16 mfd, 600 PV, 2 8 mfd, 525 PV, 4 0.05 mfd, 600v wkg.

RESISTORS:

2 100 ohm, 1 400 ohm, 1 500 ohm, 1 250 ohm, 2 1000 ohm, 1 5000 ohm, 3 20,000 ohm, 1 35,000 ohm, 2 40,000 ohm, 1 50,000 ohm, 2 .25 meg, 4 .5 meg, wire-wound—2 100 ohm, 2 100 ohm with tap.

POTENTIOMETERS:

2 100 ohm, 1 1.0 meg, 1 20,000 ohm.

SUNDRIES:

2 terminals, solder lugs, hook-up wire, nuts and bolts, power flex.

One reason we placed the control where it is was because of our intention to add an extra stage as a pre-amplifier. We have been making some experiments with low-output type pick-ups, and particularly with bass compensation circuits, we find extra gain necessary for full amplifier output. We may have something to say about such pre-amplifiers in the near future. But they will be additions to the present basic circuit, and we do not anticipate any alterations to the amplifier as a whole.

Talking of gain, the use of feedback from the voice coil reduced the gain by an appreciable amount. If you find that for any reason your pick-up is a bit lacking in output, removal of the feedback will, in all probability, not be noticed in your results, except possibly with the very best of equipment. Feedback in this circuit is not nearly as important as it would be, were the valves to operate in pentode connection, for obvious reasons. It is just one more precaution which can be taken to ensure that the extremely good output characteristics will be obtained.

FEEDBACK

To remove the feedback, it is merely necessary to omit the feedback coupling resistor from the voice coil circuit. It is interesting to note how the inclusion or otherwise of this resistor affects results.

This feedback resistor will require selection according to the voice coil impedance of the particular speaker you use. That is why we have shown alternative values on the circuit diagram.

It is obvious, of course, that with the high impedance voice coil, more voltage will be available than from a low impedance coil. Thus, in the latter case, it is necessary to reduce the value of the feedback resistor for these lower voice coil impedances.

The value of resistor given in the Radiotronic circuit is not very useful because it is operating from a 15-ohm output, and very few speakers in Australia have voice coils as high as this. The Rola K12 has a 2.3-ohm voice coil, the G12 and Amplion 12in. speakers about 8 ohms. Some others have 12 ohms.

Our circuit diagram shows values for use with these impedances, and which will give feedback values almost exactly the same as in the original design.

RESISTOR VALUE

We would point out once again that very little effect will be noticed by using a much lower degree of feedback than provided for—in fact, as we have said, it can even be removed altogether and still leave an amplifier better than the average.

It is not important, therefore, that the feedback resistor be of an exact value—should you have a speaker with a voice coil impedance differing from those shown, it will be sufficient, having first obtained a transformer which gives a good match, to estimate a resistor value from those given. It is much better to err on the large than the small side. Our values have been calculated and measured to give about 20 d.b. reduction in gain. This is just about the limit one can realise without a tendency to oscillation at the lower frequencies, and, therefore, it should not be exceeded.

Without feedback, output is about 7½ watts, increasing to over 11 watts with feedback. This is for completely clean output, but with feedback, 17 watts may be reached with little distortion. To obtain these latter figures, feedback is necessary.

RIGHT SIDE

Incidentally, it is important to connect the feedback resistor to the right side of the voice coil winding. If you get it the wrong way round, violent oscillation can be expected, as the feedback will be positive rather than negative.

These output figures line up almost exactly with those obtained from the original Radiotronics amplifier.

Concerning distortion, we made a number of measurements across a resistive -loaded voice coil both for power output and frequency response. At the present time we cannot make direct measurements of harmonic distortion, but there is no reason to think that our amplifier would be very different from the original design.

Without the bypass condensers on the screen of the 807 valves, the frequency response was quite flat from 20 cycles to more than 50,000 cycles, with a measurement of 5 volts across an 8.4-ohm voice coil winding—an output of 3 watts.

RESPONSE

With the bypass condensers, output was flat from 20 to 20,000 cycles. At 50,000 cycles it had dropped to 4.3 volts, and it was still 2.5 volts at 80,000 cycles, with a slight peak to 5.5 volts at 60,000 cycles.

If you work that out in decibels, you will see just how good the amplifier is. For audio work, it can be regarded as being virtually flat and distortionless.

Our power output checks were taken at 1000 cycles.

It isn't very much use using the amplifier except with large speakers properly baffled. This restricts it virtually to the 12in. types, with the K12 type as being a reasonable compromise. If full output is required, some of the larger heavy-duty speakers occasionally obtainable should be used.

Although flat baffles are widely used because of their simplicity, we strongly advise a better method of loading, such as the use of a vented enclosure. This device reduces speaker distortion by quite a bit, raises speaker efficiency, and by elimination of the back radiation as such, greatly simplifies the problem of making use of the output. It is unwise to feed too much input to any speaker without good loading. With the use of an exponential horn, even an 8in. speaker could probably be used with good results

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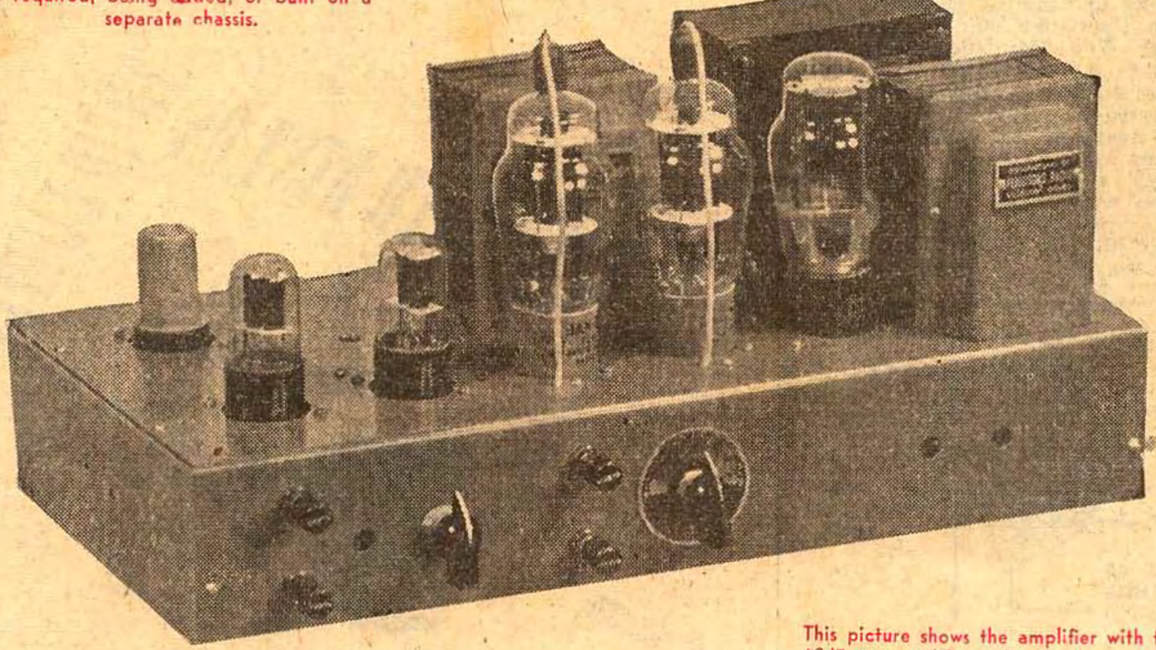
Illustrated folder Publication C1 available free on application.

Obtainable from all radio dealers.

The amplifier is essentially the same as described last month, the pre-amplifier if required, being added, or built on a separate chassis.



This picture shows the amplifier with the 6SJ7 pre-amplifier valve in place at the extreme left.

Using the New Amplifier

Having built your amplifier, the next consideration is its use with various input devices—pickups and tuners. The subject leads us into many paths. This article relates some practical experiments which to date have not been covered adequately elsewhere.

WE have already had a good deal to say on the general subject, so that a brief re-statement of the position will suffice by way of introduction.

Continuous research by the recording companies has enabled them to place on their master discs a much-improved sound track. The distortion level is lower, frequency response wider, there is greater dynamic range and better "presence," due to carefully-controlled studio technique. Heard under ideal conditions, the best recordings are really good.

RECORD POINTS

However, difficulties occur in transferring the groove pattern from the master recording to commercial discs for sale to the public—to you. Difficulties arising from bulk handling of raw materials, mass production and so on are still operating to modify the excellence of the original recording so the disc you ultimately buy may or may not be as impressive in regard to quality.

The average listener has generally not been aware of these developments because he is still using a pickup or radio receiver which cannot respond to the extended treble nor appreciate fully the difference in general quality. Some records may sound just a little more brilliant than others, may have better light and shade, but that is all. The possibilities of improved discs can only be appreciated by using better reproducing equipment.

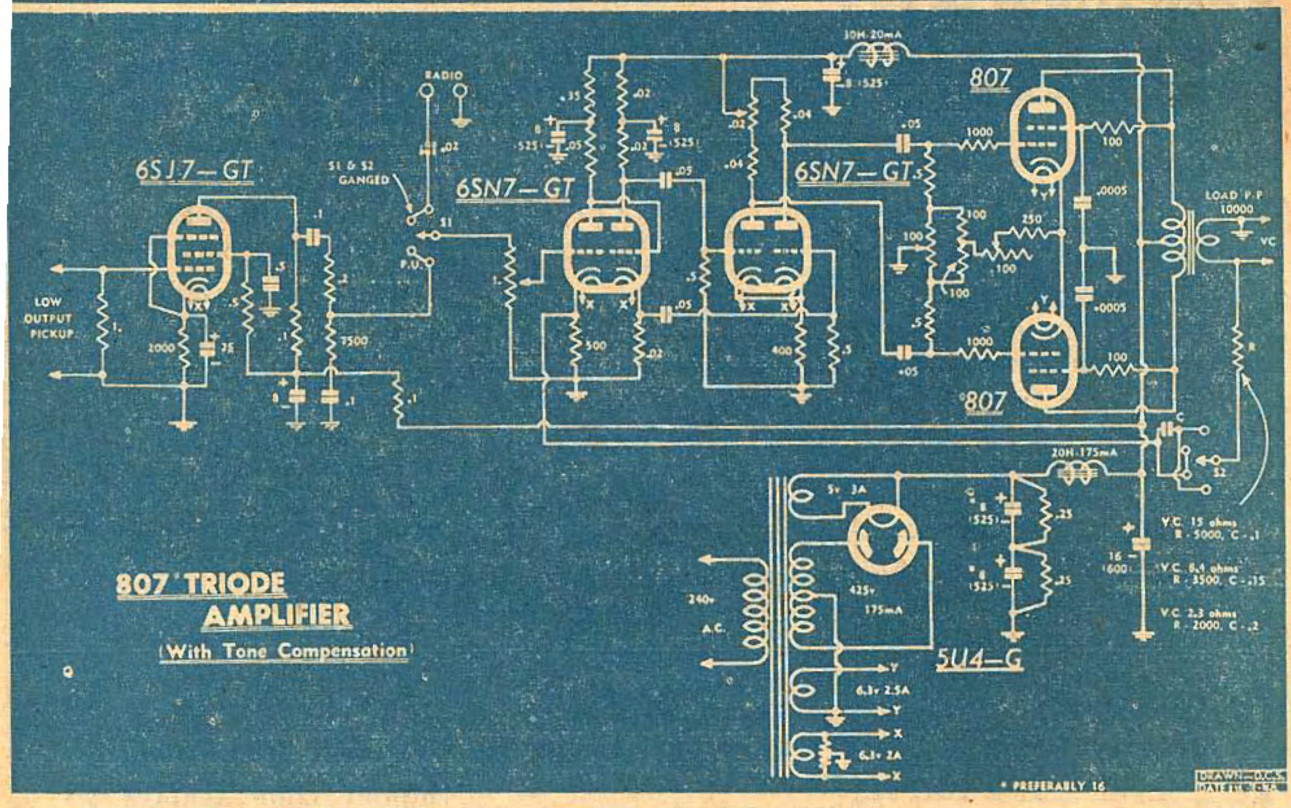
Accordingly, new pickups are appearing on the market especially designed to lift from the disc every vestige of signal impressed on it, and to do it with the minimum of wear on the groove. And when we have a complete combination of good disc, good pickup, good amplifier and speaker, reproduction reaches an entirely new standard.

Unfortunately, there is an aspect of the present transition stage which bewilders and disillusions many quality enthusiasts. New equipment is installed, probably at considerable cost, and they find that the added brilliance is spoiled by noises and distortion which the less ambitious equipment happily ignored. The reason is not hard to find, for ability to reproduce transients and treble also means ability to reproduce every imperfection of worn or imperfect discs. Some you will be able to enjoy no end. With others you will involuntarily reach for a tone control to reduce the treble to what it was before the new equipment was installed. Such is the price of progress.

REQUIREMENTS

In terms of pickup design, improved transient response, wider frequency range, lower distortion and reduced record wear can all be interpreted broadly as a need for reduced mass and damping of the needle and moving parts. The high-fiedlity pickups accordingly make use of small steel needles or a semi-

CIRCUIT OF AMPLIFIER WITH THE EXTRA STAGE



This circuit is suitable for all medium output pickups, new or old. For crystal pickups the pre-amplifier will not be required.

permanent jewel-tipped stylus. The actual principle of operation varies according to the ideas and policy of the manufacturer.

Some of the newer pickups represent a complete departure from established principles but, for the moment, these are of no more than academic interest to Australian enthusiasts. The high-fidelity pickups on the immediate horizon are mainly moving coil, moving iron and needle armature types. They have two important characteristics in common—low output voltage and absence of rising bass characteristic.

CRYSTAL TYPES

Crystal pickups, too, are being constantly improved and retain their advantage of high output and a naturally rising bass response. While they can thus be connected directly to more or less conventional equipment, it is doubtful whether they will ever equal the electro-magnetic types for absolute fidelity under optimum conditions.

In the light of this, certain broad statements can be made as a guide to readers who may wish to purchase a new pickup.

Conventional magnetic pickups are readily available in a variety of brands. They are cheap, rugged, have enough output for most purposes, and give just average quality of reproduction. Apart from minor refinements, they remain the same as ever.

Ordinary crystal pickups are rather more expensive, but have better all-round characteristics when used with standard amplifiers. They are lighter on records, but may be adversely affected in tropical or semi-tropical climates.

High-fidelity crystal pickups are capable of good results with conventional amplifiers, especially if provided with simple compensating networks as recommended by the manufacturers.

ELECTRO-MAGNETICS

However, for actual fidelity, we have been impressed most by the new lightweight electro-magnetic types, of which we have tested several. As previously mentioned, all these have low output and are normally used with a matching transformer. The associated amplifier must have high overall gain and a bass response rising at the rate of approximately 6db. per octave below 250 c/s. In a few special cases the desired characteristic can be obtained by "doctoring" a conventional amplifier but, generally speaking, the requirements call for an additional stage to provide the gain and compensation.

This, in turn, calls for extra parts and necessitates care to avoid trouble with michophony, hum, and noise, as with a microphone preamplifier stage. There can be no compromise in the matter. If you are keen to try out one of the new pickups, you must adapt your amplifier to suit or the net result will be a weak, high-pitched sound, seemingly far removed from the alleged high fidelity.

The 807 triode amplifier described last month has been used for many of our own tests, and has been adapted for the purpose both by modifying the feedback network and by the addition of two distinct types of preamplifier stage. The results of these tests will doubtless be a good guide to others who may use this equipment.

> WE are particularly keen to hear your reactions to these articles on amplifiers and pickups, particularly if you have built up this or similar equipment. Your experiences might help someone else to get good results. Drop us a line and let us know how you get on.

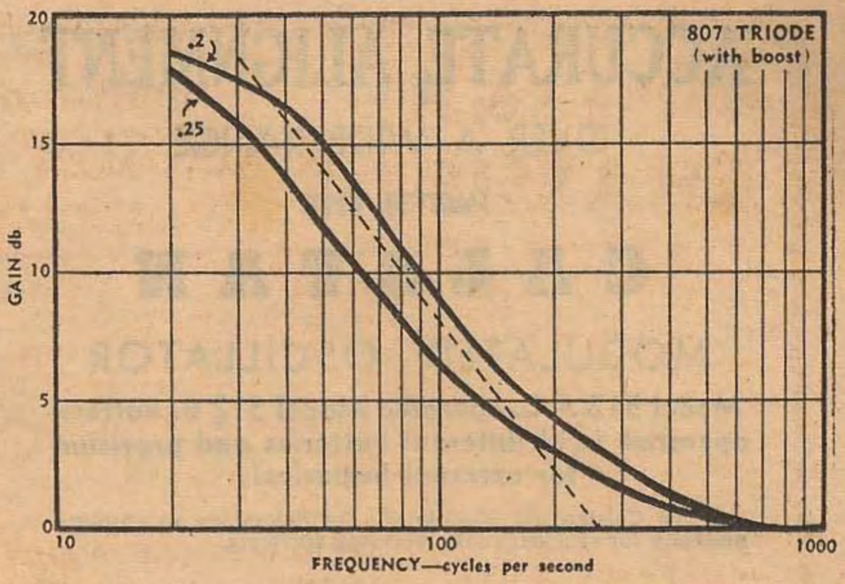
INPUT VOLTS

With the feedback fully operative, the amplifier requires an input for full output of about 1.5 volts, so that it is only suitable in this form for direct connection to a crystal pickup. Useful output would be obtained from some of the ordinary magnetic types, but it is not likely that many enthusiasts would go to the trouble and expense of building this particular amplifier and then hitch it to an inferior pickup.

With the feedback eliminated, the sensitivity is sufficient to give full output from an input of about 0.15

volt—a difference of about 10:1. There would be no point in using the amplifier this way, although its characteristics without feedback are still excellent, but the figures suggest the possibility of utilising the feedback for bass compensation.

This is accomplished very simply by inserting a selected condenser in series with the feedback loop, so that the feedback factor decreases below about 250 c/s. The optimum value of condenser depends on the impedance of the feedback circuit and the required boost, but our tests indicated that something very close to the normal 6db. per octave is achieved with a series condenser of from 0.2 to 0.25 mfd. This is for the 2.3-ohm voice coil and a 2000-ohm series resistor. For more moderate boost, a 0.5mfd. condenser would be used.



Insertion of suitable condensers in the feedback loop of the 807 triode amplifier gives this almost ideal compensation characteristic. Condenser values are for the 2.3 ohm voice coil condition. See text for alternative values.

FEEDBACK RESISTOR

With an 8-ohm voice coil, the feedback resistor is 3500 ohms, and the condenser values would work out at 0.15 and 0.3mfd. With a 15-ohm voice coil, the suggested resistor is 5000 ohms, making the condenser values 0.1 and 0.2 mfd. respectively.

Modifying the feedback in this circuit is not nearly as far-reaching in its effect as with the normal feedback amplifier. The output valves are used as triodes, and exhibit their characteristic tolerance of load variation as well as affording moderate electrical damping on the loudspeaker. Thus removal of the feedback at certain frequencies brings one back simply to normal triode output, which is a far different story from uncompensated pentodes and their high harmonic distortion.

With the suggested alteration, the amplifier retains its original characteristics for all frequencies over two or three hundred cycles, behaves as a normal triode amplifier in the lower register, but acquires a 6db.-per-octave boost just where it is required.

In this condition, we found that the amplifier worked quite well with the new English Connoisseur magnetic, operating through the step-up transformer provided by the manufacturers. Gain was not sufficient to fully load the amplifier, but it would make a satisfactory combination for home listening at moderate to high levels.

To obtain full amplifier output from low-output pickups, one can follow the obvious course of adding a simple triode preamplifier stage to boost the gain, relying on the "doctored" feedback circuit to correct the frequency response. Note that the series condenser would have to be shorted out substantially for radio programmes, where large bass boost is not required.

As an obvious alternative to the above suggestion, one can arrange the pre-amplifier constants so that it provides the necessary bass boost plus a margin of gain. This obviates the need for alterations to the main amplified and allows the feed-back to be fully operative at all frequencies.

BASS BOOST

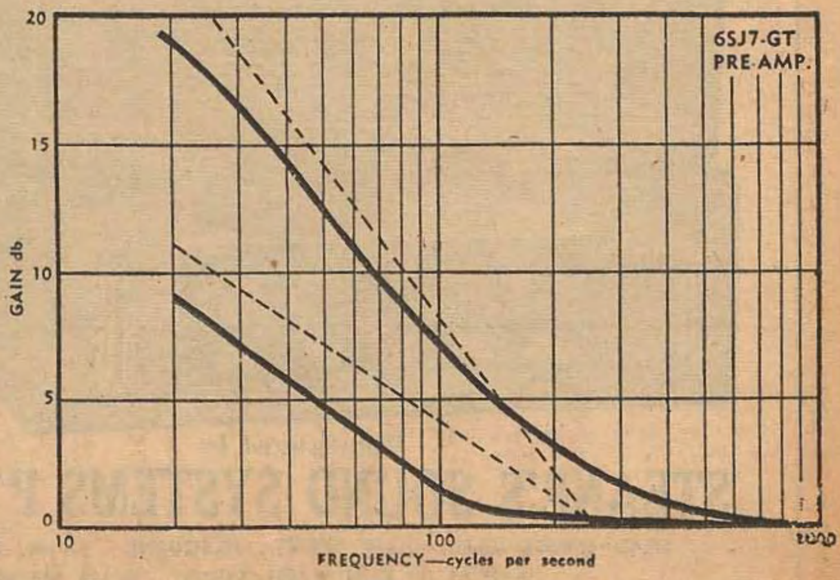
This would be quite an important point in a conventional tetrode amplifier, where good bass characteristics depend to a large extent on the feedback. In other words, a clear case for the provision of an extra stage.

This extra stage has to provide compensation at the rate of 6db. per octave below 250 c/s, and, assuming the use of a simple r/c network, there will be a loss of from 15 to 30 times gain in the frequency compensating circuit. Actually, the loss figure increases as the response curve is made to approach the ideal.

It follows that, if the stage is giving something like its full gain at the lowest frequency, the gain in the middle register will be reduced to between one 15th or one 30th of the possible gain in the valve. Hence a general purpose triode could be expected to afford the necessary compensation, but have a gain of unity or even less than unity.

In the majority of cases some additional gain is likely to be welcome so that alternative designs have been evolved to meet individual requirements.

You can expect these curves from the 6SJ7-GT stage. Constants giving the higher degree of boost will normally be used. The alternative constants and curve can be used if only moderate boost is required.



First of these is a tone control and preamplifier stage, using a single pentode of the 6SJ7 variety. As indicated by the curves, the frequency response characteristic with a 0.1 mfd condenser is very close to the ideal in the maximum boost position. The 0.25 mfd condenser gives a boost approximating 3db. per octave, and the stage can be used for straight amplification by directly earthing the 7500 ohm resistor. Switching is indicated in the circuit for those who may require it.

"MIDDLE" GAIN

At middle frequencies, the gain of the stage is approximately 2.5 times or 8db. Thus, it is an excellent choice to couple a conventional amplifier and a pickup like the Connoisseur magnetic.

In actual figures, a conventional type of gramo amplifier is usually designed to give full output with an input voltage of between 0.25 and 0.5 volts RMS—sufficient for direct use with any conventional magnetic or crystal pickup. The use of an additional stage with a gain of 2.5, reduces these figures to 0.1 and 0.2 volt. This, of course, is for full output: proportionately less input would be required to produce enough power for good listening volume.

The 807 triode amplifier is rather a special case. The degree of feedback suggested reduces the sensitivity to a point where approximately 1.5 volts is required for full output. Although it gives good volume with a Connoisseur pickup, as already mentioned, rather more gain is required for general use. The 6SJ7 stage would just about correct this position, but with nothing to spare.

Lack of space does not permit lengthy discussion of the installation of the preamplifier and tone compensating stage, but proven techniques should be followed. If the stage has to be installed on the main amplifier chassis keep it as far as possible from the power supply components and shield any lengthy grid or plate leads. Keep the grid and plate wiring and components down against the chassis to afford partial shielding.

All grid and cathode returns for the first valve must be made to one point only on the chassis, and that near the valve socket. This may involve insulating the normal earth terminal and slipping spaghetti tubing over the shielding braid to prevent earthing to chassis at more than one point.

HUM PROBLEM

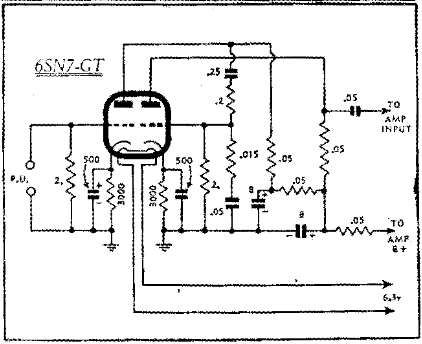
Although the gain of the stage may ostensibly be only 2.5 times, it is necessary to remember that something approaching the full gain will be effective for frequencies below 100 c/s, so that problems of hum and instability are just as acute as with a normal high gain voltage amplifier stage.

The problem or filter hum and instability demands very heavy decoupling of the power supply, as indicated on the circuit. If motorboating troubles are encountered, it may be necessary to return the decoupling resistor direct to the filament of the rectifier valve and to increase the decoupling condenser to 16 mfd.

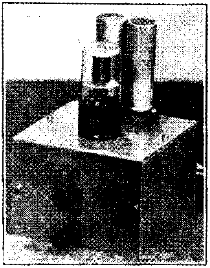
As far as the actual layout is concerned the arrangement adopted for our own amplifier appears to be the logical one. Two sets of terminals are provided on the front panel, a four position switch and a volume control.

The terminals at the end of the chassis are for connection to the pickup and the signal is fed straight to the grid of the preamplifier and tone control stage. This is wired to give a permanent bass boost of 6db per octave, but additional boost can be switched in from the feedback circuit if it is required.

CIRCUIT OF 6SN7 PRE AMP.



The pre-amplifier shown below has this circuit, and is used with the low-output moving coil pickup.



A picture of our pre-amplifier built on its own small chassis.

SWITCHING

With the switch in either P.U. position, the output from the preamplifier stage is connected to the volume control and thence to the amplifying circuits.

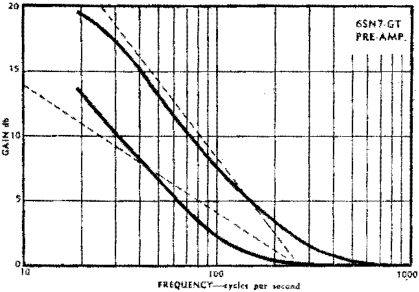
The radio position cuts out the preamplifier stage altogether and the output voltage from the tuner is fed straight to the volume control. There is good reason for this. The audio output from a tuner may amount to several volts, which would hopelessly overload the preamplifier stage, irrespective of the volume control setting. To avoid this overload would necessitate the use of a voltage dividing network so arranged that only a small portion of the tuner output was fed to the amplifier. There is the immediate difficulty of a ratio to suit general requirements, plus the fact that any residual hum and noise picked up by the connecting leads would be amplified along with the signal.

The last position of the switch leaves the input circuit connected to the tuner but brings in a small amount of bass boost for radio, derived, as previously explained, from the feedback network.

All this is more or less straightforward and should present no particular difficulties to any enthusiast who has had some experience of high gain amplifiers. The precautions outlined will be taken more or less automatically and the switching can be arranged to suit individual requirements.

But the position changes abruptly when attention is turned to some of the new pickups, where output voltage has been sacrificed to a much greater degree in the interests of other characteristics.

CURVES FOR 6SN7 PRE AMP.



Two alternative response curves for the 6SN7-GT stage. The dotted lines represent a rise of 3db. and 6db. per octave below 250 c/s. Stage gain is approximately 15 as against 2.5 for the 6SJ7-GT, but problems of hum and stability are more acute.

Typical of the lower output pickups is the Lexington moving coil type, which has a very wide frequency range, operates with ½oz. weight on the needle point and delivers .05 volt peak to the secondary of its output transformer.

Since higher sensitivity is required, the simplest approach is probably a two-stage preamplifier and tone compensator using, for convenience, a 6SN7-GT twin valve. The circuit depicted is based on one suggested by the manufacturers of the Lexington pickup and the accompanying curve shows its response in association with the 807 triode amplifier.

6SN7 CURVES

The curves are actually very similar to that for the 6SJ7 stage, the alternative condenser values approximating 6db. and 3db. per octave compensation. Switching can be arranged to select either degree of boost, or no boost at all, but the 6db. per octave characteristic will be the one normally employed. This involves the use of a .05 mfd condenser in association with the 15,000 ohm resistor.

The extra gain is obtained at the expense of additional components, but there is unfortunately more to it than just that. With the boost in operation, the overall gain at low frequencies is extremely high being in excess of that normally encountered in modulators and public address amplifiers.

A simple calculation will emphasise the requirements. The pickup may deliver a nominal 50 millivolts at 1000 c/s. At 30 c/s the output will be approximately 5 milli-volts, which the amplifier is required to boost to full output—maybe 10 or 20 watts. For pleasant listening, the hum level must be virtually inaudible and, with such high gain, hum voltage injection into the first grid circuit must be reduced to a microscopic figure.

To achieve this result it is essential to isolate the 6SN7-GT preamplifier stage from the power supply, building one or the other on to a separate chassis. We elected to leave the basic amplifier intact and built up the preamplifier stage, with compensation, on a separate small chassis measuring 4in. x 4in. x 3in. deep. This accommodates the pickup output transformer and is connected to the main amplifier by leads a couple of feet long.

MOTORBOATING

Two other points call for special attention. The very high gain at low frequencies is likely to cause instability in the form of motorboating, due to coupling via the power supply.

The circuit shows very heavy decoupling but random time constant effects can still cause trouble. Some experiment may be necessary with the constants of the network and with the point in the main power supply from which the high tension supply is derived.

Last but not least, you can expect the preamplifier valve to be somewhat microphonic at full gain, even assuming that one can choose the best valve in a bunch. There is not much one can do about it but to mount the whole preamplifier on sponge rubber in a spot where it will receive the least vibration.

All this will sound discouraging to the quality enthusiast who may be keen to purchase one of the very low output high fidelity pickups. They are good—very good—but the design of the associated amplifier calls for an approach more akin to studio line equipment than the usual commercial amplifier.

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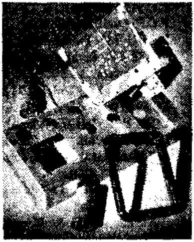

KINGSLEY "Ferrotune" Kitset

Illustrated above is a 4/5 valve Foundation Kit. The components supplied include:

- Kingsley gangless "Ferrotune" tuning unit.
- Calibrated Dial.
- Chassis.
- Kingsley "Permaclad" IFs.

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Nothing could be easier—all you require is a screwdriver, pair of pliers and a soldering iron.

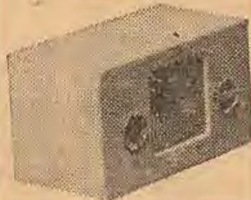
The following kits of parts are for sets that have appeared in Radio & Hobbies and have been selected for their straightforward design and efficiency.
You run no risk as we guarantee to help you with any troubles you encounter—Will check the wiring and test the completed set if necessary.
Remember that every component is of the highest quality—No inferior or used parts are supplied with any of our kits of parts.

SENIOR PORTABLE

R & H, December, 1948.
For the outdoor enthusiast a portable radio is essential. While the personal portable may be desirous as they are very small, their upkeep is rather high. The Senior Portable fills the gap between the large type and the personal portable. It is an efficient 5-valve set using miniature valves and components, in fact the set itself is a miniature, but a 7" speaker and standard size batteries give the results of the best of portables with economical operation. This combination results in a sensible size carrying case which is only 12¼" x 8½" x 6½".
The kit is complete with valves, 7" speaker, batteries and carrying case.

£16/0/0

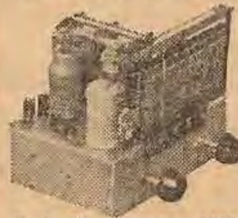
SLUMBER SET



R & H March, 1949.
Many homes require a second radio and the Slumber Set is well worth considering. The circuit is somewhat unusual, but is remarkably efficient and easy to follow. The power output is lower than the average mantel set, but is more than enough for most listeners. A feature that will appeal is its size. The cabinet measuring only 9¼" x 5¼" x 5". This kit is complete with cabinet.

£9/15/6

SHORT WAVE CONVERTER



R & H, January, 1948.
Many homes have a broadcast receiver and do not feel disposed to purchase a new dual-wave receiver. The Short-Wave Converter is the answer. Connected to any reasonable broadcast receiver excellent results can be achieved. Stations in all parts of the world can be tuned in. This converter is easy to build and connect to an existing set.
Complete kit of parts, including valve.

£5/0/0

HIGH FIDELITY AMPLIFIER

R & H, March, 1948.
The recorded music enthusiast will be interested in this amplifier. It was originally published in the Wireless World, a British magazine, and the results claimed were close to perfect. Special transformers have been developed for this amplifier and they must be used if the original performance is to be obtained. The amplifier is easy to construct and is particularly free from troubles in its final tests and adjustments. When used with a good speaker and pick-up, the results will amaze you. The kit includes all the necessary components and valves, but a speaker is not included.

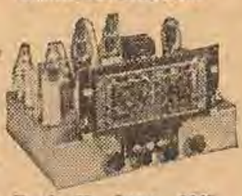
£18/18/0

SPECIAL OFFER! TORCHES

This is a quality torch worth more than double the price. Brass switch—Polished reflector—Colored body with black trim. Complete with 2.5v. bulb and two Everready No. 950 cells.

5/10. Postage 1/- Extra

SENIOR RADIOGROM



R & H, June, 1947.
If you want the best results regardless of cost, the Senior Radiogram is the receiver to select. It is a powerful eight-valve dual-wave set. Particular attention has been given to the audio section to ensure very high quality reproduction both from radio and records. The powerful tuner will bring in any station worth listening to.
The kit is complete with all valves and a 12" Rola Speaker.

£28/5/0

LOW COST AMPLIFIER

R & H, February, 1949.
There is no need to spend a large sum to obtain good record reproduction when a simple two-valve amplifier will do the job. The circuit is very easy to construct and there is practically nothing to go wrong. When used with a crystal pick-up, satisfactory volume for the average size room is achieved. The chassis is designed so that an additional valve may be added at a later date for more volume, or to use one of the lightweight pick-ups.
This kit includes all the necessary components for the two-valve amplifier, an 8" speaker and a high grade crystal pick-up.

£8/0/0

SIMPLE ONE VALVER

We thoroughly recommend this single-valve receiver to the novice.

It is simple to construct, gives ample volume in the 'phones and is economical to operate. The circuit is a regenerative type using a 1Q5GT valve with a HT voltage of only 9.

The kit includes a drilled chassis and panel, all components, valve, batteries and headphones.

£3/18/6

UNIVERSAL FIVE

R & H, January, 1949.
The most popular radio of all is the conventional five-valve broadcast type and the Universal Five is a winner. The circuit is basically similar to the Advance series, but slight modifications have brought it up-to-date and improved the performance. This powerful receiver can be used with every confidence in any district. The kit is complete and includes an 8" Rola Speaker.

£14/15/0

Please note, the quotations for the above kits do not include postage or freight. They can be forwarded freight-on, in N.S.W. only. When ordering remit sufficient for freight, any balance will be refunded in cash.

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