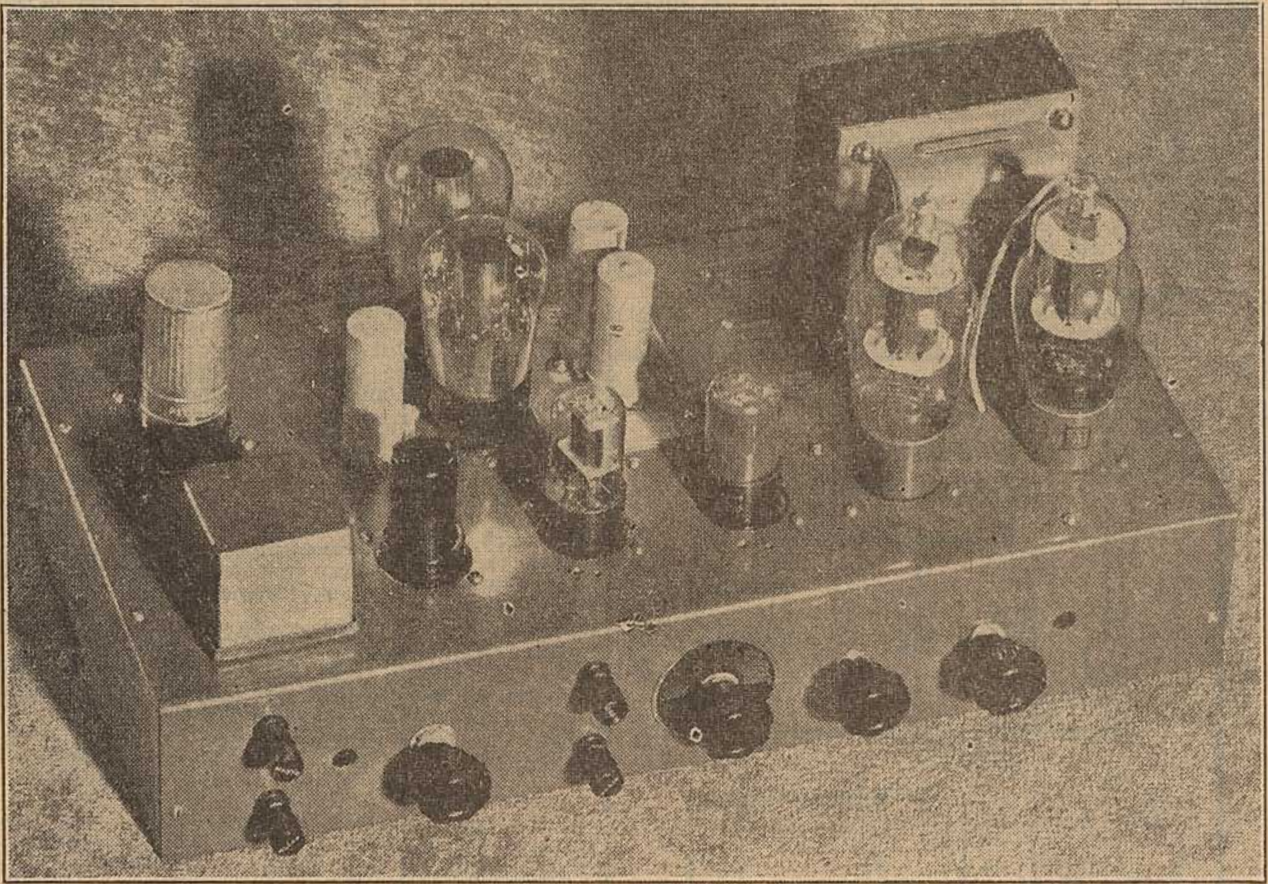


The remade "Williamson." Note that the power supply has been removed, and the output end moved to the right. The metal valve is in the bass boost circuit. Next to it is the shielded compensation pad for the pickup. The voltage regulators are in the centre. Controls left to right are: input switch, volume, and bass boost. The fourth is not in use.

SUGGESTIONS FOR AMPLIFIERS

One interesting sidelight of our experimental work on pick-ups has been the development of a high-gain quality amplifier capable of operating from all the pick-ups we have tested. This has been rather a large order, bearing in mind the wide range of outputs obtainable from the pick-ups under various working conditions.

by John Moyle VK2JU

SOME of these pick-ups have been able to operate the amplifier when connected directly into the pick-up terminals and with comparatively little compensation. At the other end of the scale, accommodation was required for a moving coil type with an output of 1 millivolt plus bass compensation of up to 12 db per octave below 300 cycles. This doesn't sound much when you say it quickly, but as our story proceeds, many of the difficulties will come to light.

BASIC AMPLIFIER

The basic amplifier used was our own version of the now well-known "Williamson" circuit, which briefly uses a pair of 807 valves as triodes in the output stage. Feeding them is a 6SN7 wired in push-pull, and this valve is driven by the two sections of another 6SN7 in cascade, and direct coupled.

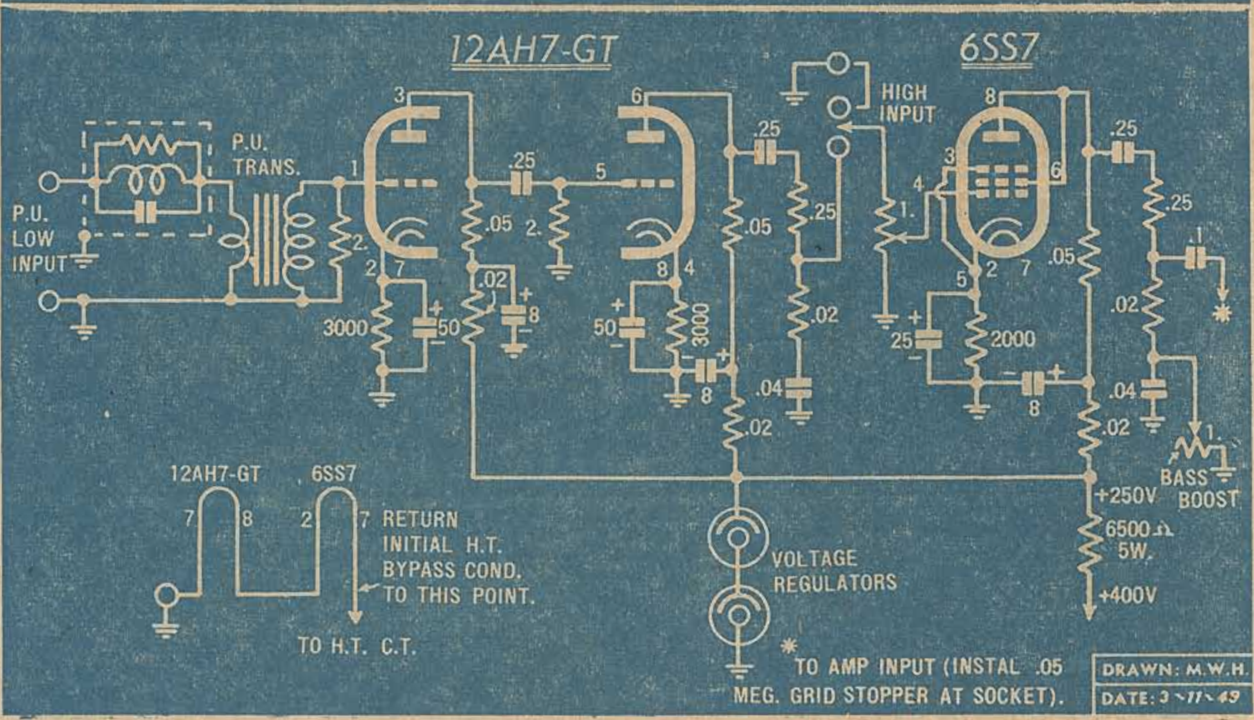
Feedback is obtained from the secondary of the special output transformer and fed back into the cathode circuit of the first amplifier. In the original circuit this feedback is considerable—about 20 db. But even without this degree of feedback, the overall distortion figures are extremely low, almost certainly not more than about one half per cent. In this respect it differs fundamentally from an amplifier using a pentode connection, where removal of the feedback allows an appreciable increase in distortion.

OSCILLATION

A main feature of this amplifier is its extremely flat response from virtually zero to 30 or 40 kc, or even higher than this. According to the designer's data, there is a peak of several db at 2½ cycles, an absurdly low frequency. But it's worth remembering this point, as we will show later on.

The first difficulty encountered when adding a preamplifier to the Williamson circuit was a tendency to very high frequency oscillation

CIRCUIT DIAGRAM OF ADDITIONS TO AMPLIFIER



The circuit of the preamplifier. Treble boost was tried out, but, although successful, is not recommended. Our pickup compensator used 450 turns of 28 B & S on an RCS choke bobbin or equivalent, condensers (low voltage) totalling 5 mfds, and 150 ohms resistor. Other pickups will probably require other values.

due, we suspect, to capacitive input and mentioned in our October issue. Williamson himself suggests a suppressor circuit, but we have found the inclusion of a stopper resistor wired right at the grid of the first 6SN7 is quite sufficient to remove the trouble. Our first job, therefore, was to include this resistor and anything around .05 meg will do.

We have been using the amplifier for some little time with a preamplifier circuit built on a separate base and remote from the amplifier itself. Wishing to incorporate the preamplifier on the same chassis, we soon struck trouble—excessive hum due to the physical proximity of the power supply transformer and choke, and also to eddy currents set up in the steel chassis by them.

It took very little experiment to determine that the power supply would need to be entirely removed from the chassis, and mounted separately. In fact, five or six feet separation was desirable before the last signs of induction from it were removed. The trouble was due almost entirely to interaction between the pickup, coupling transformer and the supply, even though the coupling transformer at least was enclosed in a mu-metal shield.

RE-ARRANGEMENT

This modification allowed some rearrangement of components. The output transformer was now mounted in place of the power transformer, and an extra hole in line with other socket holes punched in the chassis. The 807's were moved along one hole to the right, in addition to the first two valves. This made a free space almost half the length of the chassis for the accommodation of the preamplifier circuits.

At the extreme end of this cleared section the preamplifier was installed, thus keeping it as far as possible away from the output circuits.

So far, so good! Now the next trouble was struck. The preamplifier, as the diagram shows, uses one half of a 6SN7 to obtain bass boost—about 6 db per octave to compensate for recording loss. But the extra gain at the low frequencies was now great enough to set up motorboating and nothing seemed to stop it. No amount of decoupling or separation of plate circuits made any difference.

SOME further remarks on amplifier performance will be found on page 96 dealing with the subject of scratch level, an important consideration particularly with high quality amplifiers.

The trouble apparently was due to the use of a common power supply for all valves. Furthermore, the ability of the amplifier to reproduce low frequencies, plus that peak already referred to at 2½ cycles, made it virtually impossible to provide low enough impedance in the filtering to avoid interaction between them.

Most of the motorboating was at about 2½ cycles per second—the movement of the cone could easily be observed and its oscillations counted.

Two courses were adopted as remedies. The first was to use a separate power supply to feed the plates of all valves except the 807's. The isolation thus obtained stopped the trouble at once. The power supply was that employed by a tuner used with the amplifier, although careful decoupling and filtering was needed to reduce the hum level from this source.

An equally effective and more convenient method was to feed all the valves except the 807's and their push-pull driver through a dropping resistor of 6500 ohms, and to connect from this point to ground a pair of voltage regulator valves wired in series. Those used were ex-disposals types rated at 120 volts so that they pegged the voltage at this point to 240 volts.

DECOUPLING

The standard type of regulator suitable for this circuit will have a rating of 150 volts, which means that two in series will peg the voltage at 300 volts. With these regulators, a dropping resistor of about 5000 ohms should be just about right. The safest plan is to arrange that, with the regulators lifted out, the voltage at the controlled point rises about 20 volts higher than 300. A series resistor must be used, if only to ensure that, should the controlled valves not function, the current drain through the regulators will not exceed the rated maximum figure for them.

Incidentally, no decoupling condensers of any kind should be connected from the control point to ground. Not only are they unnecessary, as the regulator tubes themselves function in much the same way as a big condenser, but the time constant provided by condenser and resistor would almost

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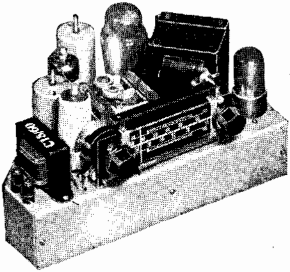

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certainly make the regulator tubes oscillate themselves at some odd frequency.

There was now no sign of motorboating. The amplifier was quite stable in this respect for the remainder of the experiments.

The next problem was to reduce residual hum to a negligible quantity, no small task with the high gain at the boosted bass end.

Careful decoupling in all possible circuits helped a great deal, but there still remained some hum which was obviously not originating from the plate supply. The heater supply was, therefore, suspect for two reasons: Presence of A-C wiring to the heater among grid connections and earthing points was one. Heater-cathode capacitance was the other, notwithstanding the generous cathode bypasses, which would have been adequate for an amplifier with less gain in the bass region.

This was verified by running the amplifier, and suddenly removing the heater voltage. The hum immediately dropped to a very low level.

HEATERS ON DC

The logical answer was d-c for the heater supply of at least the first valve, but how was it to be obtained? The solution was quite simple. The total high tension drain of the amplifier is about 140-150 mills. A 12AH7, the 12-volt counterpart or nearly so of the 6SN7, has a 150 mill heater. We wired the socket for one of these valves, and ran a lead from the power supply centre-tap to one side, the other being earthed. In the power supply the first filter condenser negative end was now connected to the HT centre-tap instead of to the chassis, thus providing adequate bypass for the 12AH7 filament.

The hum was now little more than with no heater voltage at all, and so low that, two feet from a well baffled heavy duty speaker, it could hardly be heard with the gain wide open. Valve hiss, due to the high gain, was just as obvious.

The heater is similarly placed to a back-bias resistor, so that 12 volts or thereabouts is subtracted from the total high tension. In practice, this doesn't matter greatly, nor does it matter if the actual voltage drop across the valve is as low as 10 volts or as high as 14.

BEWARE SHORT CIRCUITS!

With this connection, be very sure that you do not accidentally short circuit the high tension. If you do, you will almost certainly burn out the 12AH7, although a torch-globe fuse would probably operate first if of suitable characteristics.

This pre-amplifier was fine for the low output pickup, although, to obtain full output, not always required by the way, a reduction in feedback was made. The 5000 ohm resistor was increased to about 15,000 ohms. Listening tests showed no discernible difference in quality, nor did observation of the waveform. This is one handy feature of the Williamson circuit—it is still mighty good without feedback, which is used more as a refinement than a necessity except possibly for special applications.

In order to cater for pickups with output high enough not to require extra gain, we provided a switch to change from the pre-amplifier to a second input channel. In this case, however, the 6 db per octave bass boost was not operative. And an external boosting pad in the pickup circuit frequently reduced input so much as to provide insufficient voltage input for the amplifier.

To overcome this and to provide boost for radio, should this second channel be used for it, an extra stage was wired permanently in place immediately ahead of the main amplifier, the volume control being moved into its grid circuit. This stage gives virtually no gain but it incorporates a 6 db per octave bass boost circuit which justified its inclusion. The pickups can now be connected directly into the second channel without loss.

SINCE this article was written the top-cut filter described elsewhere has been added immediately after the variable bass boost section and ahead of the amplifier proper, so that it operates on both inputs. It is built as an "outboard" section although it could be incorporated on a larger chassis.

In order to make this bass boost section variable in character, a 1 meg potentiometer was wired across the bass boost condenser. Obviously when the pot. partially or completely short-circuits the condenser, it partially or completely removes the boost without affecting the overall gain of the stage. With the pot., completely in circuit, it has negligible effect on the boost.

BOOST VALVE

Incidentally, this extra boost circuit allows double the amount of boost to be obtained when using the low input channel. This is sometimes useful for low level listening. The filtering is so good that with the full 12 db or thereabouts of boost, and the gain wide open, the hum is hardly discernible, and certainly not above soft music.

In order to preserve low hum level, this boost valve was made a 6SS7 wired as a triode, with its filament connected in series with the 12AH7, with valves requiring 150 mills heater current. The layout now allows removal of all AC leads from the preamplifier end of the chassis, another good move. Incidentally, although the gain of the 12AH7 is less than the 6SN7 and it is somewhat more fragile, the reduction is not great enough to be serious. The amplifier can still deafen us!

A further point which may not apply to all cases, but did apply in ours, was the necessity to compensate the low output pickup to remove an objectionable peak in the 7-9kc region. The maker, apparently, didn't choose to notice it, but a frequency run and a listening test pin-pointed it beyond doubt.

The pickup, by the way, was a Lexington, to which we are somewhat attached, although its performance doesn't stand out quite so prominently when compared with a few other high-grade pickups of today. All the Lexington pickups we have tried showed peaks from about 9 to 11kc, which will stand removing. There are a few of these jobs still in use, and the following might help their owners to improve results.

As the peak was fairly well defined and symmetrical, we made up a small tuned coil to resonate in circuit at the peak frequency, when connected in series with the hot lead. This circuit wiped the peak, but was rather too sharply tuned on its own. Loading it with a resistor of 150 ohms resulted in a virtually flat characteristic at the peak frequency without apparent distortion of the wave form.

FILTER CIRCUIT

The input circuit isn't the best place for such a filter, as the impedance of the circuit varies with frequency, and such filters are best when used where "R" is constant. In our case, it resulted in a slight attentuation of all frequencies over about 11kc. However, there are so many variables to be considered in chasing this region that, so far, we haven't bothered to correct it.

At a later date we may work out some constants suitable for inclusion elsewhere in the circuit to remove this objection and also to avoid tendencies to hum pickup to which the filter circuit is extremely susceptible. It was necessary to enclose the coil, condenser and resistor in a small shield can above the chassis to avoid pickup, and it is even worthwhile to experiment with reversing its connection if a small amount of hum is experienced. But if you are careful, it will be very small.

The pickup's input transformer, too, must be shielded and placed with care, shielding leads to and from, and earthing all appropriate points to the same point as earths the first cathode bias resistor.

VALUES

The values of the filter were worked out experimentally, and different values of coil and condenser, provided the resonant frequency remains the same, should not affect performance very much. Actually, we wound the coil on a small former with an adjustable iron core, and tuned the whole thing by means of frequency records and an oscilloscope or output meter across the voice coil. It is really essential to do this if the flattest response is desired, although our values as they are should greatly improve matters in almost every case.

Overall results with the pickup are

(Continued on Page 103)

TWO U.S. NAVY SINGLE SEAT JETS

(Continued from Page 77)

North America into the field of jet military aircraft. The prototype flew just three years ago, and later the Fury went into production at Los Angeles for the US Navy.

A low-wing cantilever monoplane, it features thin laminar-flow wing section. The wings show a 5 deg. dihedral, the tailplane 10 deg. dihedral.

Of all-metal structure with flush-riveted stressed skin, the Fury has perforated "low-swirl" dive brakes above and below the wings in the sections outside the landing gear. The fuselage is oval in section. The wings do not fold.

One Allison TG-180 axial-flow gas turbine is mounted. The air intake is in the nose, the exhaust nozzle in the rear of the fuselage and provision is made for jettisonable wing-tip tanks. The aircraft has built-in wing-tip lights.

The landing gear of the Fury is of the tricycle type, and fully retracting.

The cockpit has a sliding "bubble" canopy, and the pilot's seat is fitted with cordite-operated ejector.

Loaded weight is 12,500lb.

Main dimensions are: Wingspan 35ft 1in, length 34ft, 6in, and tailplane width 17ft 7in.

ADDING TO YOUR AMPLIFIER

(Continued from Page 67)

now excellent. The prominent needle scratch is absent, and some distortion particularly on voices has been eliminated. We may have more to say about this in the Record Review pages.

A few facts on the finished amplifier may be of interest. With BFO input, the output is flat from about 10 cycles (limit of accurate reading) to about 25 kc. It rises about 2.5 db at 35 kc and drops to reference again at 45 kc, after which attenuation is sharp. Over the flat portion of the range, output is clean and constant at 15 watts, with a breakup at about 17 watts. The input was at the pick-up transformer input channel, with filter shorted out, and the output was read at the voice coil winding on resistive load. Using the Lexington and frequency records, and a 2.5 mil stylus, output is flat from 25 to 3000 cycles, rises about 2.5 db to 10,000 cycles, and then drops until it is about 7 db down from 13 to 20 kc. A 3.5 mil point would certainly improve the range above 11 kc as slight side pressure on a pickup using a 2.5 mil point indicates in this region.

Although all these notes may not apply to all amplifier enthusiasts, it is anticipated that some of them at least will be helpful to those who chase that elusive thing—perfection in reproduction.