1. Summary

RTV&H 35W P.A. amplifier.
Ebay Nov 2014

Multi-input channel 35W PA amplifier based on RTV&H 1958 articles and Dec 1961 re-run. 3 MIC and one PU input channels with 3x EF86 MIC gain stages, and an EF86 triode mode mixer stage. Then 12AX7 with 1k common cathode biased 10k long-tail PI stage with 100k anode and 1M5 grid leak resistors, and 22nF caps. EL34 cathode biased PP output stage, with 10k grid-stoppers but no screen stoppers.

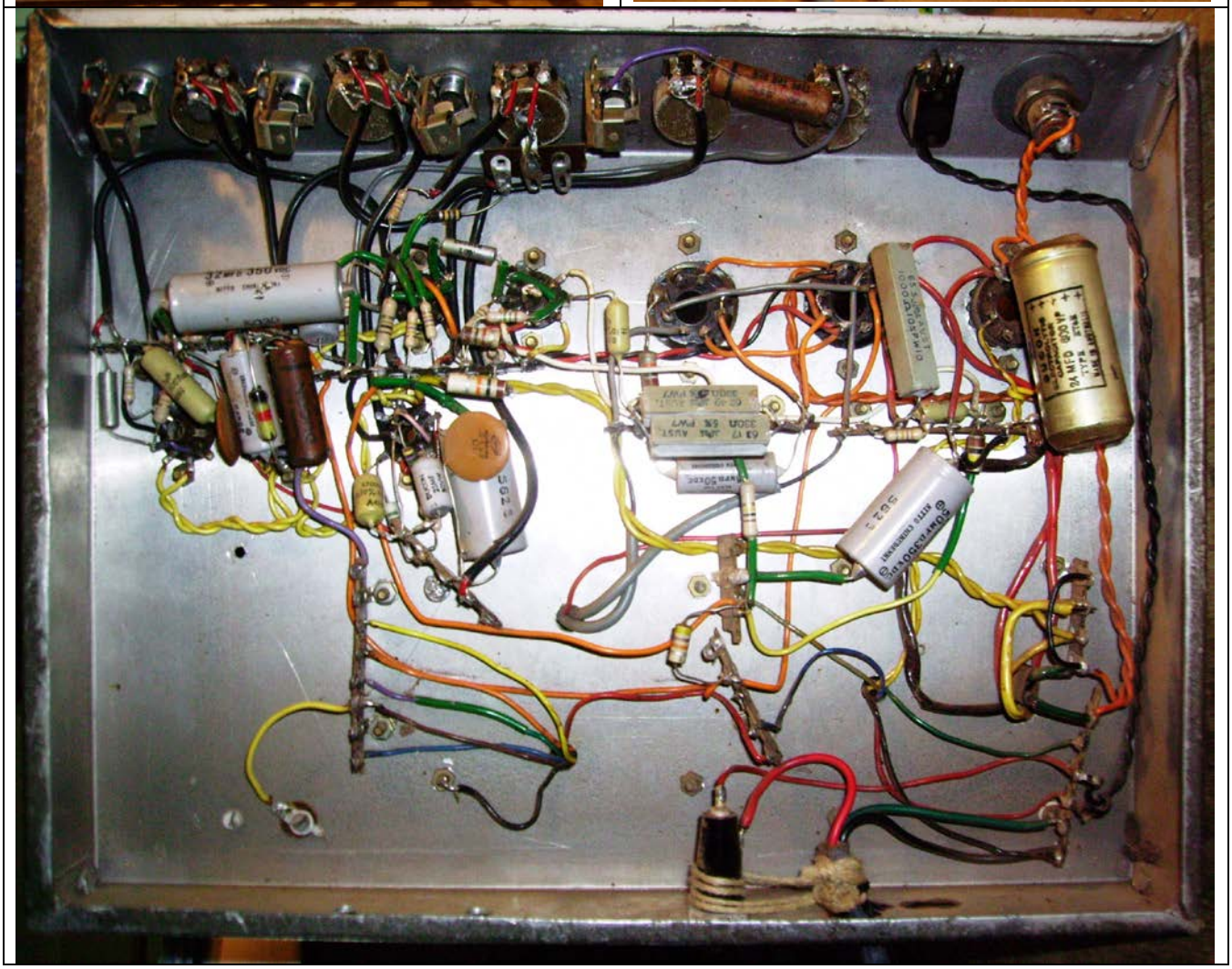
Same Ferguson PT and OT as in 1958 RTV&H 35W PA article prototype. Most likely made from a 'kit of parts' including transformers, valves, valve bases, pots, jacks, tag strips, resistors, capacitors. Date codes on PT, valves, resistors indicate amp made no earlier than 1966.

Output Transformer	Ferguson OPM12: 55W; 3,500Ω PP; Medium fidelity series (40-12k ±2dB) 50, 62, 83,125, 250, 500Ω secondaries
Power Transformer	Ferguson PF1335. 12 64 305-0-305V @ 180mA (YEL,BLU ,YEL); 6V3 CT 4A (GRN,BRN,GRN); 6V3 4A; 5V 3A (YEL,YEL); ES BLU; 0-230-240V (BLK,GRN,RED); ES GRY.
POTs	.
Resistors	IRC 5W 62 49; 63 17 IRC 10W 65 5
Capacitors	Mustards 055H, 125H, 085H
Valves	EL34 x2: Xf2 B4J3 (Blackburn Mullard, likely 1964, October) EF86 x4: 1x 8YI B4I2 ; 3x 8YI B4K5 (likely 1964) marked Miniwatt 12AX7 x1: I? 4E 5AR4 x1:

Fair visual condition; dusty; no modifications. Chassis is not commercial – no underside panel, and no top cover. General signal wiring is pretty good amateur or service technician. Chassis grounding. Poor AC mains cable clamping with disintegrated grommet and poor earth lead length and termination. No protection for AC or HV DC wiring through drilled chassis holes which are too small – brittle insulation. Two broken tag boards. Old electrolytics. Some corrosion on tag strip lugs. 30A mains fuse fitted. Rectifier 5V heater used for front panel bulb – with one end grounded (!?) . One bad EF86. All valves quite microphonic.

The PI common cathode bias is 1k, whereas the RTV&H articles use 2k2. The EF86 mixer anode has no 220pF shunt load, and the tone load is a 39nF + 3M pot. The mixer has no feedback circuit. All input volume pot wipers mix to the EF86 grid, with no other grid-leak. The PU input pot is 1M. MIC3 stage has a 47nF screen bypass, otherwise all MIC input circuits are the same, and powered from same node. 4n7 instead of 47nF PI coupling caps. No control unit interface. RTV&H uses GZ34.

As found condition.



2. Modifications

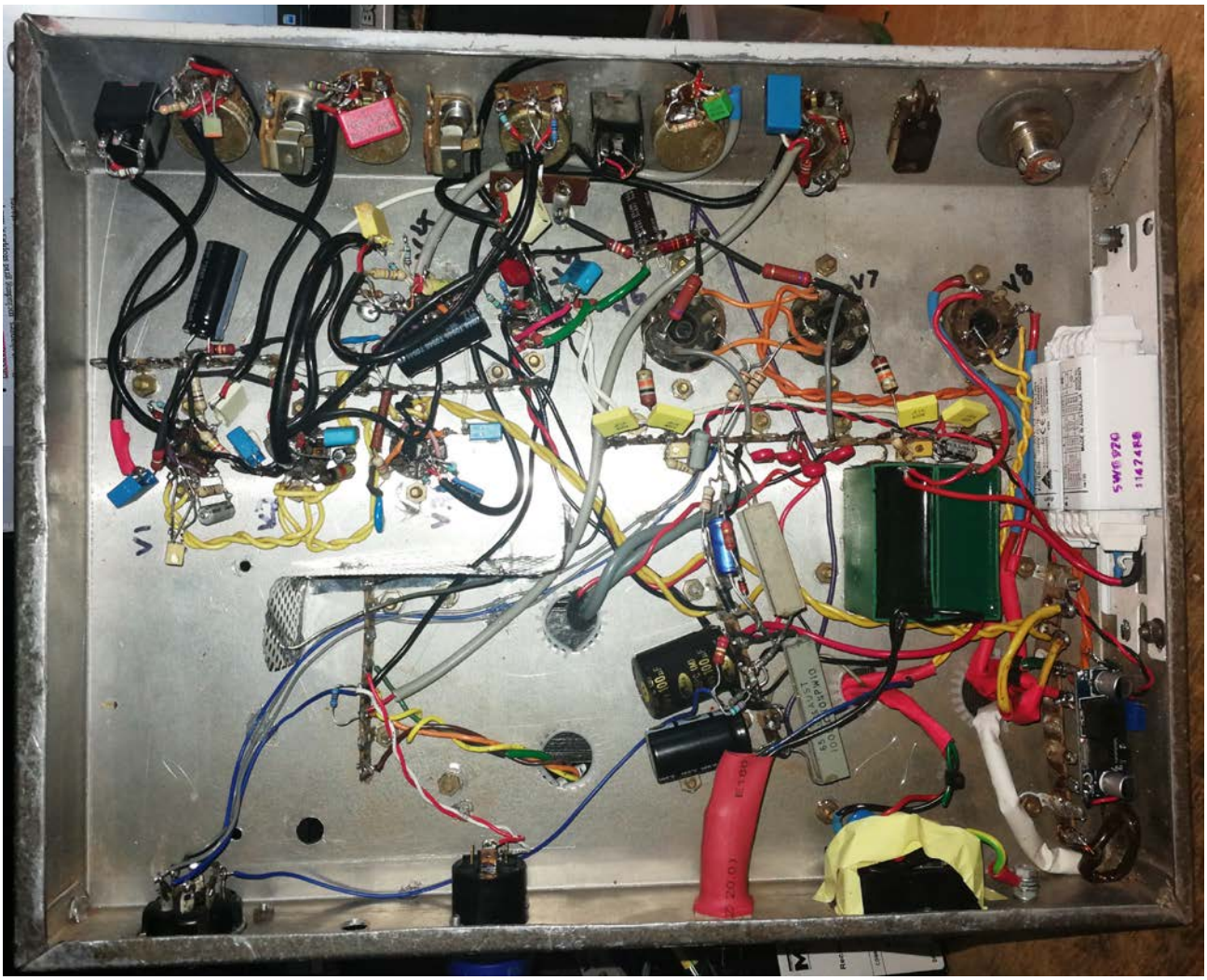
Low input 1st stage: EF86 pentode with Morph and Gain pots. 2nd stage: EF86 pentode with single tone pot (Merlin's active treble boost on one side, and output RC treble cut on other side).
High input 3rd stage: EF86 triode. 4th stage: EF86 triode mixer of low and high inputs, and pre-PI master vol pot. 12AX7 long-tail PI with Martin Manning's presonance tail circuit (treble feedback boost/cut). Feedback from unloaded winding. Output stage: EL34 mixed fixed and cathode biased PP, but suitable for 6L6GC, KT77, KT88, 6550A (heaters are fine; additional fixed bias to alleviate the common cathode bias power dissipation and loss of anode-cathode swing).

- Megger tested Txs – both ok.
- Added AC mains socket/fuse/switch combo.

- Punched larger chassis lead holes for PT and OT wiring, and protected edges. Added heatshrink to all PT leads.
- Added PT primary MOV.
- PT secondary fuse. UF4007 protection diodes on 5AR4.
- Added CL input filter to power supply: 20uF and 1.6H choke.
- Two floating switched ¼" jack inputs.
- Added Speakon speaker socket.
- Add OT primary half-winding MOVs (2x 330VDC).
- Output valve heater is half-wave rectified and then switchmode boosted using XL6009 XTW-SY-8 module. Positive output of module is grounded. Negative output of module is fixed bias supply. The heater winding has one end connected to the fixed bias supply, so may be negative by up to about 40V. The cathodes will be positive above 0V by the common cathode bias level.
- PI coupling caps replaced with 5nF 630V (higher than 400V needed) to lower bass response from about 50-80Hz, and alleviate blocking distortion.
- Common cathode bias constrained by 21V Zener and 150Ω, as well as 1N5359 (24V 5W) Zener and 68Ω.
- Electrolytics replaced.
- Circuit changes, including grid stoppers, and pot wiper loads.
- Metal screening between OT and preamp stages.
- 8-pin monitor socket for 8-meter servicing.
- PI stage 1nF shunt low pass filter added to drop HF gain and tame a 17-22kHz peak from Presonance feedback. Minor load added to feedback winding.

To do:

- Unused: Two input sockets, and switch and indicator on front panel.
- Matched 6L6GC's
- Measure total screen current (use VS2 1k dropper) when cranked. Estimate screen loss, where screen-cathode voltage ~ 300-28 = 250V; total screen current ~ 10mA; screen loss 50% x 250 x 0.01 = 1.2W.
- Road-test. Drop Lo-in gain (increase 220k). Drop V1-V3 coupling cap from 68nF to 4N7.



3. Measurements

Voltage rail regulation. 240Vac mains

Rail	Idle: 240Vac 0.44A mains	Cranked
VS1	367V 180mVrms	325
VS2	350	
VS3	311	
VS4	270	
VS5	255	
Heater	6.6	
Sec HT	305-0-305	
Dc/dc bias supply	- 7.4Vin; -15.6Vout	
VS6,7	- 5.5V	
V6/7 cathode	+18.8V	
Sec Bias	-5.5V + (+19V) = 24.5V 57mA, 57mA	

Power transformer resistances: primary 240-0V = 8 Ω ; secondary = 38+40 Ω

12VAC 50Hz nominal applied to output transformer white-black

OPM12 Winding	Voltage rms	Turns ratio; Z for 3.5K pri PP; Spec; Turns Ratio
Pri P-CT-P: BLK-RED-BLK		; Ω
Sec: BLU to BLK		; Ω; 500Ω; 1000
Sec: GRN to BLK		; Ω; 250Ω; 707
Sec: YEL to BLK		; Ω; 125Ω; 500
Sec: OR to BLK		; Ω; 83Ω; 408
Sec: RD to BLK		; Ω; 62Ω; 352
Sec: BRN to BLK		; Ω; 50Ω; 316

Output transformer primary DC resistance: 53+59Ω.
The winding section between 83Ω and 125Ω is effective 4.2Ω, with 9% of secondary turns.
The winding section between 50Ω and 125Ω is effective 17Ω, with 18% of secondary turns.
As a 4.6kΩ PP OT (eg. for 6L6GC):
The winding section between 125Ω and 250Ω is effective 16Ω, with 21% of secondary turns.

Cathode current reaches 115 / 107mA at 19V (23W) and 9% THD with VS1 sagging to 336V and Vcath at 25.4V, and scope shows one side clipping and some x/over distortion. Cathode current meters show one EL34 is conducting significantly more than other at full output.

Cathode current reaches 158 / 139mA at 22.5V (32W) and 25% THD with VS1 sagging to 324V and Vcath at 28V, and scope shows gross clipping and some x/over distortion.

Lo-in sensitivity of 2.2mV for 23W output (19V) at 500Hz, with Gain at max and MV at max, and Morph=max, Tone=min, Presonance=max. Morph=min has gain of 3.8x. Tone=max has gain of 7.8x. Pres=min has gain of 1.7x.

Hi-in sensitivity of 400mV for 23W output (19V) at 500Hz, with MV at max.

V1 stage gain of 2.12V/0.08V = 26.5x. Top of Gain pot. Morph=max.
V2 stage gain of 3.16V/0.572V = 5.5x. Gain at max. Top of Gain pot to top of 220k. Tone at min.
V3 stage gain of 0.73V/0.03V = 24x. Top of 220k.
V4 stage gain of 7.39V/0.73V = 10x. Top of 220k to top of MV.
Output stage gain of 10V/1.49V = 6.7x. Top of MV, MV at max. Speaker at 15.8 ohm.

See measurements folder for spectrum sweeps with various Morph/Tone/Pres pot settings, as well as noise floor spectrums. Mains earth loop peaks (50Hz, 150Hz) coming in to measurements due to separation on chassis between PE location and 0V link, and USB connection of EMU 0404 USB, even with amp and PC on same power board.

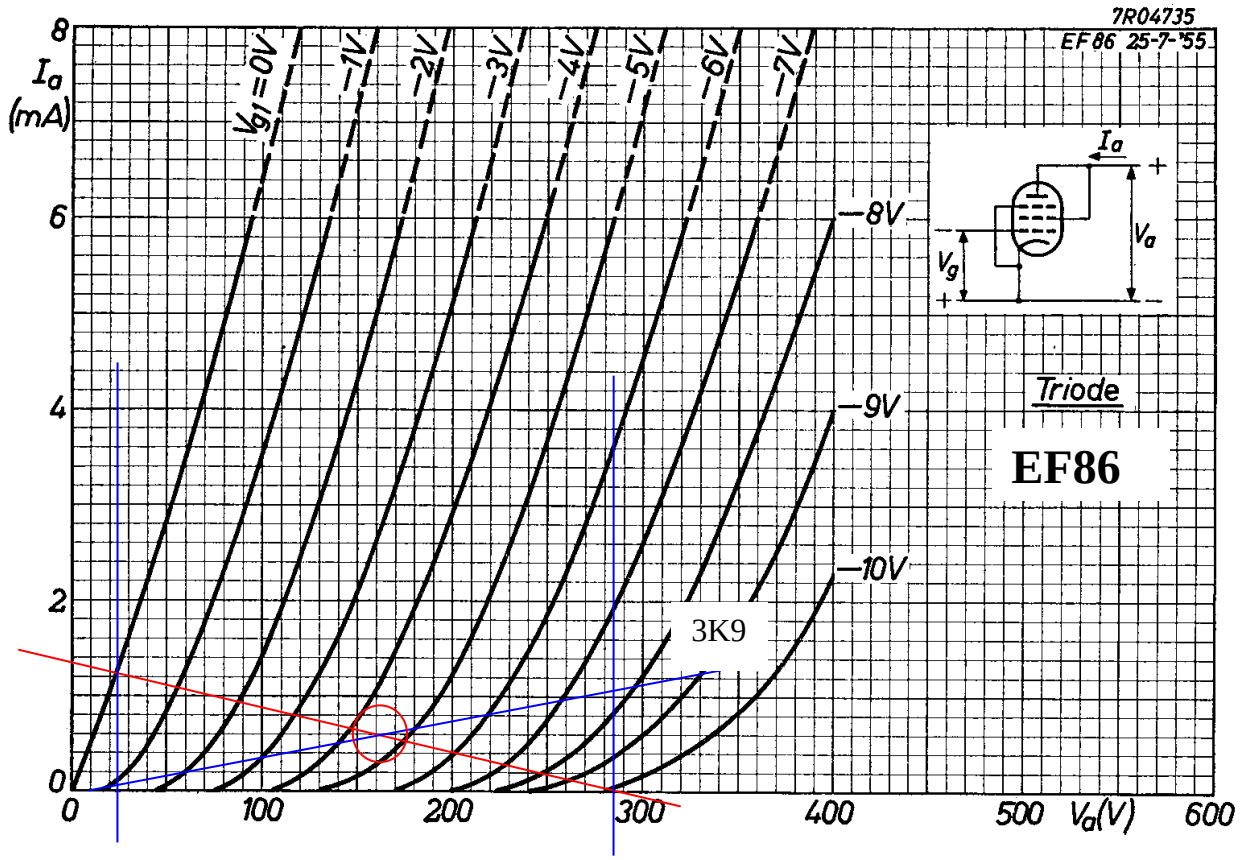
4. Design

4.1 EF86 pentode stages

Two EF86 pentode stages, V1, V2: VS4=250V; Va=125V; Rk=3k9Ω; Vk=2.6V; Ia=0.68mA; RLdc=220kΩ.

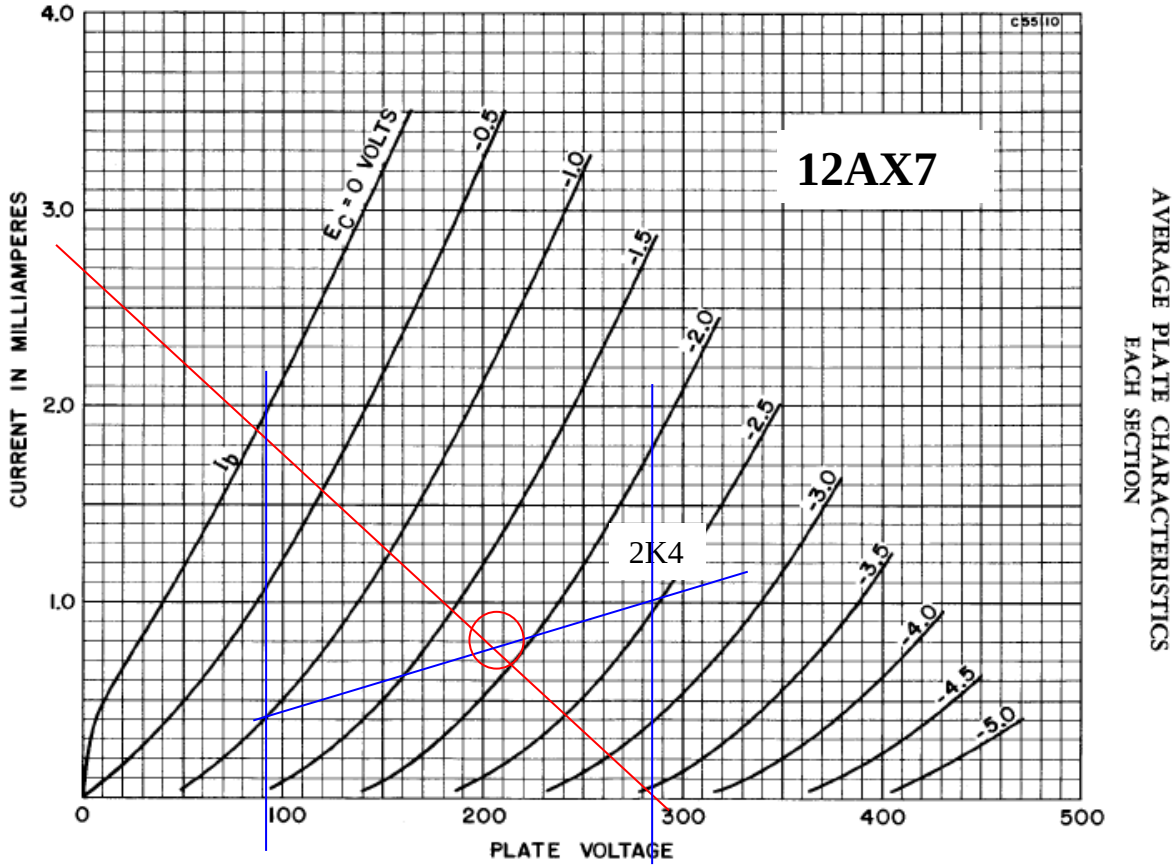
4.2 EF86 triode stages

Two EF86 triode stages, V3, V4: VS4=270V; Va=120V; Rk=3k9Ω; Vk=2.6V; Ia=0.68mA; RLdc=220kΩ.



4.3 12AX7 long-tail pair PI stage

12AX7 long tail pair; V5: VS3=309V; Va=230V; Rk=1k2Ω; Vk=1.V; Ia=0.79mA; RLdc=100kΩ. Rtail=12.3kΩ. Vtail=23.5V.



4.4 PP Output Stage

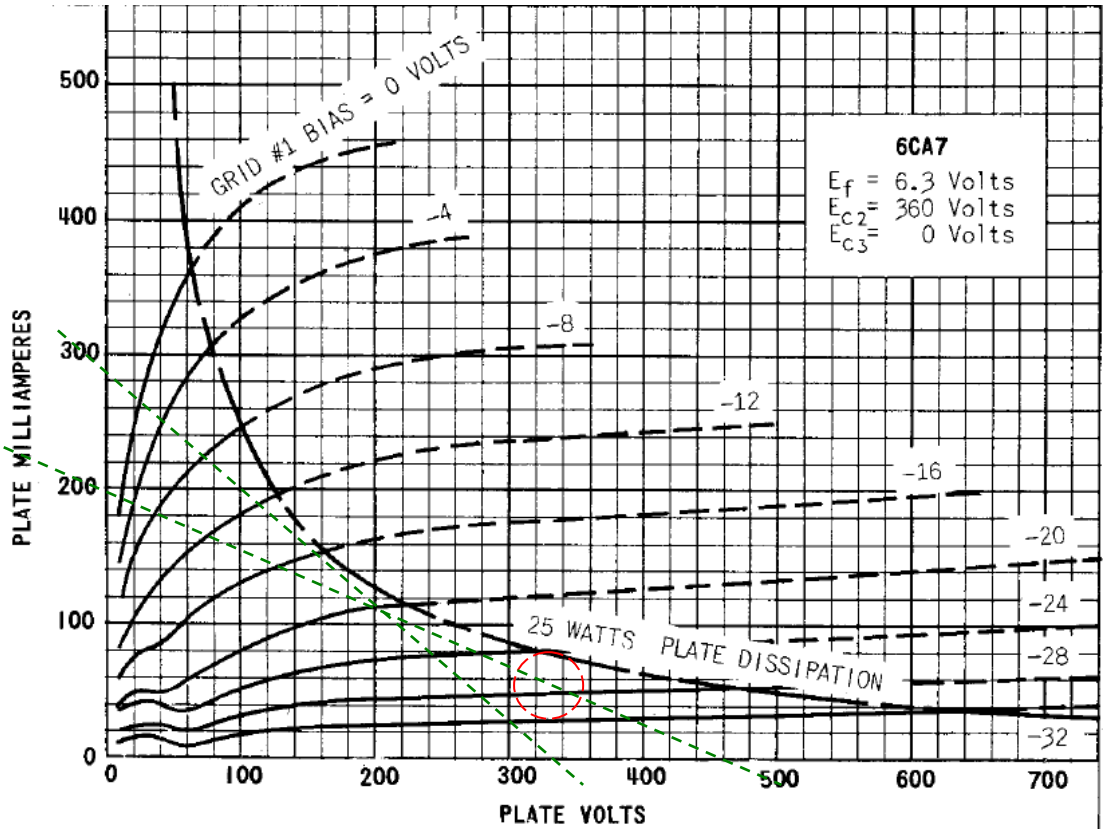
Class AB push-pull EL34 output stage with cathode bias. The effective 4.6kΩ impedance plate-to-plate OPT, presents each tube with 2.3k loading near idle, and 1.2k at heavier loading.

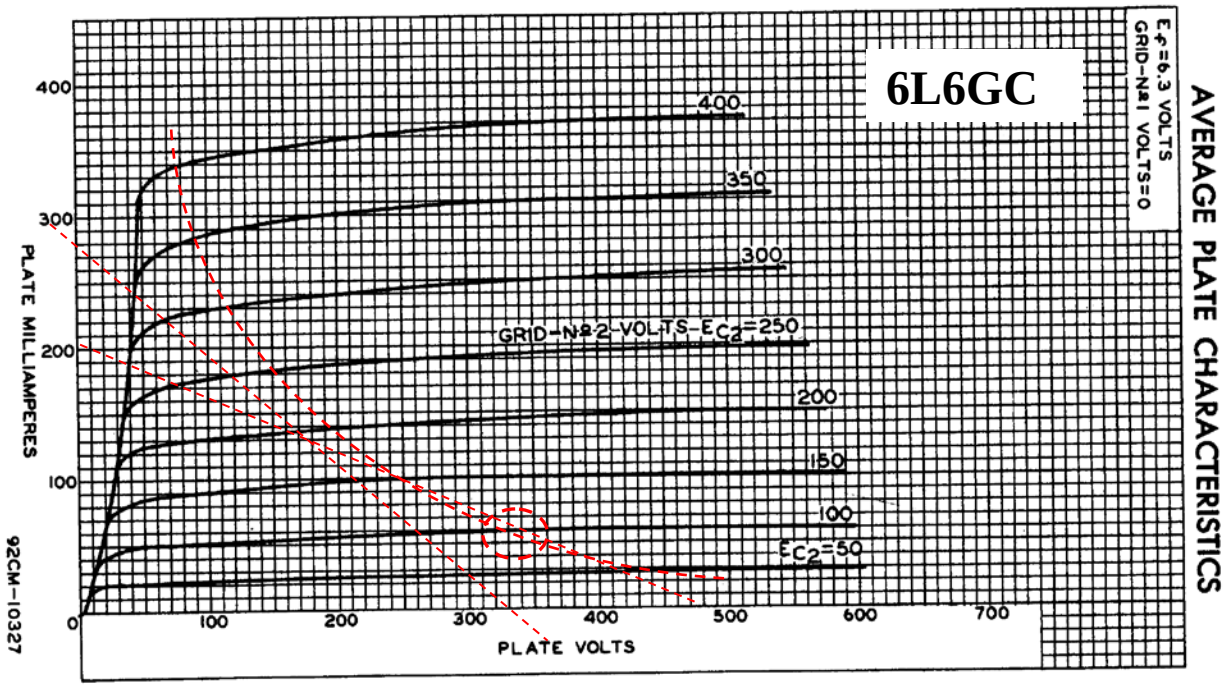
The supply voltage VS1 at idle current of 57+57mA is about 365V. Plate-cathode idle voltage will be lower than VS1 by ~0.057x55+2x0.057x165=22V; ie. an idle current of 57mA per tube, and OPT half resistance of about 55Ω, plus 165Ω common cathode.

VS2 is about 350V VS2 (320V screen-cathode) to bring 360V curves down a bit.

The max design output valve bias current allowed is dependent on the maximum recommended plate dissipation of 25W for EL34: Ibias(max) = Pd / Vb = 21W / 345V = 61mA.

The nominal output power of the amplifier will then be:
(Imax)2 x Rpp / 8 = 0.25 x 0.25 x 4.6k / 8 = 35W


6CA7
E_f = 6.3 Volts
E_{c2} = 360 Volts
E_{c3} = 0 Volts
GRID #1 BIAS = 0 VOLTS
-4
-8
-12
-16
-20
-24
-28
-32
25 WATTS PLATE DISSIPATION
PLATE MILLIAMPERES
PLATE VOLTS
0
100
200
300
400
500
600
700


6L6GC
E_f=6.3 VOLTS
GRID-№1 VOLTS=0
400
350
300
GRID-№2-VOLTS-E_{c2}=250
200
150
100
E_{c2}=50
PLATE MILLIAMPERES
PLATE VOLTS
92CM-10327
AVERAGE PLATE CHARACTERISTICS

4.5 Powering

GZ34 was original design. 5AR4 is almost identical, with small increase in continuous peak current, and possibly lower diode drop (which could make up the lower 305-0-305V HT on the PT, compared with 325-0-325V).

The indirectly heated 5AR4 has limits on the effective source resistance when feeding a capacitor-input filter. The effective source resistance is comprised of the reflected power transformer primary resistance = 8Ω x $(305/240)^2$ = 13Ω; plus the secondary resistance = 40Ω; which sums to 53Ω. The effective source resistance should be 85Ω for a secondary supply of 300Vrms, based on 40uF capacitor-input filter, where the output DC level will sag from about 450V to 370V at 100mA, with load current capability to 250mA.

Idle current of 2x57 + 15 = 135mA, VS1 ~ 365V, and diode peak continuous current is ~0.65A, with an initial surge peak of 2.7A – both those conditions are well under 5AR4 max rated levels.

The initial turn-on peak VS1 can almost reach 400V.

The PT 5V heater can handle 3A, although the 5AR4 has a very low on-voltage.

Heater 1 (6.3V 4A): (EL34 x2): 1.5 x 2 ~ 3.0A
Heater 2 (6.3V 4A CT): (12AX7 x1; EF86 x4): 0.3 x1 + 0.2 x4 ~ 1.1A

Full-wave with 135mA hot load on VS1. IEC60127-2 250mA Time-delay fuse is lowest acceptable rating for HT secondary fuse in CT, as continuous current may exceed 200mA.

Simulate period in PSUD2	20ms	40ms	100ms	500ms	continuous
Simulated RMS current	0.84A	0.97A	0.69A	0.33A	0.19A
Multiplier (based on 0.250A fuse rating)	3.4	4	2.8	1.3	0.76
IEC60127-2 Time-delay min limit multiplier	10	~7	~4.8	~2.9	1

4.6 Servicing

Connect the 8 meter servicing rig to the Octal socket, and configure the rig for:

- common cathode voltage sensing
- default 30V FS on common cathode.

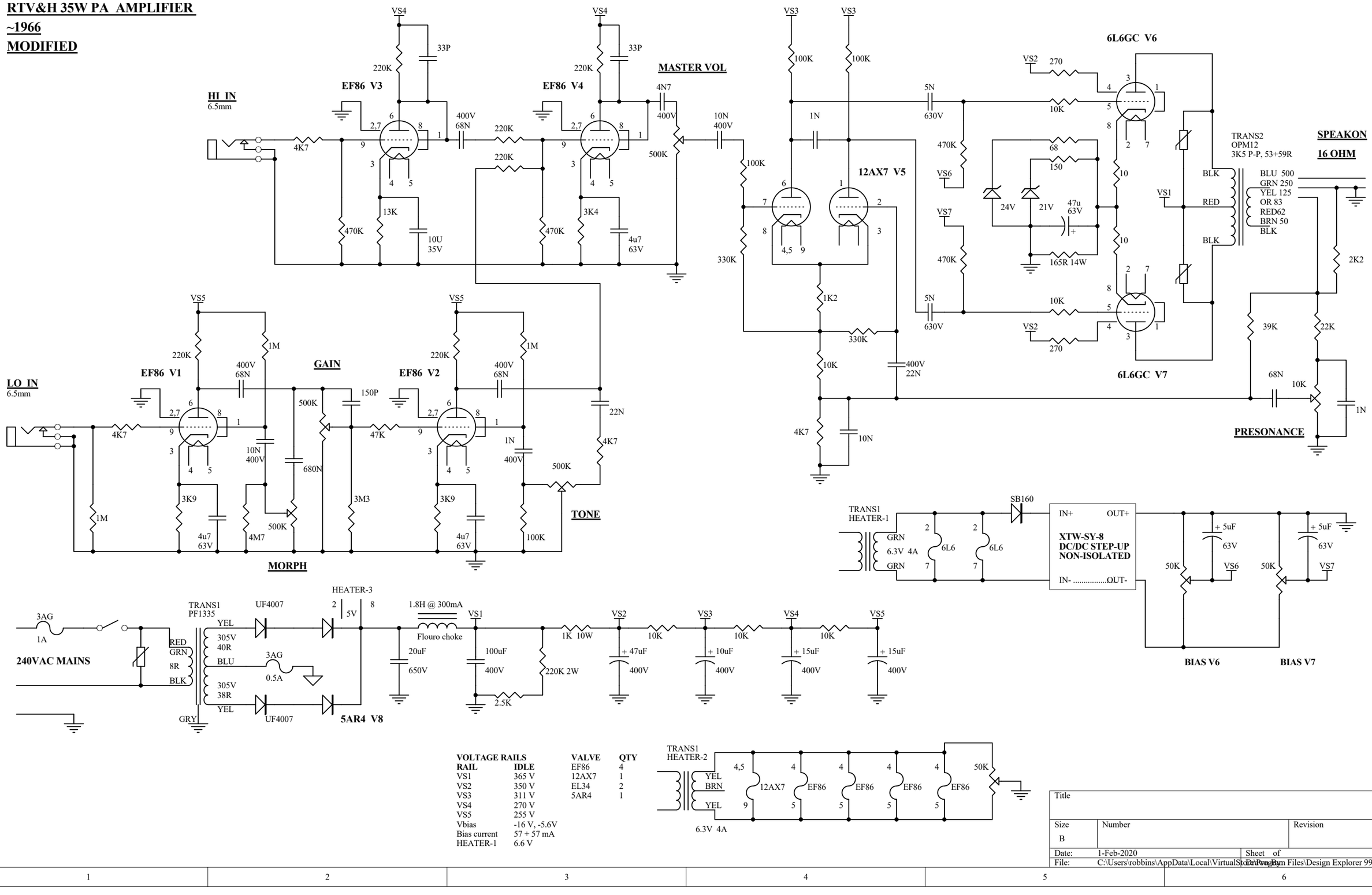
Nominal idle voltage levels:

Common cathode ~	1900	= 19V across 165Ω = 115mA	
V5 cathode current ~	0057	= 57mA	~ 20W
V6 cathode current ~	0057	= 57mA	~ 20W
VS1/100 ~	0370	= 370V	

Caution if probing the Octal socket not to accidently ground pins 2,3,4 as that would partly collapse the output stage bias voltage.

Note that the fixed bias supply has been set to -15.8V, and fixed bias to each grid to about -5.5V, so total bias is about 19+5.5 = -25V.

RTV&H 35W PA AMPLIFIER
~1966
MODIFIED



VOLTAGE RAILS		VALVE	QTY
RAIL	IDLE	EF86	4
VS1	365 V	12AX7	1
VS2	350 V	EL34	2
VS3	311 V	5AR4	1
VS4	270 V		
VS5	255 V		
Vbias	-16 V, -5.6V		
Bias current	57 + 57 mA		
HEATER-1	6.6 V		

Title		
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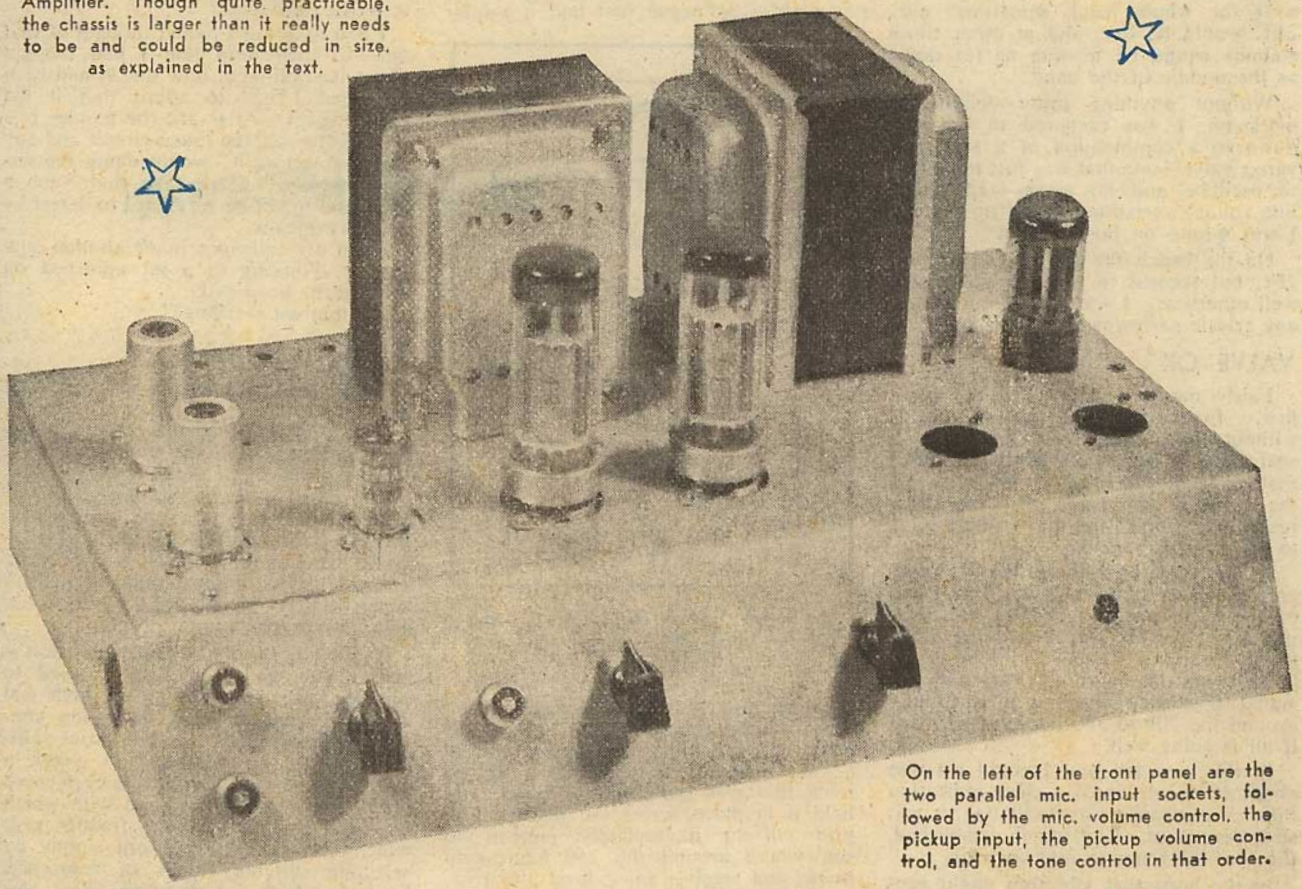
File: C:\Users\robbins\AppData\Local\VirtualStore\Program Files\Design Explorer 99 SE\Examples\Pr		

For purposes of development, the amplifier was built on the chassis which originally carried the 40-watt Factory Amplifier. Though quite practicable, the chassis is larger than it really needs to be and could be reduced in size, as explained in the text.



On the left of the front panel are the two parallel mic. input sockets, followed by the mic. volume control, the pickup input, the pickup volume control, and the tone control in that order.

A 35 Watt Amplifier For P.A.

Here's a project which should be of special interest to many of our readers—a modern 35-watt public address amplifier. It features high gain, mixing facilities and a multi-tapped output transformer to suit a variety of speaker line impedances.

by Philip Watson

IT is some time since we made any reference to the subject of public address amplifiers and re-statement of the general requirements may be of interest to newcomers in this field.

It is possible to do a P.A. job with almost any powerful amplifier, plus a microphone preamp. stage but it doesn't follow that the job will be done well or cheaply or conveniently. A public address amplifier is a special "breed," distinct from the domestic variety.

POWER OUTPUT

Power output is a major consideration, because the very use of the gear presupposes a fairly large audience in a hall or in the open air. The audience may be quiet or noisy, according to the activities of the moment.

This might be accepted as an argument for building a single very large amplifier, able to meet all conceivable power requirements and, indeed, it is. However, it takes no account of the fact that a very powerful amplifier is also likely to be very costly to buy or build, heavy to carry around and possibly more prone to trouble because of the higher voltages and currents throughout.

There is the further complication that a very large amplifier is not economical to operate from a battery-inverter supply, should this ever be necessary.

The wise course is to assess the job or jobs for which an amplifier is likely to be required, consider cost and weight factors and choose accordingly.

In the light of the foregoing, P.A. systems can well be subdivided into about four main classes.

Smallest and cheapest is the single-pentode 4-watt type of thing, which can barely lay claim to the description "public address." Unless it is used with a directional horn speaker, the acoustic power available is not much more than the unaided voice.

However, an amplifier of this type can maintain the said power indefinitely —without getting a sore throat—and is very useful for relaying speech into anterooms, for paging and so on.

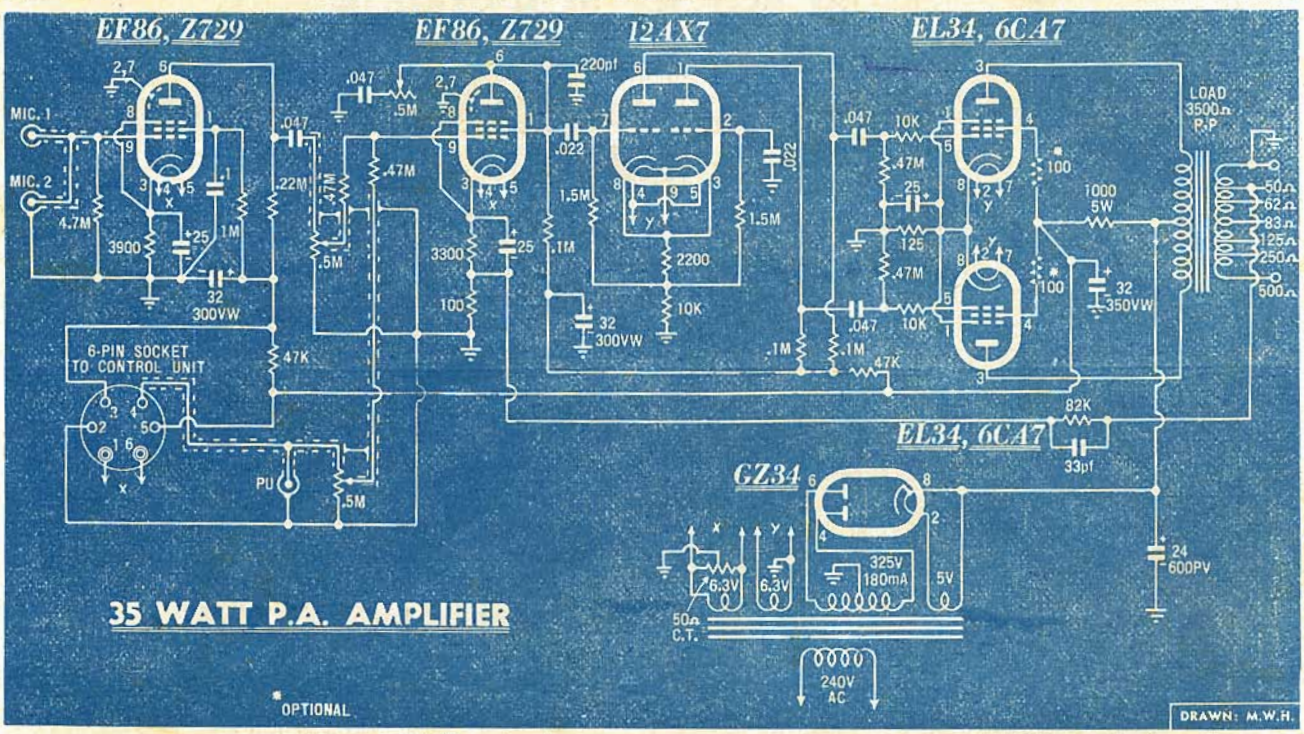
A second class of amplifier has an output of about 10-15 watts, being designed around "receiving type" valves and components. Such an amplifier is normally compact, easy to build and capable of useful speech reinforcement.

OVERLOAD DANGER

However, there is usually very little margin between average operating level and overload and the operator has to watch mic. placement and volume setting very carefully, in consequence.

A third type of amplifier has an output in the 30-50 watt region, using heavy duty power equipment and large

CIRCUIT USES EL34'S IN CLASS AB OPERATION



The circuit is quite straight forward, and follows standard practice. Note the 6-pin outlet socket, with HT supplies for either a control unit or tuner. The cathode coupled phase inverter provides a useful amount of gain, making the overall gain of the system quite high.

output valves without, however, going into the complications of fixed bias, regulated HT supply and possibly Class B2 operation. An amplifier of this type will handle most P.A. jobs without distress.

Last but not least are the really big amplifiers, using very heavy power equipment and large output valves under maximum conditions. In general, such amplifiers are only necessary for big outdoor gatherings, country shows, sports meetings and such like.

So much for power output. On the subject of reproduction quality, the standards do not need to be quite as high as for specialised domestic listening, nor the hum level quite as low.

DISTORTION

Obvious distortion must be avoided, of course, but there is no point in spending money to obtain near-perfection from the amplifier, when reproduction will be limited anyway by microphones and *speakers of strictly average quality*.

And what of the input facilities, tone control and such like? Most technicians have "pipe dreams" at some time or other about P.A. systems with multiple inputs, mixing and cueing facilities and complex tone controls. Some even build them up!

In the hard world of reality, the result may be splendid for one particular job but a decided nuisance for everything else! It's larger than necessary and it can't be left in the hands of an unskilled operator without a lengthy dissertation on what all the knobs are for.

By and large, most ordinary P.A. jobs can be handled by one or at most two microphones and one pickup, with mixing facilities. A simple top-cut tone control is handy also to temper some records and voices and as a possible aid against acoustic feedback in adverse situations.

If more channels and/or more extensive tone compensation is required, there is good argument for providing the extra facilities in a separate mixer panel, which can be taken to a special job along with extra microphones, cables, turntables and so on.

Last but not least, there is the output circuit to consider. In a modern domestic amplifier the output transformer is mounted on the chassis, feeding the speaker through extended leads running to the voice coil.

This scheme is quite adequate for domestic listening, where the leads can be kept short enough for their DC resistance to be much lower than the voice coil impedance. For public address amplifier work, quite long speaker leads are sometimes required and lead-loss can be significant, particularly when feeding into single or parallel 2-ohm voice coils.

There is good argument, therefore, for equipping all larger public address amplifiers with an output transformer having a 500-ohm secondary winding. Leads can then be run without significant loss to

PARTS LIST

1 Chassis to suit, see text.
1 Power Transformer 325V-325V, 180 mA. 6.3V 4A. 6.3V 4A. 5V 2A. PF1335 or similar
1 Output transformer. Prim. 3500 ohms. Sec. 500 ohms tapped OPM 12 or similar

VALVES

2 EL34 — 2 EF86
1 12AX7 — 1 GZ34

SOCKETS

1 Octal (Optional type)
2 Miniature 9 pin with shield
2 Octal (Amphenol Replacement Type)
1 Miniature 9 pin plain
1 6 pin
3 Single contact mic. plugs and sockets type C/1/02M and C/1/01F or similar

CAPACITORS

1 32 mfd 350VW electrolytic
2 32 mfd 300VW electrolytic
3 25 mfd 25VW electrolytic
1 24 mfd 600PV electrolytic
1 .1mfd 400V paper
4 .047 mfd 400V paper
2 .022 mfd 200V paper
1 220 pf mica or ceramic
1 33 pf mica or ceramic

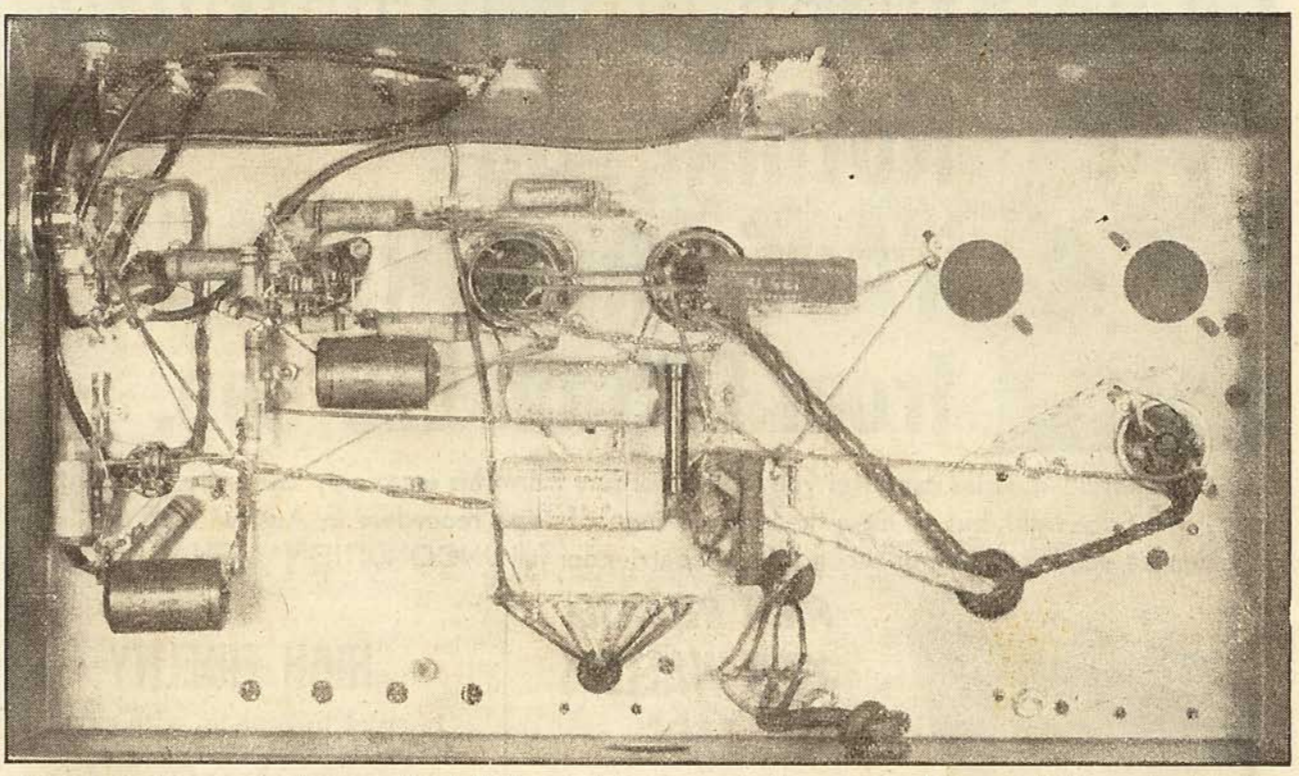
RESISTORS

1 4.7M ½W — 2 1.5M ½W
1 1M 1W — 3 .5M potentiometres
4 .47M ½W
3 .1M 1W — 1 .22M 1W
2 47K 1W — 1 82K ½W
1 3900 ohms ½W — 3 10K ½W
1 2200 ohms ½W — 1 3300 ohms ½W
1 100 ohms ½W — 1 125 ohms 10W
1 1000 ohms 5W — 1 50 ohms 5W centre tapped

SUNDRIES

1 4 tag terminal strip
7 8 tag terminal strips
3 knobs
2 yds PT9M co-axial cable, hookup wire, power flex, grommets, nuts and bolts, solder lugs etc.

UNDERSIDE PICTURE SHOWS WIRING AND LAYOUT



Here we see the power transformer on the right, the output transformer in the centre, and the two EF86's on the left. The socket hole in the rear of the chassis may be used to accommodate a speaker socket if the speaker connections are to be a fixed combination.

distant speakers, a second transformer at the speaker stepping the impedance down to that of the voice coil.

While making this provision, it is usual to provide several tappings on the 500-ohm secondary, such that the amplifier can be connected without serious mismatch to one, two or several 500-ohm speakers connected in parallel

Our present amplifier is an attempt to satisfy one of these requirements, that of the third category. It would be suitable for all but the most elaborate systems, yet still remain within reasonable limits of size and cost.

The result is a unit capable of delivering 35 watts to the secondary of the output transformer, having provision for matching from one to 10 speakers via 500-ohm lines, and with facilities for mixing one twin microphone channel and one pickup channel. As we said earlier, this will be adequate for the great majority of ordinary P.A. jobs.

POWER TAKE-OFF

However, we have not overlooked those who may require more elaborate input facilities. An output socket is mounted on the side of the chassis, similar to the Playmaster system and this can power an auxiliary control unit, containing as many input and mixing facilities as we like to provide.

The output of this can go to the existing pickup channel, allowing the present pickup control to become a master fader. At the same time, the existing microphone channel is still available via the present mixing circuit

Reference to the circuit will show that the output stage uses a pair of EL34's (6CA7's) and these are operated in class AB at close to their maximum ratings. Under these conditions we had no difficulty in obtaining the expected 35 watts with negligible distortion of a sine wave input.

We spent some time arriving at a final design for the power supply, particularly as regards the final voltage it would deliver. With output valves of the type we are using, and when endeavouring to operate them as close to the maximum ratings as possible, more than usual care is necessary to ensure that dissipation ratings are not exceeded.

H.T. VOLTAGE

Such factors as the power transformer primary and secondary DC resistance, the output transformer primary DC resistance, plus the inevitable tolerances in other components—including the rectifier—all have a significant bearing on the voltage finally applied to the plate and screen.

Since it is impossible to control accurately all these factors, we have nominated a set of operating conditions which should keep everything wihtin ratings with most combinations. The power transformer is rated at 325V, 180 mA, and this should deliver just over 350 volts, measured at the output plates.

The screen dropping resistor is 1,000 ohms, which is higher than recommended by the valve manufacturers. However, it is a handy way to control the total cathode current, and may be varied, as required betwen 500 and 2,000 ohms.

A simple method of controlling the final voltage is to use a GZ32 or 5V4G rectifier. These will give from 10 to 20 volts less than the GZ34 and may therefore be preferred, if it is desired to use an existing transformer having a higher voltage rating. Alternatively a selected wire-wound resistor, wired between centre tap and chassis can reduce H.T. voltage to the required figure.

By avoiding the use of a filter choke we save considerable cost and weight, and the push-pull circuit eliminates any trace of hum due to ripple which may be present at the rectifier cathode. The earlier stages are supplied from a simple decoupling network, which is quite effective by reason of the small current drain required.

A 12AX7 twin triode is used as a cathode-coupled phase inverter and is thus able to contribute a useful amount of gain to the system. It is very similar to the circuit used in the No.12 Playmaster.

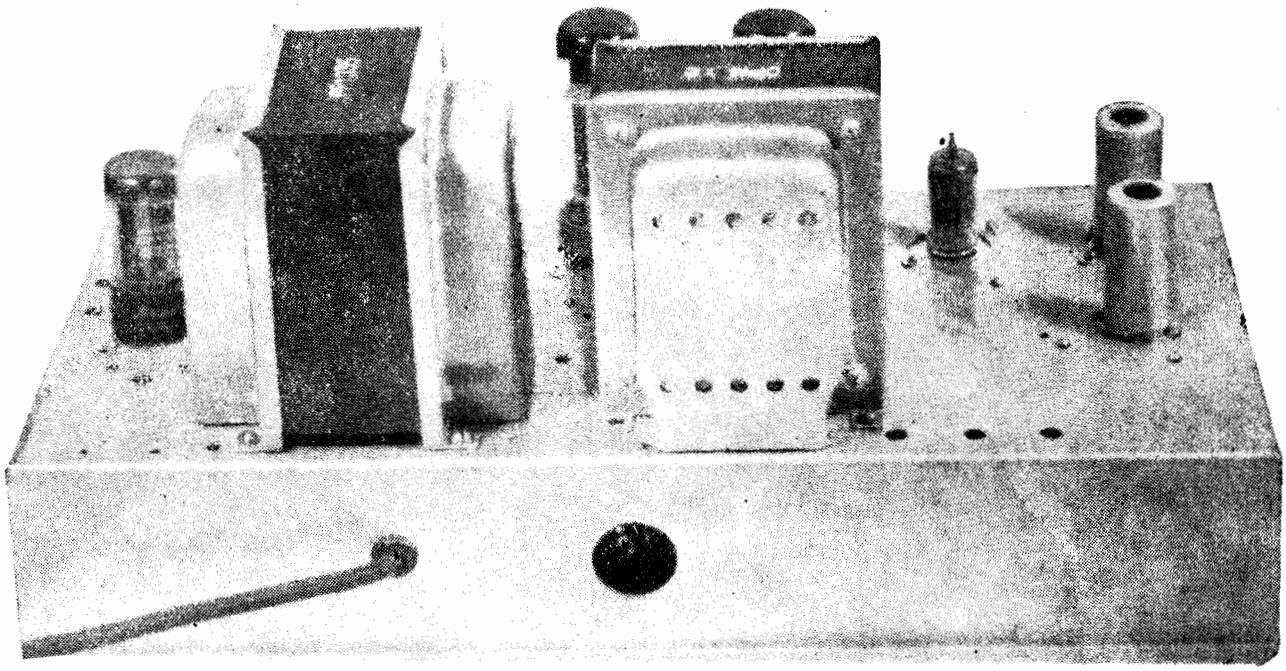
MIXER CIRCUIT

Ahead of this is an EF86 (or Z729) triode-connected, as a straight voltage amplifier. In the grid circuit is a simple mixer network, using two volume controls and two isolating resistors, one section connecting to the pickup input and the other to the output of the microphone pre-amplifier.

The pre-amp is another EF86, pentode-connected this time. The low noise and rigid construction of this valve shows to good advantage in this application, there being virtually no problem with noise or microphony and no need to resort to shock mounting of the socket

The overall gain of the amplifier is quite high. The pickup channel will drive the system to full output with less

REAR VIEW SHOWING POSITION OF LARGER UNITS



An excellent idea of the wiring and layout can be obtained from this underhassis picture. The GZ34 socket is on the extreme right, the two EL34's top entre, and the 12AX7 and EF86's on the left. Note the placement of the various terminal strips supporting the minor components.

than 200 millivolts input, while the microphone channel requires little more than a millivolt for full output.

As an example of what this means in practice, we were able to obtain satisfactory operation from a low impedance moving coil microphone without the benefit of any coupling transformer. While an unlikely condition in practice, it nevertheless gives a good idea of just what can be expected. When used with a conventional crystal microphone the gain control does not need to be advanced more than a few degrees.

MIKE INPUTS

Two microphone input circuits are provided, being simply two parallel circuits. This arrangement has a number of limitations, but is so simple that we felt it was a worthwhile improvement over a single input. The limitations are that the two microphones must be of similar type and have similar output, plus the fact that it is not possible to control each microphone individually.

However, provided these points are appreciated, the scheme can be quite a useful one.

Negative feedback is obtained from the 50-ohm tapping on the output transformer, and the constants are so selected as to give approximately 12 db gain reduction. This amount is adequate to provide most of the advantages expected from a feedback loop, yet not so great as to introduce serious instability problems, particularly when we consider the probable variety of loads likely to be presented to any PA amplifier.

The decision to take the feedback from the low impedance tap was made after a number of checks, and on the advice of the transformer manufacturer. The arrangement appears to offer two advantages; a reduction in phase rotation with consequent lessening of instability risks, and a more constant feedback characteristic with varying load conditions, since the feedback is aways taken from a loaded portion of the winding.

An important feature of the feedback loop is the 33pf capacitor shunting the 82K feedback resistor. This value was selected experimentally to give the best square wave performance (which is quite good, incidentaliy) consistent with maximum stability under varying load conditions.

However, if another make of output transformer is employed it may be necessary to alter this value. If a square wave generator is not available, the equipment should at least be checked with a sine wave and CRO, over the full range of power output, to ensure that it cannot be shocked into oscillation under any condition of operation. Ideally this test should be made into a speaker load, but a resistor may have to be substituted if there is no speaker system available to handle the full load.

FEEDBACK CIRCUITS

Another possibility we considered was the use of a feedback system which took the signal from one of the output plates, thus avoiding the output transformer and any associated variables. Unfortunately, from either plate singly, we get a very substantial hum signal, even though this is completely cancelled in the secondary circuit. Thus we could only employ this system if we were prepared to use a large and expensive filter network.

All things considered, the present scheme appears to be the best one. The above problems are only mentioned as a precaution; being the kind of trouble likely to result from indiscriminate alterations to the circuit.

The output transformer is a new model by this particular manufacturer, and is intended to replace some of the older types. The primary is rated at 3,500 ohms plate to plate, and the secondary at 500 ohms, with suitable tappings. These are arranged to accommodate 2, 4, 6, 8, and 10 speakers, each having its own 500 ohm-to-voice coil transformer.

The provision of two speaker increments instead of single steps is a compromise, but a justifiable one. If an odd number of speakers should be required, the mismatch is still quite small, while the cost of the extra tappings would be appreciable.

TONE CONTROL

A simple top-cut tone control is provided and, although within the feedback loop, the constants chosen give an adequate degree of control. In most cases nothing more elaborate will be necessary.

The 6-pin outlet socket on the side of the chassis supplies heater voltage, a signal input circuit, a chassis connection, and two HT circuits. One of these is decoupled to suit the pre-amplifier stage, and is intended for use with whatever control units we develop. The other comes from the main HT line and is intended for use with a tuner, if this should ever be required. Note, however, that a tuner might easily draw 20 milliamps, requiring a transformer rating nearer to 200 milliamps.

The amplifier you see pictured is built on the same chassis as originally used for the 40-watt Factory Amplifier, described some years ago. This much is obvious from the fact that small valves occupy octal-sized holes, while the EL84 valves sit completely on top of the chassis, instead of being let part way through it, as was done with the 807's in the earlier unit .

What is more, space which was originally taken up by the filter choke is now vacant.

We would very much like to have made up a new chassis to correct these

anomalies but had to cut corners in the physical sense to allow us more time to concentrate on the electrical circuit.

Looking at the present chassis, it is obvious that the rectifier valve could come forward into the vacant socket hole alongside the EL34, allowing the chassis to be shortened by at least two inches. The change would not involve any alteration whatever in the layout of the components in the amplifier section proper, so that our ideas and remarks in this connection stand good.

Readers, who are interested in the P.A. field may have their own ideas about amplifier size and layout, of course, but we will re-examine the situation during the coming month and possibly issue a blueprint bringing the chassis into line with present requirements.

A good idea of the wiring can be obtained from the photographs, and we must assume that anyone tackling a project of this kind will be able to work out the main points of the layout for himself. However, there are some important details worth noting and which will help the reader to duplicate the original.

First the orientation of the valve sockets. The EL34's have the keyway toward the power transformer, the 12AX7 toward the pickup volume control, and the two EF86's toward the end, and slightly to the rear of the chassis.

TERMINAL STRIPS

Liberal use is made of terminal strips to support the minor components, there being seven of the eight tag variety, and one four tag. The latter is used to terminate the primary leads of the power transformer.

The others are used as follows: (1) To terminate the output transformer secondary leads. (2) To support the 1,000 ohm filter resistor, the 50 ohm centre tap resistor, and to terminate the 32 and 24 mfd electrolytics. (3) To support the EL34 grid resistors, one of the .047 mfd coupling capacitors, and to terminate the grid stopper resistors and the other .047 mfd coupling capacitor.

No.4 (near the 12AX7 socket) accommodates most of the components associated with the phase inverter, including the HT decoupling components, while No.5 is almost an extension of No.4 and carries the plate, screen, and decoupling circuits for the mic. pre-amplifier stage.

No.6 (parallel with No.5, on the other side of the socket) accommodates the grid and cathode circuits of the pre-amplifier stage, while No.7 (in the corner near the other EF86 socket) carries the grid and cathode circuits, as well as the two feedback components. Note that these latter should be kept clear of the grid circuits.

Next point for consideration is the "earthing" of the input circuits and the avoidance of "earth loops" and associated hum problems.

The three input sockets (two mic., one pickup) are a standard type which is easily insulated from the chassis, the necessary insulating washers being supplied with them. However, no spacing washers are provided and these may have to be improvised. Very short lengths of about 8mm plastic tubing make ideal spacers.

A large solder lug is provided with each socket and these should be fitted under the mounting nut, but insulated from the chassis. This enables the earthy side of each socket to be earthed at a selected point near the appropriate EF86 socket.

All the input wiring is made with PT9M co-axial cable. This has the advantage of low capacitance per foot, as well as being insulated; an essential requirement where earth loops are to be avoided.

For the pickup input, the selected earth point is the earth tag on the terminal strip near the EF86 socket, and close to the grid pin (9). The two lugs either side are input points, one from the pickup, and the other from the pre-amp. The two .47M isolating resistors are mounted between these lugs and the grid pin of the socket.

They must be mounted in this position, with not more than a half-inch or so of lead attaching to the grid pin.

The shielding braid of the co-ax. is earthed at this point only. The earthy lug of the potentiometer is earthed to this braid, while the earthy side of the input socket bridges directly to this same lug. The co-ax. between the socket and the pot is also earthed to the pot lug.

A similar procedure is followed for the mic. input circuits. The two sockets are connected together with co-ax. and the two earth lugs bridged together. The bridging co-ax. is earthed to one of the earth lugs, as is a longer length which runs to the grid of the first EF86. An earth point is established here, on an earthed terminal strip lug, as before.

The co-ax. connecting the mic. volume control to the mixer network of the second EF86 is earthed near this valve, as already mentioned. The other end of the braid serves to earth the earthy lug of the mic. volume control. Similarly, the co-ax. going out from this point (to the plate circuit of the first EF86) is also earthed here.

As well as the above precautions against earth loops, it is also desirable that the other earth points in the system be connected together by means of an "earth bus" of tinned copper wire. This is mainly to guard against poor contact with the steel chassis, either now or in the future.

The circuit shows a centre-tapped resistor across the heater line supplying the early stages. This will only be necessary if the power transformer has no built-in centre tap. In our case the transformer was a hurriedly built sample, but it is likely that the commercial version will be so equipped.

We tried connecting this centre tap to the cathode of the output valves to provide a "bias" on the heater line as a precaution against hum. However, it provide a "bias" on the heater line as the simpler arrangement of earthing it direct to chassis.

In its final form the hum level was well below any practical level likely to be encountered in microphone circuits, and should not be a problem of any kind.

PART TWO

A view of the completed amplifier. Controls from left to right are, two microphone input sockets, the microphone channel volume control, the pickup input socket, the combined pickup volume control and master control for the mixer unit, the tone control, and the on-off switch and indicator bezel.

A 35-Watt Amplifier With Control Unit

Here is part two of our article on a 35-watt public address amplifier. It describes construction of the amplifier on a new, smaller chassis, then introduces a completely new preamplifier-mixer unit for use where multiple input channels are required.

by

Wes Yashin

As described last month, the basic amplifier is adequate for most P.A. needs, having a twin microphone and one pickup channel, mixing facilities, a treble-cut tone control and ample power output.

FUNCTION OF UNIT

The new preamplifier-mixer unit is intended to supplement these basic input facilities for stage or other specialised work, requiring several microphone and pickup input channels. While intended primarily for our 35-Watt P.A. Amplifier, the mixer unit can obviously be used with other existing amplifiers, to increase their usefulness. It will be described fully in the latter portion of the article.

The developmental work on the circuit of our basic amplifier left us little time to consider an ideal physical layout and we were more or less forced to compromise by showing it built up on the previously available 40-watt amplifier chassis.

However, as we intimated in the article, we have since had opportunity to review the position. The result is the same amplifier, built on a chassis of smaller dimensions but having an almost identical component layout. Only the rectifier and the associated wiring has been shifted.

The new chassis was hand-made from 16-gauge aluminium, measuring 13¼ x 7¼ inches across the top and 13¼ x 9 inches across the bottom, the difference being due to the sloping front.

The original depth of 3 inches was maintained.

While readers could likewise make up their own chassis, a blueprint will be released and a ready-punched steel chassis should therefore become available through trade houses in the normal way.

We went a step further and had a chassis manufacturer make up a perforated metal cover. As the photograph shows, the result is a very neat and attractive piece of equipment.

METAL WORK

The sides of the cover are of sheet metal and overlap the chassis sides by a half inch or so. Nuts and bolts through the overlapping portions hold the cover in place. A pair of handles on the top of the cover facilitate handling and add to the appearance.

The addition of a label to the front panel will also enhance the appearance and facilitate use of the controls. Our original label was made from white card with Indian ink lettering and protected by celluloid sheet. Should the demand prove sufficient, at least one manufacturer plans to make an etched label available.

A glance at the front view of the chassis will reveal that the layout is essentially the same as that of the original, the difference being in the closer grouping of the components, a more forward position for the rectifier socket and the addition of the "on-off" switch and indicator bezel on the front panel.

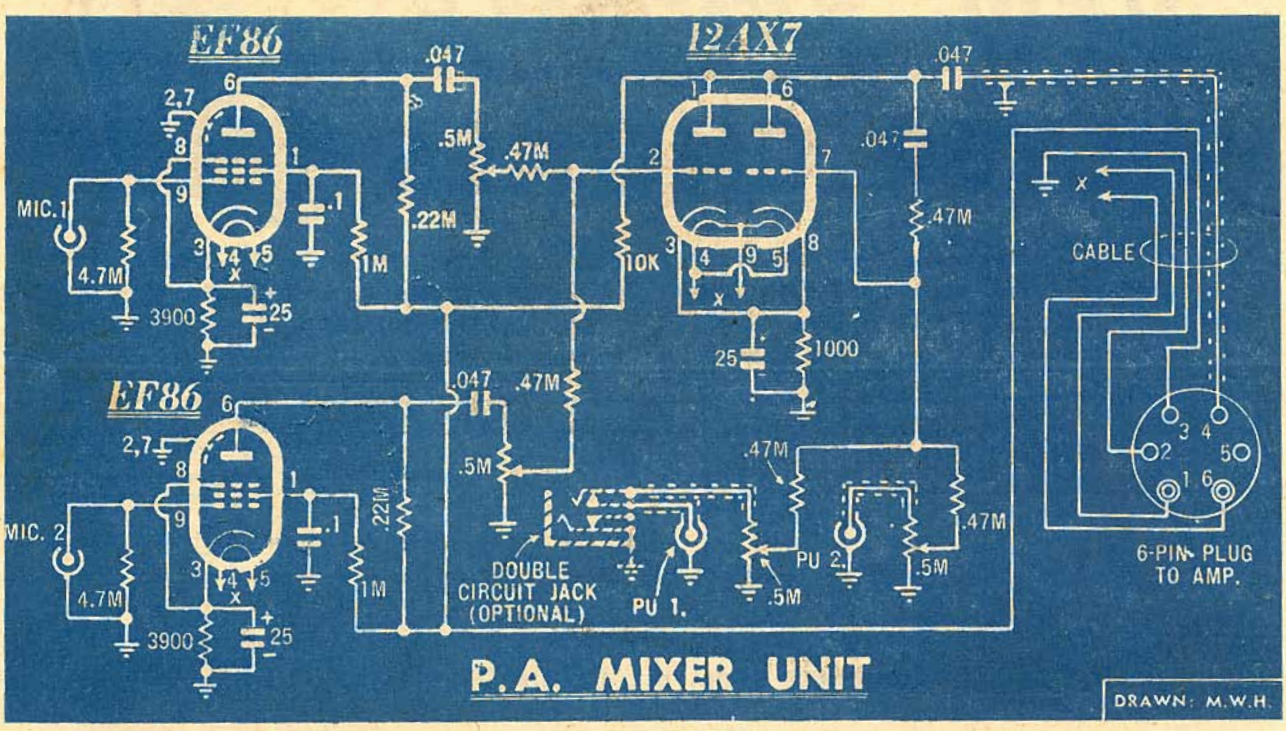
Some of the under-chassis wiring has been altered to suit the altered grouping, but the rest of it remains unaltered. In fact, in rebuilding the amplifier we were able to transfer whole sections of the wiring onto the new chassis.

EARTH POINTS

As with the original amplifier, certain precautions should be observed when wiring. A common earth point for each of the voltage amplifier stages is essential, if hum due to earth loops is to be avoided. The input connectors must be insulated from the chassis and connected to their respective common earth points near the relevant valve sockets.

It is a wise precaution to connect the remaining earth points together with a common run of heavy tinned copper wire, to guard against poor contact with

CIRCUIT DIAGRAM OF THE PRE-AMPLIFIER UNIT



The circuit of a suggested mixer unit. Note that feedback is used to control the gain of the pickup section of the mixer valve.

the chassis in the future, due to rust or corrosion.

A further critical piece of wiring involves the two .47 meg isolating resistors in the grid circuit of the second stage. These must be mounted as close to the grid pin as possible, with no more than about half an inch of attaching lead. Two lugs of an eight-lug mounting strip are used to support their free ends while the common end is anchored directly at the grid pin of the valve socket.

The method of terminating the output transformer secondary leads is also worthy of mention. In the new version, the secondary leads are terminated at a seven-lug bakelite strip equipped with screw terminals. This arrangement is ideal for temporary installations. An octal socket is wired in parallel with the bakelite strip and provides an alternative means for connecting to the speaker system.

INPUT REQUIREMENTS

Although the amplifier is quite versatile as it stands and is likely to cover most situations met with in public address work, we felt that a separate mixer unit with a number of extra channels was warranted. We have certainly had numerous requests for such a unit.

After some consideration the present design was evolved. It consists of two microphone and two pickup channels feeding into the grids of a twin triode mixer. The mixer output is then fed into the pickup channel on the main amplifier, the gain control of this stage becoming the master gain control.

The net result is that three microphone channels and two pickup channels are now available with mixing facilities for each.

The number of mic. and pickup channels in the mixer unit need not be limited to two as a slightly longer chassis than specified could quite easily accommodate three of each. Alternative schemes to suit unusual situations may be quite readily introduced.

A possible modification may consist of an amplifier valve in each pickup channel designed for low level pickups and with suitable compensation for recording characteristics. A suggested circuit is reproduced and consists of a high gain pentode, with a compensating network in the plate circuit. The constants chosen are for the R.I.A.A. curve, which has now become standard with practically all recording companies.

Also included by way of interest is a double circuit jack, connected into one pickup channel. It was not physically wired into the mixer unit and can be treated as entirely optional. However, telephone jacks, wired as shown into one or more channels, provide an extra input facility and also allows rapid interchange from one programme source to another.

Referring to the circuit, you will note that mixing of each pair of channels is accomplished by simple resistance networks feeding the respective grids of a twin triode. The output from all four channels finally come together in a common plate load.

The gain of the pickup section of the mixer valve is deliberately kept low by the use of a small plate load and, plate-to-grid feedback through an isolating capacitor and a .47 meg resistor. Feedback around this stage does more than reduce the gain; it also reduces distortion by an appropriate amount and any residual treble loss due to smaller effect.

PARTS LIST

For parts lists of amplifier see March issue.

1 Chassis with sloping front panel (10in x 3½in top, 10in x 4½in bottom.)
1 Top cover to suit above.
1 Bottom cover to suit above.
2 Noval sockets with shields.
1 Noval socket.
1 6-pin plug with cover.
4 Single contact microphone connectors.

VALVES.
2 EF86, 1 12AX7.

CAPACITORS.
3 25 mfd 40 volt electrolytics.
2 .1 mfd 400 volt paper.
4 .047 mfd 400 volt paper.

RESISTORS
2 4.7 meg ½ watt.
2 1 meg ½ watt.
5 .47 meg ½ watt.
2 .22 meg ½ watt.
1 .01 meg ½ watt.
2 3900 ohm ½ watt.
1 1000 ohm ½ watt.
4 .5 meg potentiometers.

SUNDRIES
1 8-lug strip, 1 6-lug strip, 1 3-lug strip, 2 2-lug strips, hookup wire tinned copper wire, coaxial cable, spaghetti, nuts and bolts, solder lugs, knobs.

The actual gain of this stage is a little over two times to offset the two-to-one loss introduced by the mixing circuit in its grid. The input sensitivity of the pickup channel on the mixer unit thus remains equal to that of the pickup channel on the main amplifier, being something over 100 millivolts for full output.

Although we did not draw up a set of frequency response curves for the unit, we checked to see that the response was flat to at least 10Kc and therefore adequate for PA work. The overall response of the amplifier, too, is quite good, being level to well beyond 10 Kc, depending on the secondary tap in use.

No effort has been made to reduce the gain of the microphone section of the mixer valve, as this extra gain in the mic. channel is of no consequence.

PREAMPLIFIERS

The mic. preamplifier stages use EF86 (or Z729) pentodes, whose low noise and rigid construction show to good advantage in this application. Under normal operating conditions the noise is quite low and microphony problems of no consequence, allowing the use of standard socket mountings.

Common earth points are not essential in the mixer unit since there are no low frequency chassis currents to cause hum through earth loops. However, if a steel chassis is used, the precaution of joining all the earth points with a run of heavy tinned copper wire is advisable.

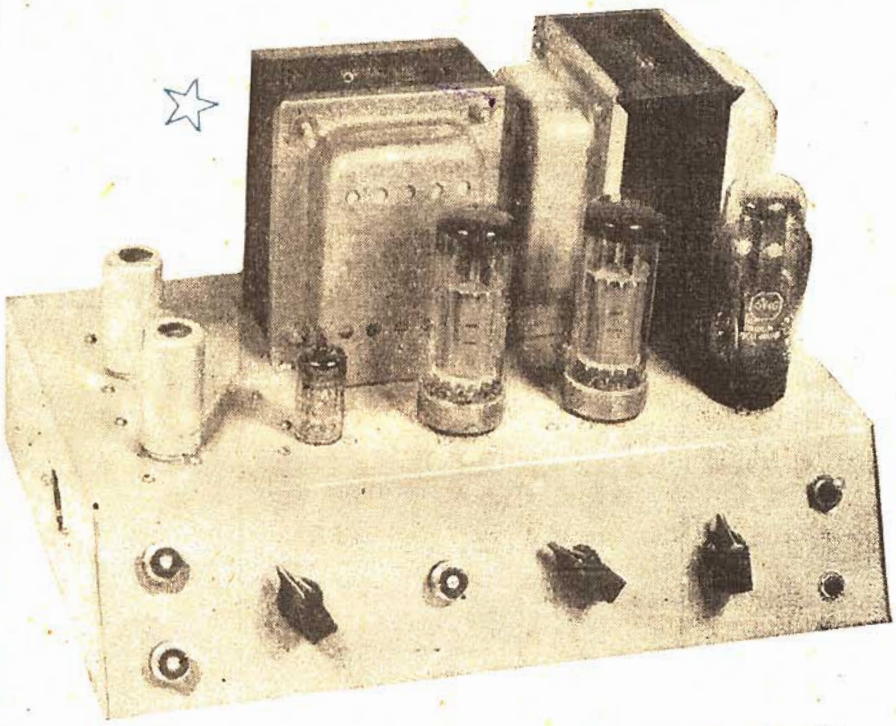
The HT supply to the mixer unit is taken from the main amplifier through a 6-pin plug and socket arrangement. Two high tension points are available at the 6-pin socket on the amplifier, one connects directly to the main HT line, while the other is taken from the de coupled point feeding the microphone preamplifier tag. This latter point was also used to supply the HT to the mixer the decoupling being quite adequate.

The extra drain of the mixer unit lowers the HT at this point and consequently the gain of the stages feeding from this point. However, the decrease in gain is not substantial and in practice would not be missed, since there is plenty to spare.

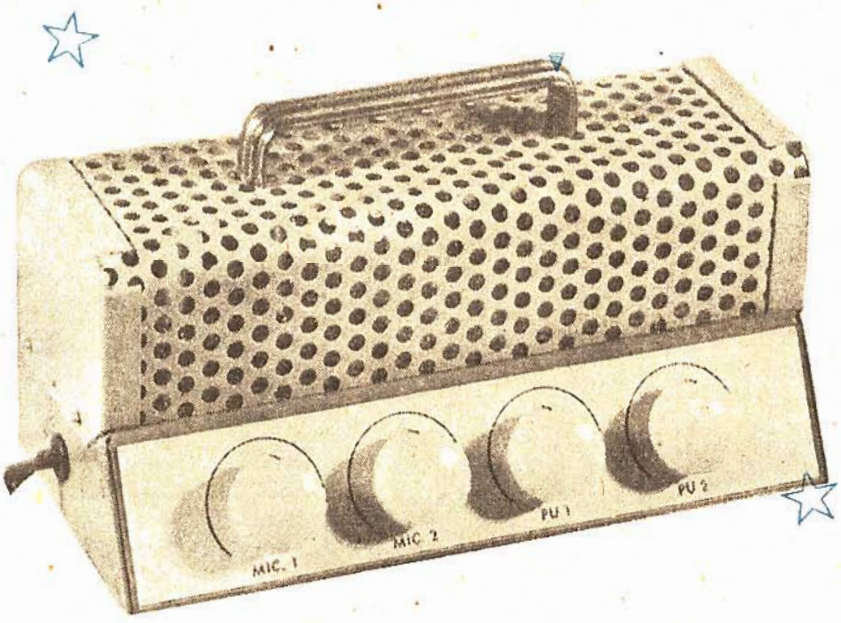
At no time did we experience instability even with all the gain controls turned full on. Operated in this manner the noise level is naturally fairly high, but this is a completely unrealistic situation, since the unit is not likely to be operated with more than two gain controls turned partly on at any one time.

The input sensitivity of the mic. channel is very high requiring less than one millivolt input for full output. In practice it is possible to obtain satisfactory operation from a low impedance microphone, even without an input transformer. Although this again is an unlikely situation, it gives a good idea of the overall performance.

We constructed the mixer unit on a chassis measuring 10in x 3½in across the top and 10in x 4½in across the bottom, due to the sloping front to match that of the main amplifier. A perforated metal cover was also made to match.



The amplifier with cover removed. A considerable saving in space was achieved by the closer grouping of components. The GZ34 is at the extreme right, the EL34s top centre, the 12AX7 and the EF86 to the left. The microphone preamplifier directly behind the first EF86.



The mixer unit matches the main amplifier. Knobs left to right are, wo microphone volume controls and two pickup volume controls.

LAYOUT

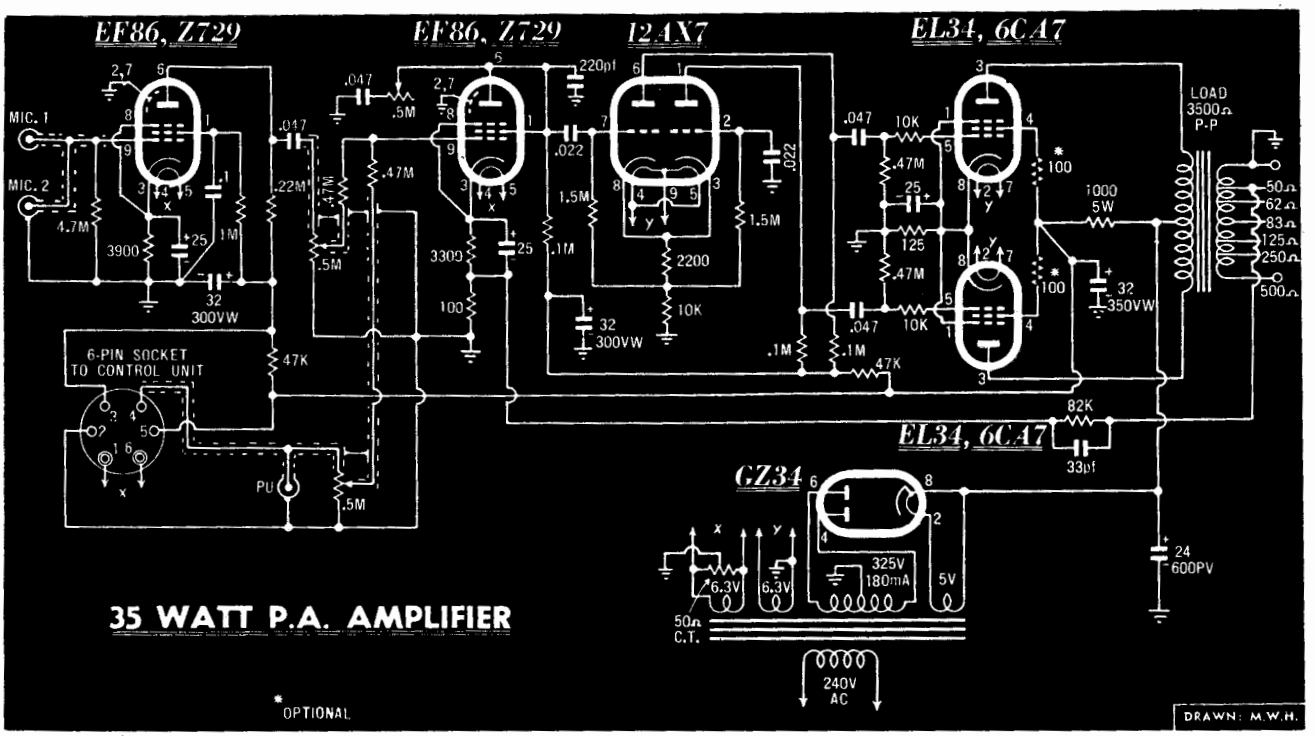
A suggested valve layout is to place the preamplifier stages along the rear of the chassis while the mixer valve may be placed forward in the centre of the chassis. The controls may be grouped and spaced to suit the number of stages used. The input connectors are placed along the rear edge of the chassis, resulting in very short leads to the grids of the mic. preamplifiers.

Liberal use is made of tag strips in mounting the various minor components, although a number of these are suspended by their pigtails.

Looking over the rear edge of the chassis, the 8-tag terminal strip, parallel to the left edge of the chassis, supports the outgoing power supply and output leads. It also provides anchor points for the screen dropping resistor and bypass of the nearer mic. stage and the bias resistor and bypass of the same stage.

A 6-lug strip directly in front of the

CIRCUIT USES EL34'S IN CLASS AB OPERATION



The amplifier circuit is quite straight-forward and identical with that published last month. Should it be necessary to control the high tension due to the use of a different power transformer, a GZ32 or 5V4 rectifier may be substituted. Alternatively a wire wound resistor wired between the centre tap and chassis will also reduce the voltage to the required figure.

second mic. stage supports the plate and screen resistors for that stage as well as the plate load for the adjoining microphone stage and the mixer stage. The coupling capacitors to the volume controls are suspended between points on this strip and the appropriate lugs on the volume controls.

A two-lug strip directly in front of the 5-lug strip and at right angles to the front edge of the chassis supports the isolating resistors for the two mic. stages and the connecting lead to the grid of the mixer valve.

The coupling capacitor to the mixer plates and the outgoing output lead are anchored at another two-lug strip, which is betwen the second and the third potentiometers and is held by one of the mixer valve socket mounting bolts.

MIXING CIRCUIT

A 3-lug strip to the right of this supports the isolating resistors in the pickup mixing section, as well as the feed back components around that section of the mixer.

Any additional stages could follow the same order of component layout which is not extremely critical provided the usual precautions pertaining to grid and plate leads are adhered to.

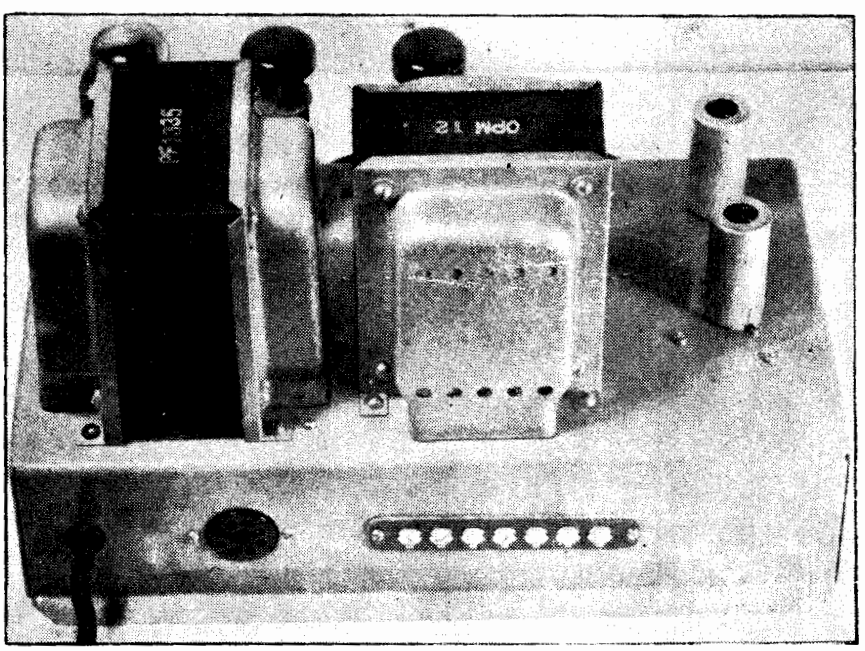
Finally, a few words about the various types of PA microphones may be of value.

Crystal microphones are probably the most popular types in use to-day, mainly because of their low cost. (Some of the cheaper inserts are available for less than £2.) This, coupled with fair average performance and reasonably high output makes them an attractive proposition

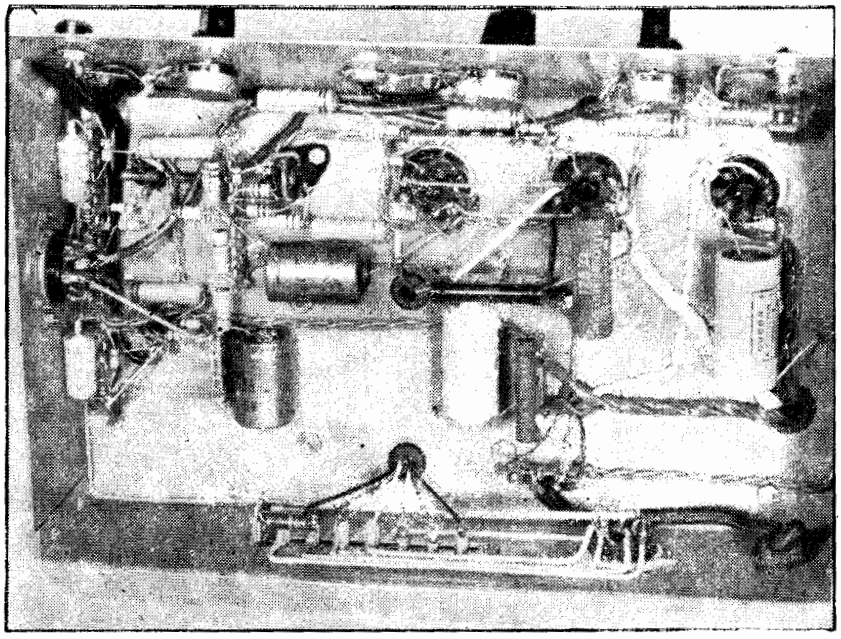
At the same time these units have their limitations, and an appeciation of these may help the reader to make a better choice when he considers his own particular requirements.

The very cheapest inserts have a marked peak in the response around the "speech region": a characteristic which can be quite useful in some communications systems, but which can seriously aggravate the feedback problem in PA systems. Better quality inserts, costing a little more, have much smoother response curves and are definitely to be preferred. In fact, the best crystal units are capable of excellent PA performance.

Crystal devices are, by their very nature, fragile in some respects, and need to be treated with a certain amount



This rear view of the amplifier chassis shows the terminal strip on the rear edge, a useful feature for temporary installations. For a permanent installation the octal socket would be used The power and output transformer placement is clearly indicated The power transformer is to the left while the output transformer is to the right.



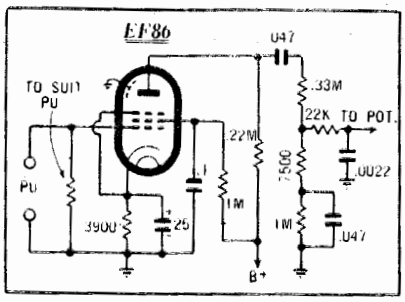
This picture gives an excellent idea of the wiring and minor component layout

of commonsense. Their two greatest enemies are humidity and heat. The makers can guard against most humidity problems by careful sealing techniques, but precautions against heat are up to the user

HIGH TEMPERATURE

At temperatures around 120F and higher a crystal can be completely destroyed, no matter how well it is sealed. Temperatures of this order are easily produced inside a microphone case left in bright sunlight for any length of time, making this type unsuitable, in general for exposed daytime outdoor work.

Crystal microphones have a high impedance output, meaning that losses can be quite severe if long lengths of shielded cable have to be used However, due to the high capacitance of the crystal itself, these losses are essentially constant at all frequencies, so that the problem is



A suggested circuit for a low level pickup input channel. Compensation is for an RIAA characteristic

mainly one of providing sufficient reserve of gain in the amplifier to take care of this. Usually, this is not a difficult requirement to satisfy, for lengths of cable up to, say, 30 ft

Probably next in popularity is the dynamic type, again due to the fact that their cost is reasonable, though usually greater than the crystal types. Some of the cheaper types suffer from peaky response in much the same manner as the equivalent crystal types, and are thus equally undesirable.

However, assuming a smooth response, this type has much to recommend it. It is robust, being ruggedly constructed and immune to heat and other weather conditions, and therefore well suited for outdoor use.

Its natural output impedance (the "voice call" impedance) is generally 50 ohms. This is a useful figure and a line operating at this impedance may be almost any length without introducing serious losses, and need not be shielded. In fact almost any form of twin cable may be employed, such as twin lighting flex etc.

It may even be possible to couple the microphone directly into the amplifier at this impedance if the gain of the latter is high enough, but it is more usual to provide a transformer close to the main amplifier to convert to a high impedance. This transformer will be quite prone to hum pickup from the power transformer and will need to be mounted several feet from it, or employ expensive mu-metal shields.

RIBBON TYPE

Two types are normally available. One is the true "velocity" type having the ribbon open to sound on both sides, and the other a modified version, with one side of the ribbon closed off.

The velocity type has a "figure 8" pattern, being equally sensitive back and front, but quite insensitive on each side. This feature is sometimes useful in controlling feedback if the speakers can be located in the "dead" regions.

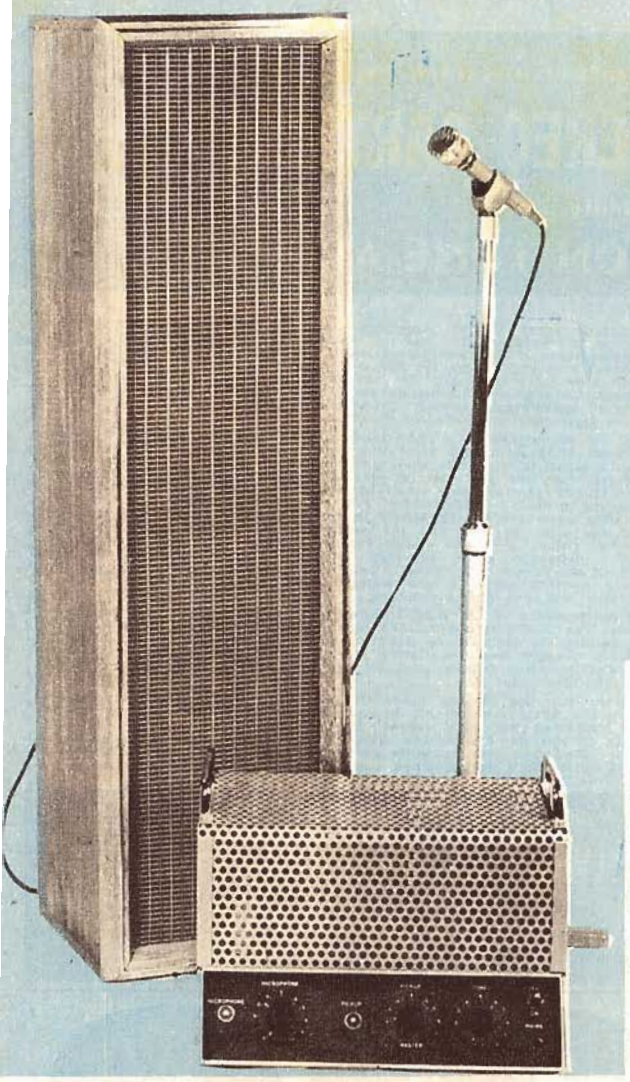
Due to the "velocity" characteristic, the bass response tends to rise if the source of sound is closer than about two feet. This may be a serious restriction in PA work if the bass boost cannot be tolerated

The other type has no appreciable pickup from the rear and, because it is no longer a "velocity" type, has no bass boost problem and can be used for close talking. In fact, the response favours the high note region, making the repoduction rather high pitched and tending to aggravate the feedback problem, in spite of its more restricted pickup pattern

A HIGH QUALITY 35-WATT PUBLIC ADDRESS SYSTEM

Here is a story of a public address system which we recently had occasion to make up and install. The requirements were so typical and the final set-up worked so well that we felt it would be well worth while passing the details on to readers. Even if your requirements are not exactly the same, it provides a good basic plan from which to start.

By P. Watson and J. Davidson



The complete PA system. The column measures only 3ft high, not much higher, than the Zepher banquet style microphone stand alongside it. The amplifier is similarly compact, yet has ample power for any likely application. An additional mixer unit can be added if required.

THE project started with a request from our Parent Company for a public address system suitable for use at various moderate size gatherings or meetings, often in a formal atmosphere, which invariably occur in any large business organisation.

Although the requirements for such a system might appear, at first glance, to be quite simple, more detailed examination of the problem will show that there is really a good deal of planning required is the end result is to be completely satisfactory. It is not, for example, simply a matter of connecting *up any old microphone, amplifier, and* speaker, selected at random, and hoping for the best.

FEEDBACK PROBLEM

A major problem, with any PA system, is feedback, and this becomes doubly important where it is envisaged that the equipment may have to be set up and left to the mercy of relatively unskilled persons. The more prone the system is to feedback, the more likely are those concerned to get into strife, with general dissatisfaction all round.

Again, a system which is to be set up in all kinds of temporary circumstances, where acoustics may be anything but ideal, may often be battling to keep feedback within acceptable limits. Unless it is relatively free from this tendency in the first place it may be well nigh impossible to provide any worthwhile coverage.

While feedback is a basic problem, and there is no complete cure for it, it will be very seriously aggravated by any link in the chain which exhibits a prominent peak in the audible spectrum. Feedback will occur first at this frequency, and at a gain setting which is lower than it would otherwise be by approximately the amplitude of the peak.

Since both the microphone and speaker system can easily suffer from this undesirable characteristic, they need to be selected with a good deal of care.

Again, the question of appearance must be considered. Whether for use in *a church, board room,* or banquet hall, the visible portions of the system must be made as unobtrusive as possible. Horn speakers may be a logical choice out of doors or in a factory, but they are hardly objects of beauty.

Similarly, the microphone, being probably the most obvious part of the system, must be selected with some thought as to its appearance as well as performance.

This, then, is something of the background against which we set out to make up our complete PA system.

Although, initially, only a bare minimum of requirements had been called for, we felt it would be wise to have something in reserve, both as regards available power and, if necessary, the variety of input circuits, mixing facilities. etc.

After giving the matter some thought, we finally selected the 35 Watt PA Amplifier described in the March and April 1958 issues. This offers ample power output, yet is of compact construction. It is fitted with a simple microphone/pickup mixing system capable of coping with most ordinary requirements, or may be coupled to a more elaborate plug-in mixing unit on the rare occasions when this may be needed.

Being designed as a PA amplifier, it is equipped with a "500 ohm line" output transformer, capable of accommodating from one to 10 loudspeakers, using 500 ohm inputs, over any likely length of line. This means that it can cope with virtually any likely speaker requirement.

The gain has been kept high in both the pickup and microphone channels, again making it ideal for use with whatever units happen to be selected for other reasons. Even so, the circuit provides for approximately 12 db of feedback, which is adequate for an application of this kind.

EARLIER ARTICLE

This is necessarily a brief summary of the amplifier's characteristics. Those who require greater detail should refer to the original article. A few back copies of both the March and April 1958 issues are available as we go to press.

The next decision concerned the microphone. As already stated, a smooth response is essential here if feedback is to be minimised, and peaky microphones probably cause more feedback problems than any other single factor.

The unit we finally chose was a dynamic type, the AKG D19B. This is a microphone which has proved extremely popular with radio and television stations even though, by such standards, it is a relatively inexpensive unit. It has a cardioid directional pattern and a smooth response from 40 to 16,000 cps. This range is perfectly adequate for good quality musical reproduction, while the absence of peaks and the directional characteristics are most valuable in controlling feedback.

The unit may not appear cheap when compared with what might be termed the "popular" types, but its price would

seem to be fully justified for an application of this kind. We felt it was a sound investment which would amply repay its first cost.

Output impedance of the unit is 200 ohms, which means that a transformer must be provided to step this up to a value more suitable for feeding the grid circuit of a valve. While this calls for some modification of the amplifier, the use of a low impedance microphone line has many advantages. Both stray pickup and cable losses are reduced to a minimum, meaning that the cable may be almost any length required.

EXTRA PRECAUTION

(In fact, at this impedance, it is often feasible to use long microphone cables without any shielding at all. However, this can be risky, leaving the system open to hum or RF pick-up in extreme circumstances. RF may come from nearby broadcast transmitters, or mobile utility services. Inadvertent reproduction of the latter, in particular, can be extremely disconcerting.)

As supplied, the microphone is fitted with a twin conductor, shielded cable, as commonly used in professional studios. In this arrangement, the shield forms no part of the signal circuit, being merely connected to the microphone case at one end and the amplifier chassis at the other. The signal is carried on the two conductors, one of which is made earthy at one point only, the common chassis connection for the pre-amplifier stage.

In the event that the original cable is not long enough, any additional or replacement cable should be of the same type, such as the Zephyr type 14. Although it is possible to open the microphone case and fit a new length of cable, this is quite an intricate job, and any damage which results might prejudice the maker's guarantee.

For this reason, we strongly recommend that any extension of the cable be made by removing the cable connector, and carefully splicing the extra length on to the existing cable.

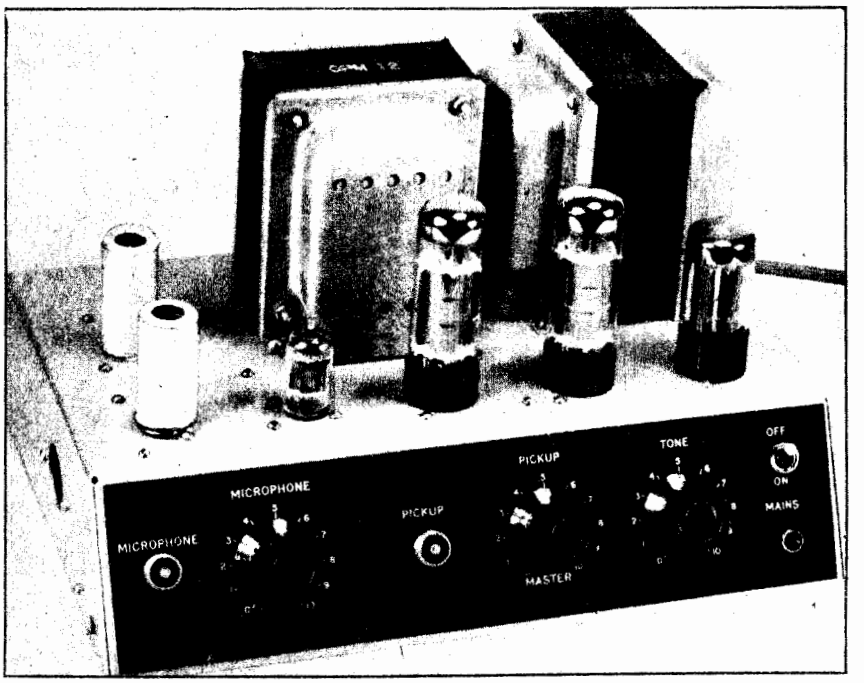
The microphone transformer is also an AKG unit, type U204. This has a matching ratio of 1 to 15, a response from 50 to 20,000 cps at the 2db points, is mu-metal shielded, and is intended for under-chassis, single hole mounting. It is quite small, measuring only ⅞in diameter by ⅞in long.

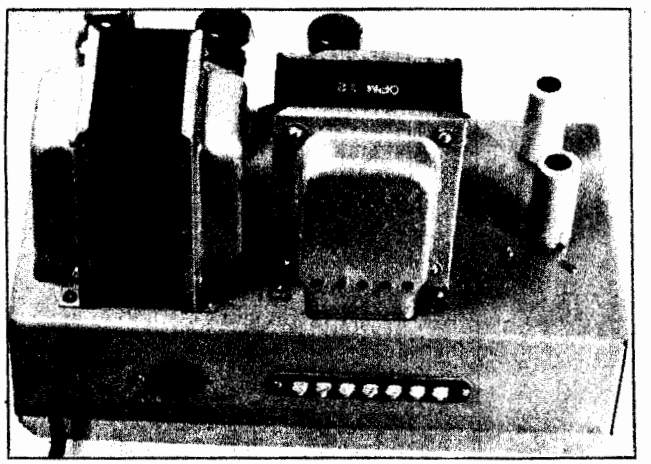
NO HUM PICKUP

We mounted it against the end of the chassis, adjacent to the microphone input socket. The shielding appears to be perfectly adequate, no pickup from the power transformer being experienced, and no particular orientation found necessary.

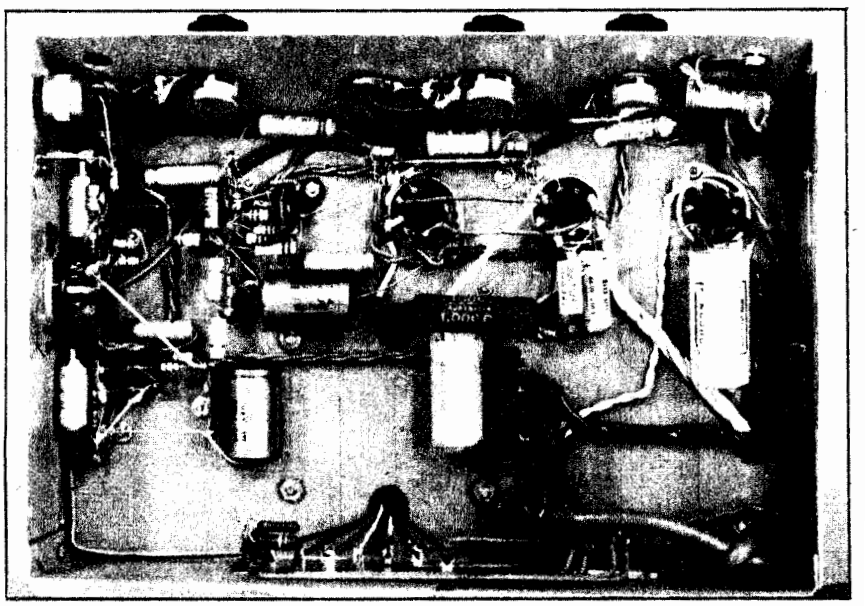
Whereas the original amplifier was fitted with two microphone inlets, wired in parallel, we felt that this was no longer necessary. A single socket was therefore fitted, the position of which can be seen in the photograph. A new engraved panel helped to hide the old mounting holes. Note that the microphone socket must be insulated from the chassis, with the washers provided, in order to maintain the single point earthing system—the earth point being adjacent to the preamplifier valve socket.

Next we had to consider the speaker system, both as regards the speakers themselves and the method of housing them. Remembering our experience





These three pics- show the front, rear, and underside views of the 35 Watt PA amplifier. Modifications to the original chassis (discussed in the text) include the fitting of a microphone transformer adjacent to the microphone input socket (top left corner in the underchassis view), and the fitting of a single microphone socket in place of the original parallel connection. The octal socket and the terminal strip on the rear of the chassis both provide output circuits at line impedance to suit a wide variety of speaker combinations. Permanent speaker systems may be wired to the appropriate pins of an octal plug, temporary installations direct to the most suitable terminals.



with the column described in the July issue of this year, we were immediately inclined to use this same system again.

A major advantage of the column is the relatively narrow angle of radiation in the vertical plane. This means that, by mounting it at an optimum height, most of the signal can be made to pass over the heads of those seated close to the speaker, becoming progressively more effective towards the rear of the auditorium. In this way, those at the rear may be given adequate level, without the risk that those in the front will have to endure an uncomfortably high level. In short, we get a substantially even level of sound along the entire length of the hall.

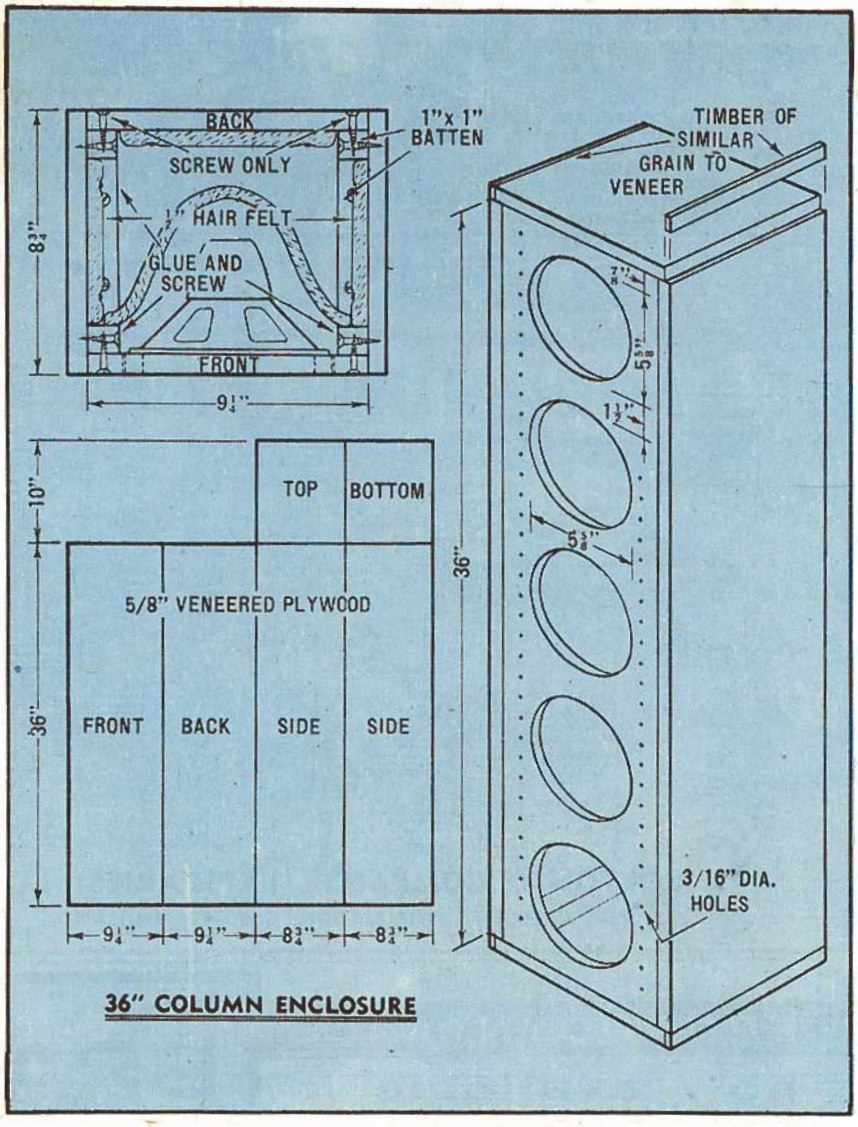
SIMILAR PROPERTIES

It is true that somewhat similar characteristics exist in the conventional horn type PA speakers, and can be used in the same way. However, as already mentioned, these are hardly objects of beauty nor can they boast any degree of fidelity.

The only problem was the need, if possible, to produce a column rather smaller than our previous model, but to do this without seriously sacrificing performance. On the other hand, we felt that such a column, if practical, would have a considerable appeal to readers, and so was worth a try.

We were encouraged in this idea by the characteristics of a speaker in the Magnavox range which seemed to suit our requirements particularly well. This is the 6WR, a six inch, twin cone, wide range model, with a bass resonance of only 40 cps.

This latter point is most important. The effect of mounting a speaker in a closed box is to raise the cone resonance quite markedly, meaning that either the box must be inconveniently large or we must tolerate a peak relatively high in the range. If we can start with a naturally low resonance cone, then a small box may not raise it to an unduly high figure.



36" COLUMN ENCLOSURE

This diagram gives all the measurements required to construct our new column. It can be cut from a 3ft x 4ft sheet of ½ thick plywood, preferably with a veneer finish. Note vent holes along each side of the front panel.

The basic behaviour of this column turned out to be no different, in principle, from that of the previous model. With five 6in speakers mounted in it, the bass resonance rose from the nominal 40 cps to around 125 cps. While high, perhaps, by "hi-fi" standards, it was still very gratifying considering the compact nature of the column.

However, as before, the amplitude of this peak was also quite high, and this called for the same technique as we used before; the provision of a large number of small holes in front of the panel to act as a distributed vent. The advantages of this arrangement over the conventional vent are twofold; it gives each speaker an equal "share" in the vent system, and the small holes act as an acoustic resistance to provide a useful amount of damping to the "Q" of the enclosure.

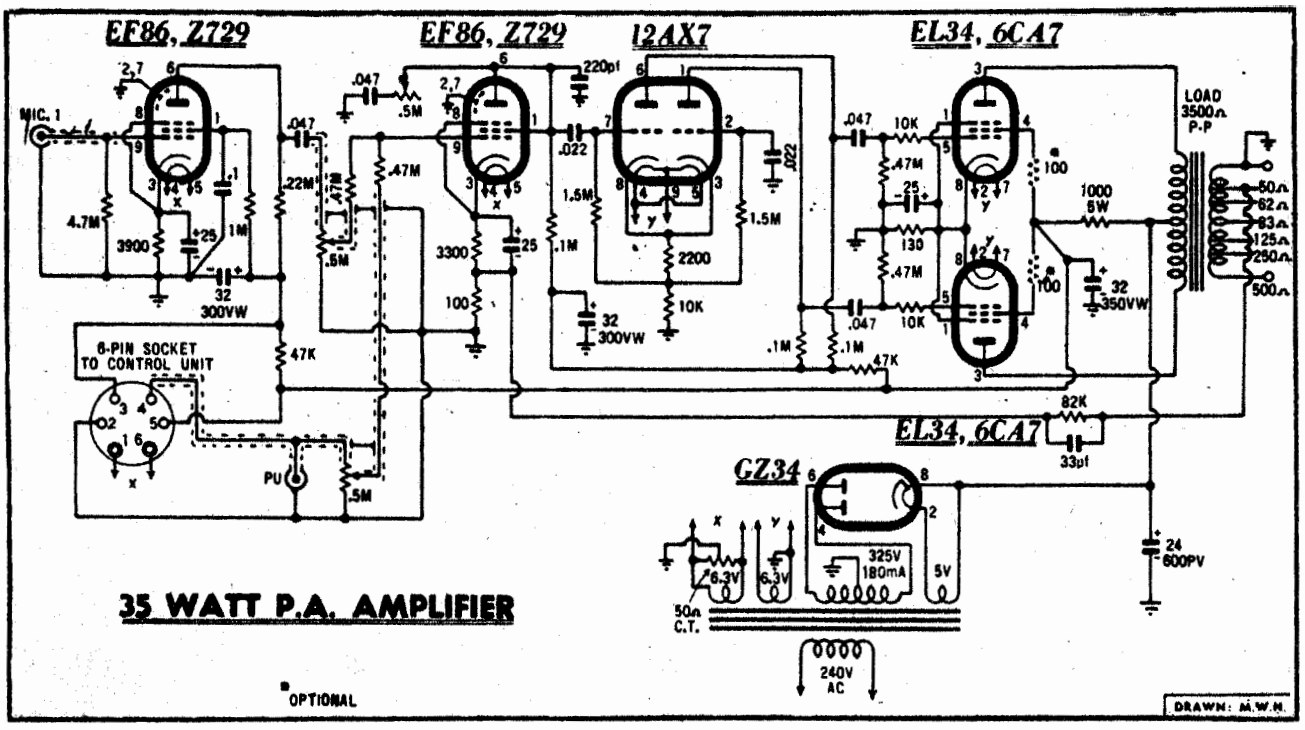
The final result is a quite modest peak at around 125 cps, with a gentle rise to a similar peak at around 30 cps. Within the limitations of its size this behaviour is similar to that of a normal vented enclosure; the production of two fairly well separated moderate peaks in place of a single large one, with some extension downwards in frequency.

This result may not satisfy the out-and-out "hi-fi" enthusiast but, as we have emphasised on previous occasions, this type of column speaker is not intended for such application. It is intended, primarily, for PA systems, particularly where it is desired to provide something better than average in both performance and appearance.

Matching the column speakers to the amplifier is achieved by means of "line to voice coil" transformer mounted inside the column. It has a 500 ohm primary and a tapped secondary providing 3.75 and 15 ohms. The voice coils are connected in parallel and fed from the 3.75 ohm tap. Although not strictly accurate, the degree of mismatch is negligible.

Alternatively, this transformer may be used as an auto transformer if it is desired to feed the unit from an existing 15 ohm system.

In conecting the speakers together, it is important to maintain correct phasing. Normally, assuming speakers of the same make, type, and — ideally — batch, the voice coil connections should have consistent polarity, and it would be in order to wire them accordingly. However, it is



a simple matter to connect a torch cell across the assembly and note that all cones move in the same direction.

To build the column, we purchased a sheet of 5/8in maple veneer plywood. Although a full 6ft by 3ft sheet, it is expected that some of the more obliging timber firms will supply a sheet 3ft by 4ft which allows for a minimum of offcut.

The markings and cutting out of the sheet is straightforward and the drawings on page 57 have been laid out to reveal the greatest amount of detail. Having cut the sheet, the edges should be planed straight and square, remembering to plane from both ends to prevent chipping of the corners.

Begin to mark out the front panel by running a centre line from top to bottom, along which the positions of the five 6in speakers can be marked as follows. Allowing 7/8in at the top, measure off 5 5/8in per speaker cutout, each spaced 1½in appart, so that the lower cutout will finish 1in from the bottom.

CUTTING THE HOLES

The cutouts will have a radius of 2 13/16in and the waste material can be removed by drilling a series of 1/8in holes along the waste side of this line and cutting out with a compass or keyhole saw. Firstly a wood rasp and then sandpaper will soon clean up any rough and untidy edges.

As with our previous enclosure, we used 1in by 1in dressed batten in the four vertical corners and also along the sides at both top and bottom. This batten will be screwed and glued in all corners except to the back panel, which is screwed only.

The plan drawing shows the position of the screw clearance holes and when these have been drilled, the glueing and screwing can begin. Casein blue is the logical choice for this job. It has the advantage of cold mixing, a long setting time which permits unhurried assembly, and excellent strength when dry. Care should be taken that the glue does not stain the veneer surface.

The circuit features high sensitivity output pentodes, a "long tailed pair" phase inverter, and low noise valves in the first two stages. It has ample gain for most microphones or crystal pickups, with a simple mixing system between the two channels.

With one side placed on a flat surface, two main vertical battens are glued and screwed in position, allowing a margin along both edges equal to the thickness of the plywood. Two short strips of batten then join the end of the vertical strips, flush with the ends of the side sheets. The same routine is followed for the other side.

The next step will be to screw the back to both side sheets, then glue and screw the front sheet in position. Providing the original trueing-up work has been done correctly, the cabinet should be reasonably square and can be allowed to dry.

The next stage will be to square up both ends in preparation for the top and bottom pieces to be glued and screwed in position. Special care should be taken, when planing the ends of the column, that the veneer does not split.

Having been planed straight and square, the top and bottom pieces are positioned flush with the front and rear of the cabinet but equally spaced from both sides by approximately ¼ inch, as shown in the isometric sketch. While gluing these pieces, keep in mind that the back must be removable and is at present in position solely to provide a more rigid assembly, and must not be glued. We were able to screw the top and bottom in position by holding the screwdriver through the speaker cutouts.

To remove all traces of end grain on the four corners, strips of maple or other timber of similar characteristics to the veneer, are planed to fit these corners. In gluing these, application is made to both strip and cabinet and the two surfaces are rubbed together to remove any

air bubbles. A couple of pins will hold each strip in place while the whole cabinet is left overnight to dry and set.

The vent is a series of holes drilled along the front panel. This is done by drawing a pencil line down both sides of this panel, just clear of the speaker frames, and drilling two lines of 3/16-inch holes at 1 inch intervals.

The front and rear edges of the side sheets can be planed level with the front and rear faces. In planing the corner strips, the plane blade should be finely set and prevented from coming in contact with the veneered finish. Otherwise, an ugly cut may permanently mar the appearance of the cabinet.

CABINET FINISH

Finally the whole cabinet can be sanded, firstly with a medium grade and then with finer grades of sandpaper. We planned to cover the front panel with "Tygan" fabric and, to prevent the speaker cutouts from being visible when this is in position, the front panel was given a coat of flat black paint. A piece of this fabric 36in by 10in is required and this is either stapled or glued using the recommended PVA glue.

The moulding chosen for the edges is supplied with a gold bead which is fitted to a centre groove. This moulding was first mitred then attached using 1½in panel pins nailed into this groove. The heads were driven home using a piece of sheet metal as a punch. The gold bead can be mitred using either a fine file or a razor blade but the fitting should be left until the rest of the work is complete. (The razor blade should be one of the single edge variety with a rigid back. Its use in this role may seem drastic, but it provides a convenient way of performing an otherwise awkward task.)

To give the column a professional finish we decided to use one of the liquid plastics (Estapol, Bourne Plastic, etc.) popular for wooden floors and furniture. We purchased the smallest quantity of "Estapol" available, which consists of two solutions, A and B, each in ½ pint tins. A tin of "Estapol" Reducer, a quantity of methylated spirit, a clean brush, and a measuring glass are also required.

Before doing any finishing work on the column, it is a good idea to mask any sections which need to be protected, such as the speaker fabric. Proper masking tape, or most other "sticky" tapes may be used for this job.

WOOD FILLER

Following the directions of the liquid plastic manufacturer, the timber was filled with "Wattyl" wood filler and after being wiped off, was allowed to dry over a weekend. At least two days should be allowed after filling otherwise faulty adhesion will almost certainly result.

(In some cases, excellent results can be obtained by applying the plastic directly to the unfilled wood, the finished colour depending on the extent to which the plastic "wets" the particular type of wood. Experiments may be conducted on waste pieces from the speaker cutouts.)

Having allowed adequate drying time and made sure that all excess filler has been removed, the plastic coating can be commenced. It is most important that the manufacturer's directions be carefully read and fully understood before attempting to mix the plastic. For Estapol, MEASURE and mix equal quantities of A and B solutions, sufficient only for the immediate requirements. Any excess will not keep more than a few hours, and is therefore wasted. Two ounces of both A and B solutions mixed together produced a little over enough for one coat of this enclosure.

The solution can be applied to the surface somewhat more generously than might be done with paint, providing that it does not run. Brush marks will not normally be visible after drying. Some 6 to 24 hours later, after a light sanding, a second coat can be applied. In preparation for the final coat, sand with No. 500 wet and dry.

The brush must be cleaned immediately after each coat and a brush washing solution is prepared by mixing one part of "Estapol" Reducer with three parts of methylated spirit. Firstly wash the brush in a small portion of this solution and brush dry on a wooden surface, repeating this procedure two or three times using fresh portions of solution each time.

When the final coat of plastic is completely dry the gold bead can be fitted into the centre groove of the front moulding and the adhesive tape removed from the edges of the speaker fabric.

HAIR FELT

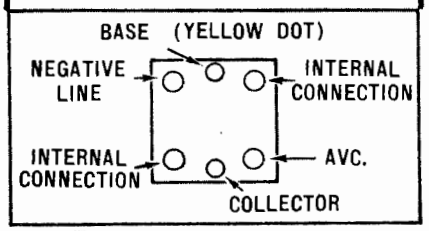
All inside surfaces with the exception of the front panel are then covered with ¼in hair felt. A baffle curtain is also draped loosely around the rear of the speakers and tacked in position.

And what of the end result? How did the whole combination sound when finally set up to do the job for which it was built?

In a word: Excellent. In fact, it can fairly be described as one of our most successful projects. As we said earlier, performance is not to be judged on "hi-fi" standards, yet the combination a high quality microphone, wide range speakers free from serious peaks, and the column housing, resulted in clean smooth sound as is heard all too, rarely from PA systems.

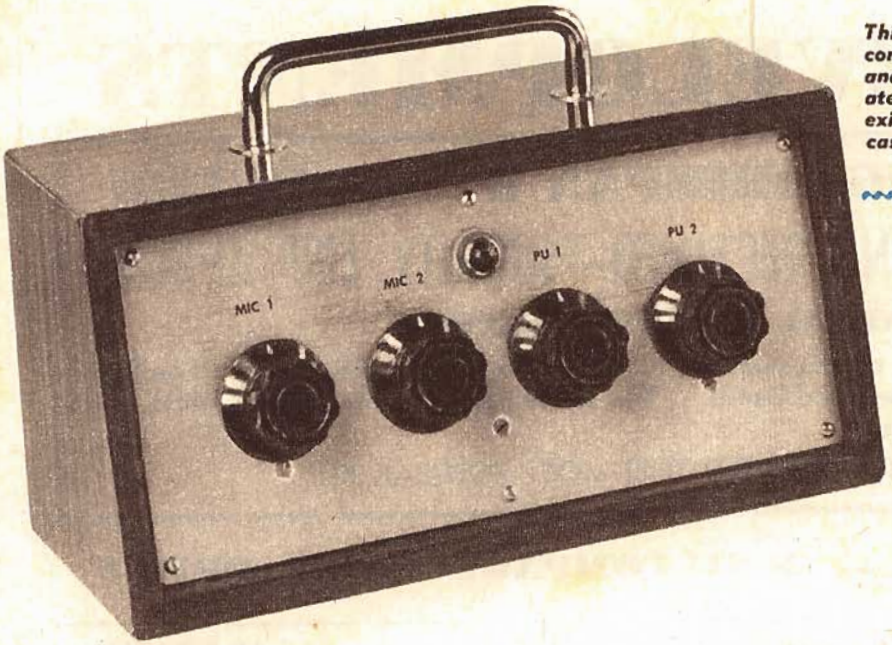
Precisely the same remark applies when the system is reproducing recorded music. This would indeed be an excellent system for use in churches or places of public entertainment.

3-BAND TRANSISTOR EIGHT RECEIVER



A FEW readers have experienced difficulty in identifying the base connections on commercially available IF transformers intended for use with this set.

The transformers used in the original set were supplied by Telecomponents Pty. Ltd., and the connections for these units are shown here to clarify the situation. They are the same for both the type 919 and 9181.



This view shows our new audio mixer unit complete in its case. Made from plywood and covered in wood-grain plastic laminate, the case blends well with almost any existing audio setup. Full details for the case are given in the text, for readers wishing to duplicate the original.

VERSATILE 4-CHANNEL AUDIO MIXING UNIT

Here is a four channel audio mixer unit which enables owners of amplifiers, movie projectors and tape recorders having only one input to blend the signals from four sources. Having two in-built microphone pre-amplifiers and completey independent volume controls for each input, it is powered by an in-built silicon diode power supply. With a response flat over the audio spectrum, low hum and noise, and negligible distortion, it will perform extremely well in most audio applications.

By Jamieson Rowe

MANY tape recorders, projector amplifiers and public address units of the more conservative variety have only one input facility, which is usually intended for medium to low level inputs in the range 10-100 millivolts. If it is desired to blend and fade a number of audio sources, such as is required for the compilation of tape commentaries, film sound tracks, etc., the single input becomes embarrassing.

Makeshift methods are sometimes employed in such instances to perform signal mixing, such as placing the single microphone near the speaker of a record player when music is desired rather than speech. However, such methods are usually very unsatisfactory and result in inferior recording, due to operating difficulties, distortion in the speaker-microphone setup, and acoustical reverberation effects.

Alternatively, the amplifier of the recorder or projector may be modified to provide a second input connection and volume control, but this method also has its difficulties. Multiple functioning of many sections of the usual economical design renders the addition of a second input connection difficult, apart from the worry of somehow fitting another control and input connector to a crowded panel.

Such modifications, even if successful technically, often tend to reduce the resale value of the unit.

The most satisfactory solution to the problem is by the use of an external mixing unit. This accepts the signals from the various source devices (microphones, pickup, etc.), controls the relative volumes of each, and sends a composite signal to the recorder or amplifier unit.

Electronic mixers come in two types, called passive and active mixers. The passive type of mixer is simply a network of fixed and variable resistors, arranged to control the volume of each input signal and to provide reasonably independent blending of the signals into a composite output. Such a simple mixer would have a circuit such as that shown in Figure 1.

The circuit shown is quite practical, and will allow a microphone and pickup to be fed into a normal tape recorder microphone input socket. However, in common with all passive mixing circuits, it possesses a number of undesirable features.

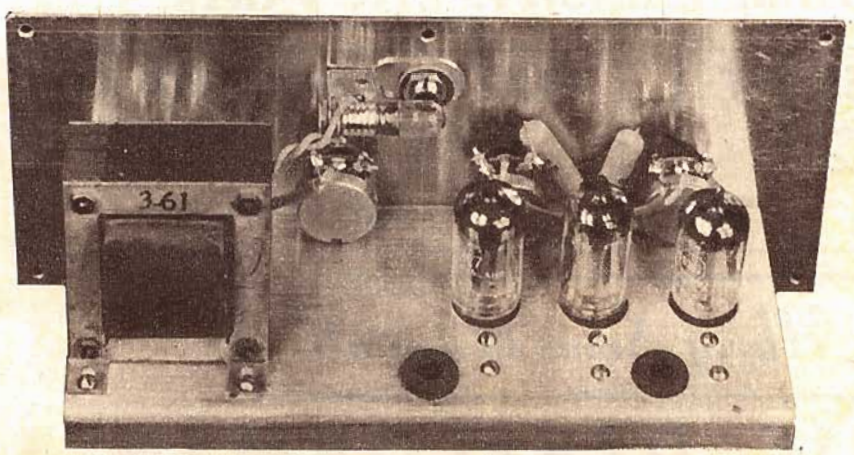
DRAWBACKS

One feature is that the microphone control potentiometer must be kept fairly high in value (here it is 1 megohm) to provide a reasonably good match for the usual crystal microphone. High value potentiometers are often noisy, however, and thus introduce a relatively high noise level into the microphone signal. When used in circuits such as the one shown, where a high gain amplifier follows, the noise is usually too high in level for serious audio work.

The potentiometer cannot be reduced in value, for although the noise might be reduced, so would the bass response of the microphone.

(Readers having relatively low impedance dynamic microphones should note that this does not apply to them. If a dynamic microphone of about 50-100K output impedance is used, the microphone pot, may be changed to 50K or 100K rather than the 1 megohm specified. The simple passive mixer of Figure 1 would then be quite a good proposition apart from the gain problem, which we discuss below.)

The second problem with passive mixers of this type is that they reduce the volume of the signals passed through them. In the mixer circuit shown, this is of little concern where the pickup input



Here is a rear view of the chassis and panel. The power transformer is on the left, and three valves on the right. Note the microphone pre-amp output coupling capacitors behind the centre valve, and the grommets at the rear of the chassis to take the input and output leads from the rear panel.

is concerned, since it is already reduced in volume by the 470K—22K resistive divider. A little more hardly matters, since the output of the mixer feeds to a microphone input and pre-amp valve.

To the low-level signal coming from the microphone, however, the loss in the mixer circuit becomes embarrassing. Since the mixer loss is about 6 dB (meaning that the output is half the input), this means that the usual tape recorder amplifier will be "flat out" to provide enough volume. Some recorders may manage to compensate for the loss, but many will not be able to do so, unless modified in some way, with consequences as before.

Thus the question of whether such a passive mixer will serve your purpose will depend for its answer upon many factors. These include the recorder or amplifier used and its gain, the microphone used, the nature of the sounds recorded (close talking or distant sounds, etc.), and the final quality tolerated. Remember also that simple passive mixers such as that shown will cater for only two input signals if satisfactory mixing is desired.

Because of the disadvantages inherent in passive mixers, the active type of mixer is usually preferred. With this in mind, we have developed a four-channel active mixer unit, which is presented on these pages. Reference to the circuit diagram will show the principle

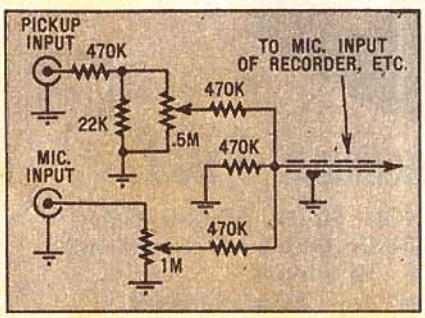


Figure 1: The circuit for a simple passive mixer unit which may give reasonable results with a crystal microphone and pickup. It should be built into a small shielded box to prevent hum pickup. The text explains why this type of mixer is not favoured for serious audio work.

features of the active type of mixer, compared with the passive type shown in Figure 1.

Firstly, before the actual mixing and volume control operations take place, the low-level microphone signals are passed through pre-amplifier stages. These stages (using the two Z729/EF86 valves) raise the signals to about the same level as pickup signals (about 500 millivolts) and allow mixing to be done in medium impedance, high-level circuitry. Thus the noise level is kept to a minimum.

The actual mixing is done, as before, by a fixed resistive network. Each signal is controlled by its own volume control potentiometer. Fixed 470K isolating or "adder" resistors placed in series with the moving arms of the pots. prevent the controls affecting the other signals to any extent. .

Since this type of network cannot deal satisfactorily with more than two input signals, another type of signal mixing is employed—electronic mixing. A twin triode valve is connected with its two plates and cathodes connected together. It thus behaves as a single triode valve having two control grids and will mix signals applied to its grids, while keeping them separate, as far as their sources are concerned.

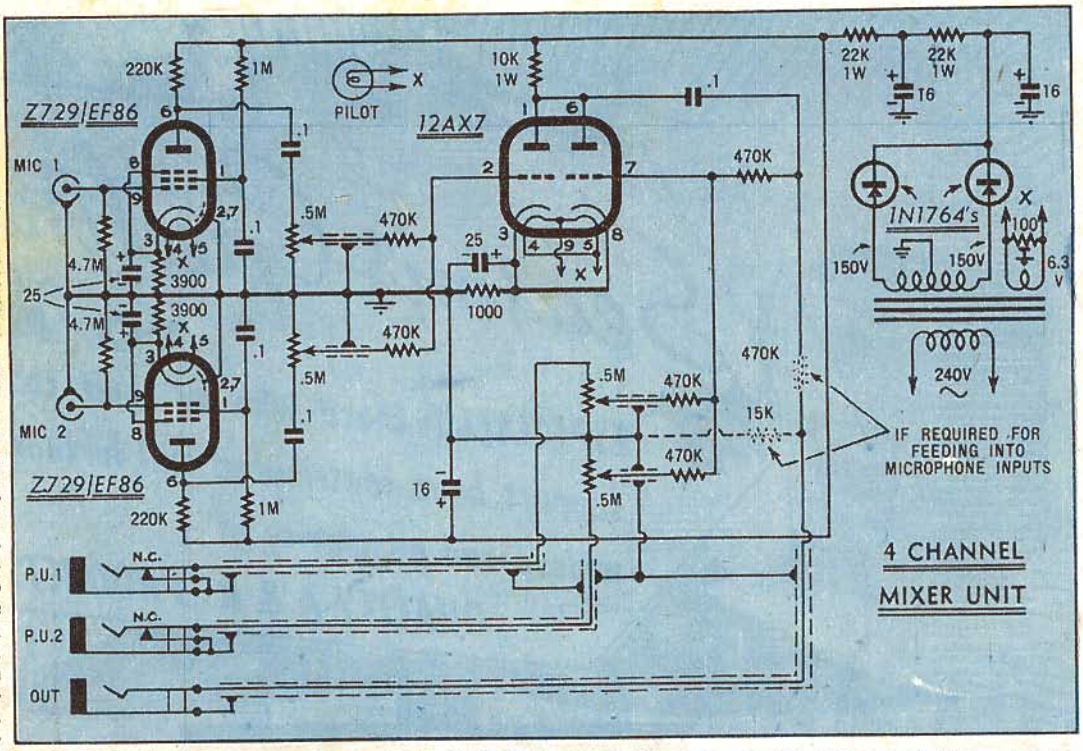
Thus the final mixer unit uses resistive mixing to combine the two microphone signals, resistive mixing to combine the two pickup signals, and electronic mixing in the 12AX7 valve to produce the final composite output signal.

Since the 12AX7 valve is connected up as a triode amplifier stage, it is capable of increasing the level of the signals. Here is another advantage of the active type of mixer, for the mixing triode valve can be used to compensate for the loss in signal level caused by the resistive mixing circuitry.

With the circuit as shown, the gain in the 12AX7 valve raises the output signal to the level of the pickup input signals—approximately 500 millivolts. Thus the output is suitable for direct connection to the pickup jack or terminals of any radio, amplifier, recorder or film projector.

If the recorder or amplifier used has only a microphone input connector, the output of the mixer will have to be reduced in level. This may be done by adding the two resistors shown dotted on the circuit diagram, which constitute a voltage divider.

To sum up our preliminary discussion, then, here are the main features and advantages of the active type of mixer unit: It has in-built microphone pre-



The circuit of our new mixer reveals that it is quite simple in design. Using but three valves and two silicon diodes, it is most economical to build, yet offers full mixing facilities. Note the divider resistors (shown dotted) required if a low level output is needed for a microphone input.

PARTS LIST

1 Wooden case as per diagram.
1 Panel and chassis to suit.
1 Connector panel, ditto.
1 Power transformer, 150-0-150V at 30 MA. with 6.3V at 1.8A
1 Pilot lamp and bezel.
3 Miniature 9-pin valve sockets.
5 5-lug tagstrips (miniature).
2 3-lug tagstrips (miniature).

VALVES AND DIODES

2 x Z279/EF86, 1 x 12AX7, 2 x 1N1764.

CAPACITORS

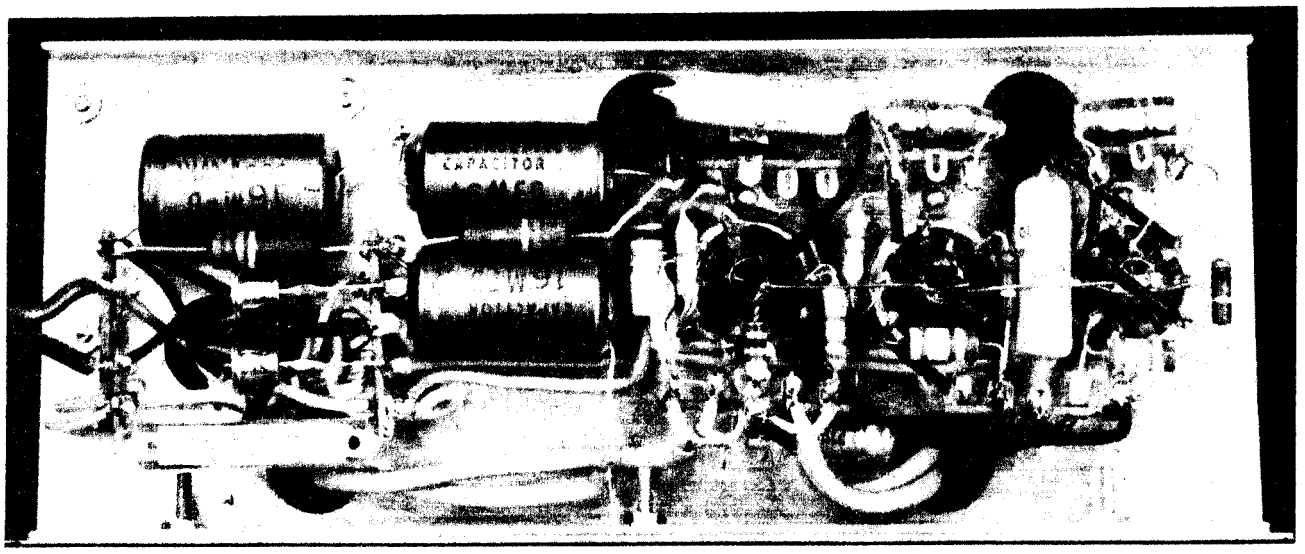
5 0.1mfd 400VW plastic.
3 16mfd 300VW electrolytic
3 25mfd 12VW electrolytic.

RESISTORS

2 x 3.9K ½ watt; 1 x 1K ½ watt;
1 x 10K 1 watt; 2 x 22K 1 watt;
2 x 220K ½ watt; 5 x 470K ½ watt;
2 x 1 meg ½ watt; 2 x 4.7 meg ½ watt;
1 x 100 ohm w.w. slider pot;
4 x 500K log. carbon pots.

SUNDRIES

Connecting wire, shielded cable nuts, bolts, solder, mains flex and plug, etc.



Here is the underchassis view of the mixer unit. Note the use of a common earth line running between the valve socket centre spigots. This is used to earth all the valve circuitry, and connects to the chassis at one spot only—the centre lug or "foot" of the tagstrip in front of the 12AX7 socket. The 12AX7 is the valve closest to the centre of the chassis, with the two Z729/-EF86 valves furthest from the power transformer.

amplifiers, mixes the signals at a relatively high level to reduce noise and does not introduce a signal loss.

The disadvantage usually pointed out for active mixers is that they are more expensive than passive types. This is true, but an active mixer provides a greater ease of operation and produces far better results.

This being the case, we feel quite justified in presenting the mixer unit shown on these pages. Catering for two microphones and two pickups, it is self-contained and features low noise and distortion with a frequency response flat over the entire audio spectrum (3dB down at 25 c/s and 27 Kc/s).

The unit employs only three valves, two silicon diodes and a minimum of components. Power is obtained from a miniature 150-0-150 volt transformer.

As mentioned in the preamble, two Z729/EF86 valves are used as the microphone pre-amplifiers. They are connected as conventional pentode amplifiers, and have an input sensitivity of approximately 4 millivolts (full volume) for a mixer output of 500 millivolts. This means that they will cater for most crystal and dynamic microphones, and many ribbon microphones when used with a step-up transformer.

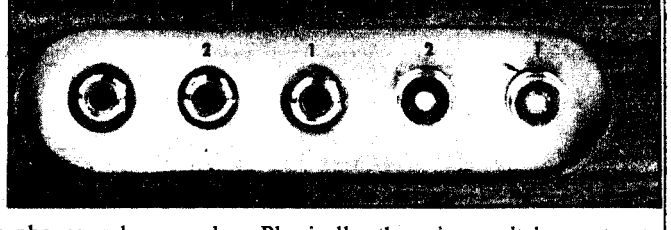
The outputs of the microphone pre-amps are controlled by 0.5 meg log. carbon pots, which are also employed in the pickup input circuits. Thus each input signal has its own volume control, independent of the other signals.

From the resistive mixing circuitry, the signals pass to the grids of the 12AX7 mixer triode. There they are amplified, and the final signal appearing at the plate is a composite of all the inputs. A 470K resistor from the plate to the pickup signal control grid introduces negative feedback to keep gain and noise to a minimum and to improve frequency response.

The output is taken from the 12AX7 plate via a 0.1 mfd capacitor and fed to the output jack. If a low level output is required, for feeding into an amplifier having only microphone input, the output may be reduced by the addition of two resistors (shown dotted).

Power supply for the unit, as mentioned, involves a miniature 150-0-150 volt 30-milliamp transformer and two 1N1764 silicon diodes in a full-wave circuit. A two-stage resistance-capacitance filter provides adequate HT filtering but adds little to the overall bulk of the unit.

To reduce hum to a suitable level, the heater supply is balanced with respect to earth and is provided with a slider potentiometer (100 ohm) to allow hum-backing to be performed. The technique of single-point earthing is used in the amplifier circuitry to further reduce hum with the result that the final (hum plus noise) figure is 60 dB below the reference output level of 500 millivolts. This is low enough to be negligible in all but highly critical applications.



This view shows the rear panel mounting the input and output connectors, simply a sheet of aluminium measuring 6¾ins x 2¼ins.

Physically, the mixer unit is constructed on a simple panel-and-"U" chassis assembly mounted in a small wooden carrying case. The four volume control potentiometers are mounted centrally along the front panel, with the mains pilot lamp near the top of the panel.

As the rear view of the chassis shows, the miniature power transformer is mounted at the rear of the chassis at one end. The valves are mounted at the other end along the centre of the chassis, with the two Z729/EF86's furthest from the power transformer.

The input connectors and output jack

are mounted on a small aluminium plate, which is screwed behind a hole in the rear of the case. This keeps the connections to the unit away from the operating knobs, and simplifies operation. The use of an output jack rather than a captive output cable necessitates the use of an output cable having a plug at each end, but it has the advantage that the mixer does not have a bulky cable permanently attached.

This cannot be done easily in the case of the mains cord, but since a two-core flex is used, little bulk is added. The mixer is not eathed directly to the mains but connects via the shield braid of the output cable. This ensures that multiple earths do not occur, with consequent hum troubles.

Underneath the chassis, two miniature 5-tag strips directly under the power transformer support the mains termination and transformer connections. The

This sketch shows the dimensions of the case, panel and chassis used for the prototype mixer unit. We finished the chassis and panel with a matte surface, by brushing the aluminium and spraying with clear laquer. The matte surface blends well with the dark, polished surface of the plastic laminate, giving a professional finish to the unit.

strips also support the silicon diodes, the 100-ohm slider potentiometer and the first 22K filter resistor.

The three high-tension electrolytic capacitors fit close to the chassis between the power supply circuitry and the 12AX7 socket. The circuitry for this valve is supported by miniature 5-tag strips to the front and rear of the socket. The front strip anchors the mixing resistors and the cathode components, while the rear strip handles the output components.

The components associated with the two microphone pre-amplifiers are supported by three miniature tag strips. A 3-lug strip at the rear of each socket supports the cathode resistor and bypass capacitor, while a common 5-lug strip mounts the plate and screen circuitry. The coupling capacitors do not mount beneath the chassis, but may be seen above the chassis close to their respective controls.

The main things to watch when wiring up the unit are that the mixer resistor leads are kept as short as possible (the resistors being as close to the 12AX7 socket as possible), and that the common earth of the valve circuitry connects to the chassis at one spot only.

In the prototype, the earth line runs between the three valve spigots. All earth returns for the valve circuitry are taken to this common earth line, which connects to the chassis at one point only —the centre supporting lug of the tag strip in front of the 12AX7 socket.

The carrying case used for the prototype was constructed from half-inch plywood and has a sloping front. Small cleats are fixed to the inside of the case to which the front panel mounts. The case was finished in wood-pattern synthetic laminate of the "Laminex"-"Formica", etc. variety. We are publishing the dimensions of the case for the benefit of readers wishing to duplicate the original.

When applying the laminate, follow the manufacturer's instructions carefully. For best results, cut and trim each piece carefully before you start, undercutting each edge to ensure that it will fit neatly at the corners. When you are satisfied with the fit, apply the contact cement to the case and laminate and wait until both surfaces are practically dry (this normally takes about 20-30 mins.).

When applying the laminate to the case introduce it with a rolling action to prevent air bubbles forming between the two cement surfaces (bubbles would cause bumps and lumps in the finish). Roll the laminate firmly into contact with the case with a rolling-pin or similar device.

Any wood grain visible after the main surfaces have been covered with the laminate should be painted with dark brown enamel to match the laminate. If the operation is performed with care, the case will have a most attractive appearance and will grace the most elaborate audio setup.

This completes the description of our four-channel mixer unit. Small in size and cheap in cost, it will allow quite elaborate mixing to be done with the most modest of audio equipment.