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★ **Startling development gives improved quality of reproduction.**

★ **Cathode follower theory applied to power amplifier circuits.**

★ **Operation of the Novacord electronic piano described.**

★ **Impedance and capacity meter is handy equipment for service.**

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THE AUSTRALASIAN RADIO WORLD

Devoted entirely to Technical Radio

and incorporating

ALL-WAVE ALL-WORLD DX NEWS

Vol. 9 OCTOBER, 1944. No. 5

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CONTENTS

EDITORIAL

Frequency modulation is headline news in the papers these days, following on statements which have emanated from Canberra. Following the usual routine, these statements have in due course been denied, and counter-statements have been issued. But where there is smoke you usually find fire, and so people gain the impression that there must be something to this frequency modulation business. The talk about frequency modulation has caught many radio engineers "on the hop", and we have been inundated for the back numbers in which the subject was dealt with, but these are no longer available.

We have not had time to get a full story ready for this issue, but we plan to cover the whole subject in detail in next month's issue, including the possibilities which the scheme may open up.

We do not under-estimate these possibilities, but at the same time we feel sure that they will take a considerable time to reach fruition and there is not quite as much need for a rush as some of our readers seem to feel.

First the war has to be completely cleaned up, then the plans have to be laid, and we cannot imagine that frequency modulation will be a completely established service until at least a couple of years after the cessation of hostilities.

In the meantime, radio technicians will have ample time to become thoroughly acquainted with the new technique.

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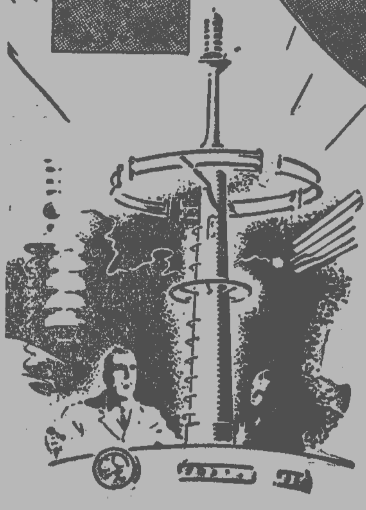

Radio developments, accelerated by increased war production and research have been "put in the ice" in the R.C.S. Laboratories until the end of the war. The directors of R.C.S. Radio feel confident that constructors and manufacturers who cannot obtain R.C.S. precision products fully appreciate the position and wish R.C.S. well in their all-out effort to supply the imperative needs of the Army, Navy and Air Force. The greatly increased R.C.S. production has been made possible by enlarged laboratory and factory space and new scientific equipment, all of which will be at the servict of the manufacturers and constructors after the war.

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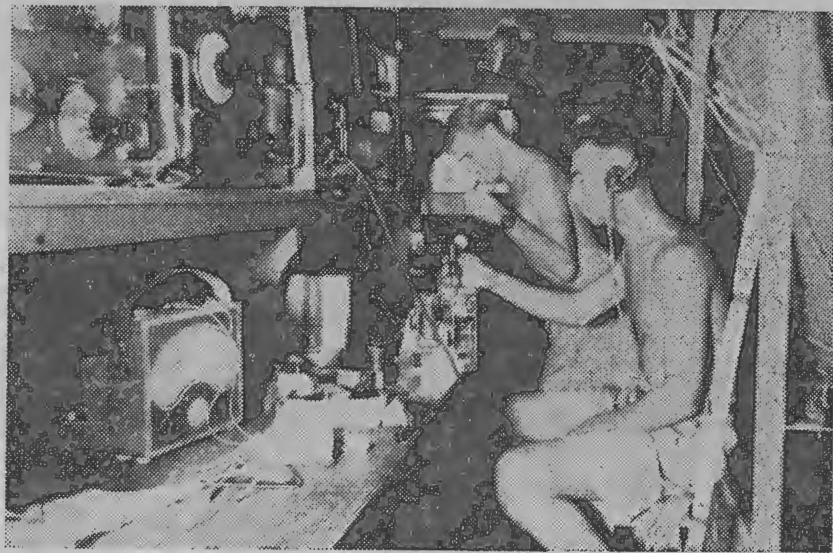
SOMETHING FRESH IN AMPLIFIERS

By

A. G. HULL



Repairing and adjusting A.I.F. service radio equipment in a trailer workshop just behind the front line.
—Photo from Department of Information.

IT is quite easy to get the impression that technical radio is stagnating, but not if you happen to be on the inside of the secret developments associated with army communication, radar equipment and other items which will be considered when the time comes for their publication. Keen enthusiasts can get some idea of these unprintable affairs if they study the details of some of the latest valve type releases.

But even in the midst of these secret developments there comes quite a sensation in amplifier technique which is quite open for discussion. As if to discredit Flight Sergeant Edwards, who recently wrote of "an amplifier beyond reproach," comes the plan of using the cathode follower circuit for amplifier work.

Super Feedback

The cathode follower circuit is so named for the cathode potentials follow those on the grid, thereby getting what amounts to a big percentage of degeneration or feedback as we usually call it in these modern times.

The scheme has been used for some time past in amplifiers in laboratory equipment, as for example, in "Q" meters.

The idea of applying it to the audio amplifier for radio and gramophone use has been toyed with a bit, but first brought forcibly to our notice by an article in a recent issue of the English "Wireless World", which speaks for itself as it is reproduced in this issue. Just as our interest was aroused by this article we received an additional spur from a New Zealand enthusiast who sent along a suggested circuit which he was unable to try in practice on account of lack of spare time.

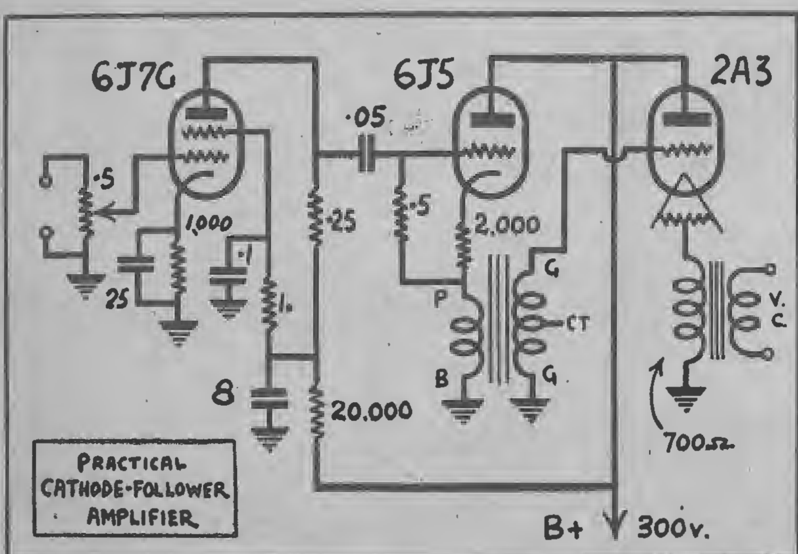
We are also short of time, but the scheme was too good to miss, and so we squeezed a few hours in which to run up a haywire amplifier to this circuit. We were unable to really bring it to an entirely final conclusion, but we proved that it is something really worthwhile and of intense interest to the large number of our readers who are keen on quality reproduction.

Solves a Problem

In a nutshell, the cathode follower circuit gives one solution to the problem of the speaker input transformer, previously one of the weakest links in any amplifier. With an ordinary amplifier feeding into a plate load there is the tendency for the effective output from the speaker to be affected by the impedance of the primary of the input transformer, which will vary according to the frequency being handled. But in the cathode follower circuit the matter of impedance is of little importance. In practice this means a vastly improved low note response with the ordinary commercial type of speaker input transformer. And by an improved response we do not mean a boominess, but a cleaner, clearer-cut low reproduction which is a definite step towards realism. The improvement is readily distinguished by the

(Continued on next page)

CATHODE FOLLOWERS—
See also pages 11 and 16 in this issue.



The single-ended amplifier. In the push-pull version. See page 16.

SOMETHING FRESH

(Continued)

ear under ordinary listening conditions.

The idea can also be applied to the interstage audio transformer, a cheap transformer with comparitively low primary impedance becomes adequate to give response which would otherwise be obtainable only with an expensive hi-fidelity type of transformer.

Still further, the scheme allows a single-ended amplifier to become almost as good as a push-pull one. The old bogey of the d.c. current in the primary of the speaker transformer and its effect on the inductance of it becomes of little importance. The extreme feedback effect takes care of harmonic distortion.

The Drawbacks.

The drawbacks are mainly in regard to voltage gain, but these are of little importance in these days of pick-ups with high signal output and audio pentodes with effective gain of a hundred a stage. In round figures, the valve which is cathode loaded loses all of its normal gain, and has even a slight "loss." This is all covered in the other articles on cathode followers which have been included in this issue to cover the subject fully. After you have read them all you will know as much about the subject as most of us!

Practical Work.

Our practical work on the subject amounted to only a few hours. We ran up the amplifier exactly as described by our New Zealand reader, but using an audio transformer with a three-to-one ratio which was the only type available to us at the momnt. Results were right up to expectations as regards tonal quality and completely substantiated the above statements in regard to the quality possible with a cheap transformer. Ours was one which originally sold at a list price of six shillings and sixpence, yet the final reproduction compared more than favourably with two other amplifiers which we were able to plug in one after the other to compare results by ear. These others were both resistance-coupled jobs, one with beam power valves and concertina phase changer with feedback to he screen of the first audio. The other had triodes with a direct-coupled phase changer. Both of these amplifiers were considered to be pretty good, but we immediately switched our affection to the new job with the athode follower. It was obvious, howver, that we did not get full power output and a higher ratio of audio ransformer is required.

Single-ended Amplifier

To confirm this belief we changed things around so as to have a single

(Continued on page 26)

"NOVACHORD" IS ELECTRONIC PIANO

By
CHARLES MUTTON
1 Plow Street, Thornbury, Vic.

MANY of us are inclined to develop a "one track mind" with regard to vacuum tubes and their uses. We think of them applied to receivers, transmitters, amplifiers, talkie equipment and various items of equipment. But when it comes to applying vacuum tubes to the vast new electronic field, the average man is usually at sea, also many radio men are in the same boat. When it is realised, however, that the electronic field is destined to open up a tremendous untouched market in Australia and elsewhere in the post-war period, radiomen will be well advised to wake up to the amazing potentialities of "electronics" in general.

It is proposed to discuss and describe the "Novachord" electric piano produced by the makers of the "Hammond" organ. Such a discussion should provide many of our readers with food for thought as there are many principles involved in the design of this instrument which can be applied to many other devices in the electronic field.

Principle of Operation

The "Novachord" electric piano has no moving parts such as strings, reeds, or rotating tone wheels, all its tones being generated by employing in all, 163 individual vacuum tubes. Quite an impressive total at a glance, but when split up into groups and taking sections the mode of operation is fairly simple.

As most people are aware, there are twelve notes in a musical octave including full tones and semi-tones. The top twelve notes in the Novachord are generated by twelve separate audio oscillators which operate continuously. These are the only oscillators in the instrument. However, associated with each of the twelve oscillators are a number of frequency divider tubes which halve the frequency of the preceding tube, thus we get our octave frequencies of the top range by dividing down and down say from 4,000 cycles to 32 cycles. As there are 6 octaves for each note or oscillator, we have 6 frequency halvers following each of the twelve oscillators. Fig. 1 shows the fundamental circuit of one of the 12 audio oscillators. The two triode sections shown are really one tube, a 6C86 which has two independent triodes in the one envelope. It can be seen that this is really a relaxation type of oscillator, the frequency of which is adjusted by a sliding core of powdered iron in or out of the coil. The output of the first triode is essentially sinusoidal in waveshape, one of the peaks being slightly lopped off. The second triode is operated almost at cut-off point which provides an output extremely rich in harmonics. Many will exclaim "What about distortion." Remember, however, that a sine wave output when reproduced can become extremely monotonous to listen to and as far as music is concerned we want lots of harmonics to give the sound life and character. Two separate output points are used for isolation and to provide a high amplitude signal on the following divider tube.

Divider Circuit

Figure 2 shows the divider circuit. The tube used in the "Novachord" is a 6W7 remote cut off RF pentode similar

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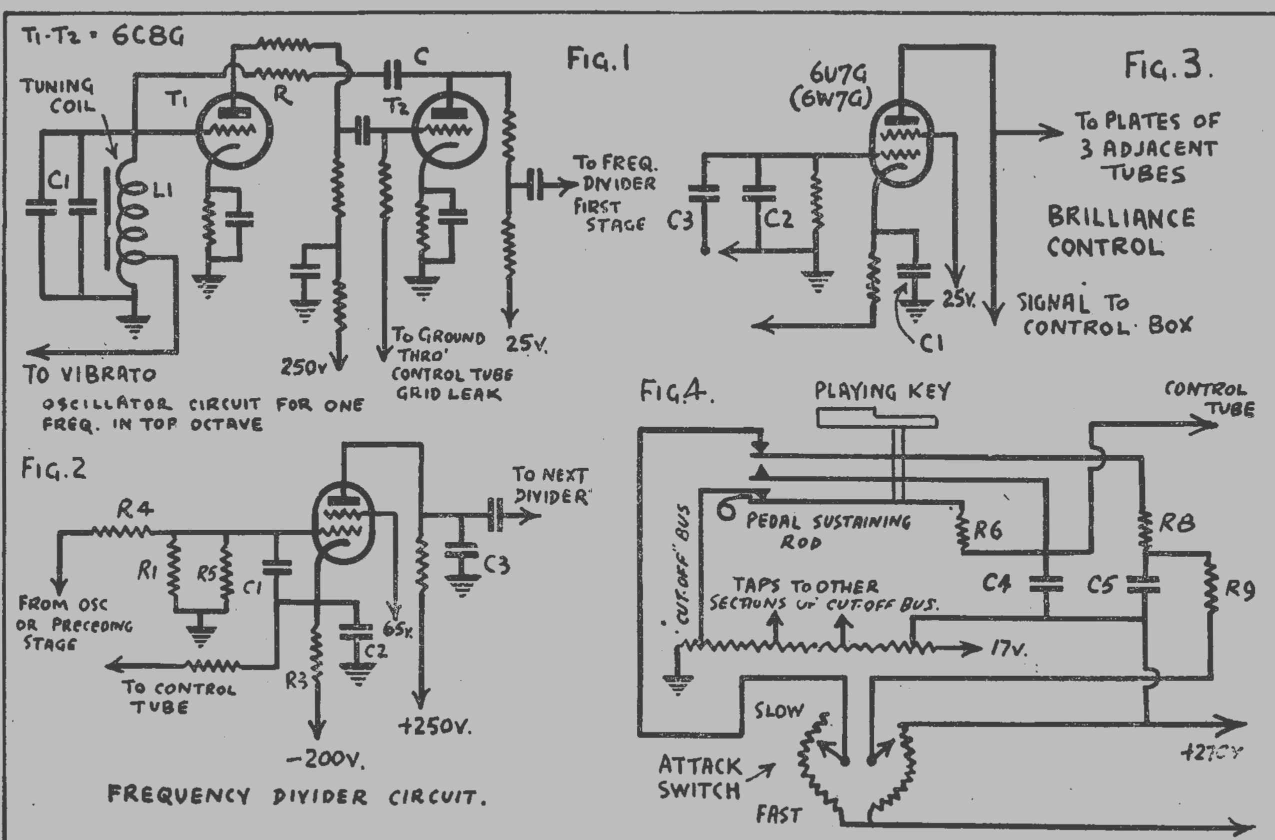

ELECTRONICS

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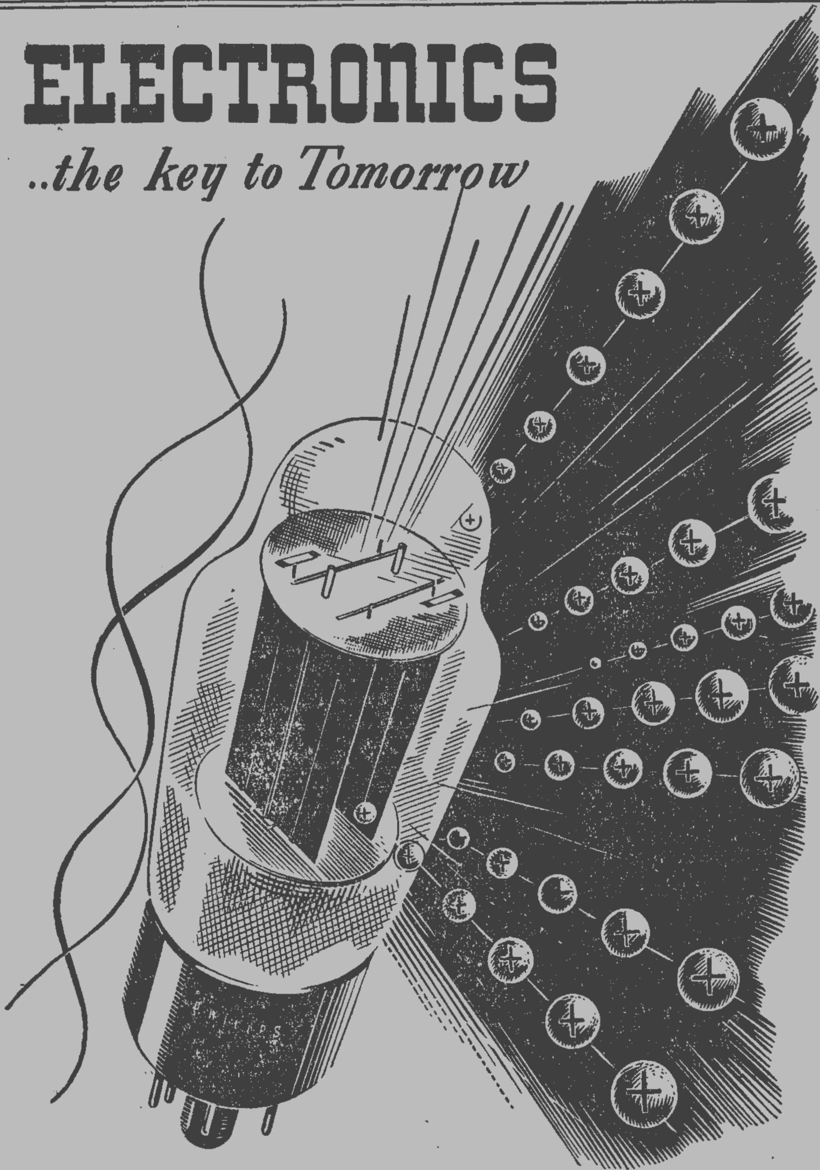

THE radio valve is really an electron tube. It controls *electrons*—the smallest particles of matter known to science. It operates in the world of sub-atoms, where these electrons travel at speeds approximating the speed of light—186,000 miles a second!

In the development and applications of electronics to the science of war and of post-war industrial problems, PHILIPS are playing a major role.

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"NOVACORD"

(Continued on page 7)

to our 607G except for a heater current of .15 amps instead of .3; the reason for this is obvious. The divider circuits are also rich in harmonics, but it must be realised that these dividers are not oscillators for, if one of the oscillators should fail to operate the dividers cease to function in the absence of an input signal. The divider merely passes current for every second positive grid voltage alternation and actually acts as a non-linear amplifier. The cathode floats at a direct current potential with respect to ground so that the voltage between cathode and grid will be the cut-off voltage of the tube. Hence the direct current in the tube is almost fixed almost independent of the input signal and very small in average value.

Wave forms across C3 and C2 are sawtooth in character, that at C3 being larger in amplitude and slope and thus drives the next divider more effectively. Increasing R1, R3 beyond 1 to 3 megs may result in the frequency being divided by three or more instead of two as desired. Below one meg the output frequency may be the same as the input.

Control Tube

The purpose of the control tube is to provide a wide choice of the timbre of the final tone in the output system. With the playing key up the grid is so negative that plate current does not flow through the tube, even with a signal on the grid. Under normal conditions the input signal to the grid is sawtoothed so that the control tube acts as a distorter, thus furnishing an extremely rich harmonic output. By adding C3 the sharpness of the positive signal voltage alternation renders a tone more mellow by altering the upper harmonics.

The keying arrangement on the control tube circuit in Fig. 4 permits slow, medium or fast attack as well as the sustaining of the tones by means of a foot pedal which gives a similar effect to an ordinary piano pedal which serves to remove the string dampers.

The function of this part of the instrument is as follows. For organ effects the attack switch may be placed at "slow" so that condenser C5 has very little charge when the playing key is up, owing to R8 being much lower in resistance than R9. By depressing the key C5 charges up slowly through R9 and in turn the increase of negative potential carried over to C4 through R8, results in slowly diminishing the positive cathode potential, so that the positive signal peaks are effective in producing very brief plate current pulses of increasing amplitude. The transient charging over, the plate current pulses continue constant in amplitude as long as the key is depressed, since the voltage across the attack switch provides a bias value less than cut off. By releasing the key C5 is nearly discharged by R8 and C4 quickly returns to normal cut-off potential because of the shorting of R6.

In the case of fast attack C5 starts off with a large charge when the key is up rapidly losing it across R9 plus C4 R8 combination. This results in only a momentary application of grid bias less than cut-off.

An intermediate setting of the attack switch produces assimilated tones of the plucked as well as bowed string (violin and piano). Fig. 7 shows amplitude-time curves for various settings of the attack switch.

Tone Control

Fig. 5 shows the tone control section of the instrument consisting of resonant filters which serve to attenuate or accentuate either the treble or bass ranges as desired.

The keyboard range is from 43.7 C.P.S. to 2,637 C.P.S. a full six octaves. It may be noticed that in the tonal control section that the resonant frequency of the third tuned circuit is approximately 2,500 cycles. However the harmonics of the fundamentals extend well beyond 2,637 C.P.S.

If one of the resonator circuits has its largest resistance setting and all other resistances are at minimum setting, then a given band of harmonics will be emphasised. A setting of some resistance at the "full tone" will allow part of the regular output from the control tubes to pass through unaltered as well as diminish the accentuation of a particular resonant frequency range by that resonator.

Foot Pedal

The foot pedal volume control operates a 350 uuF variable condenser to vary the gain of a pre-amplifier tube through altering the plate to grid negative feedback. This system elimin-

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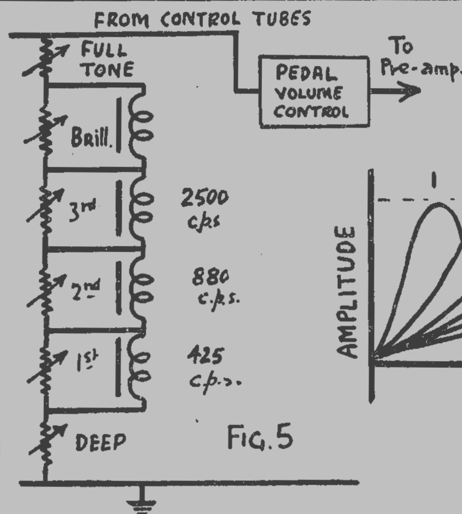

FIG. 5

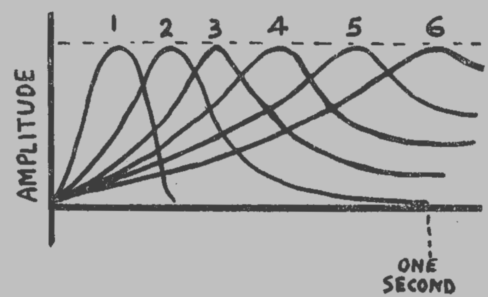

FIG 7 AMPLITUDE-TIME CURVES FOR ATTACK SWITCH POSITIONS.

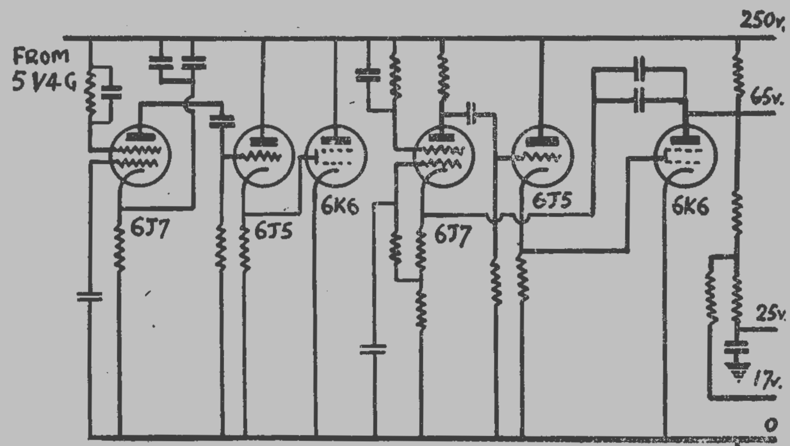

FIG. 6 POWER SUPPLY WITH VACUUM TUBE FILTERS.

CATHODE FOLLOWER OUTPUT STAGE

By

C. J. MITCHELL

A.M.I.E.E.

Reprinted from the "Wireless World" (Eng.)

THE cathode follower is finding many applications in modern radio technique, and has been described in some detail in previous issues of this journal* The basic circuit is shown in Fig. 1, where it is seen that the device is a single-stage amplifier with its load connected in the cathode lead instead of the anode lead, while the output is taken from the cathode instead of the anode. The effect of such an arrangement is to reduce the stage gain to a value slightly less than unity, for the total output voltage appears on the cathode and therefore is opposing the input voltage, but the salient features of the device are a high input impedance and a low output impedance, which render the stage suitable for interposing between a signal source with a high output impedance and an amplifier with a low input impedance.

It is not intended to derive complete expressions for the characteristics of the cathode follower, and the following brief survey of the nature of the circuit will suffice.

In the first place, the stage gain can be calculated from the well-known feedback formula:

$$A = \frac{Ao}{1 - BAo} \quad .. \quad .. \quad .. \quad .. \quad (1)$$

where A = the gain of the amplifier with a fraction B of the output fed back into input terminals

Ao = the gain of the amplifier without feedback.

Since B is negative, and in this case equal to unity, the expression becomes:

$$A = \frac{Ao}{1 + Ao} \quad .. \quad .. \quad .. \quad (2)$$

$$\text{or, } A = \frac{uZ}{Ra + (u + 1)Z} \quad .. \quad .. \quad (3)$$

(since $Ao = \frac{uZ}{Ra + Z}$, where Ra is the valve AC resistance, u the amplification factor and Z the load impedance) Ao is always large compared with unity, so the gain is always slightly less than unity.

The effects of inter-electrode capacitances in a valve are in proportion to the voltages developed across them. From Fig. 2 it is seen that the grid-to-anode capacitance is virtually in parallel with the signal source; therefore one of the components of the input capacitance is the grid-to-anode capacitance (Cga). The grid-to-cathode capacitance, however, has but little effect on the input capacitance, for the potential difference developed across it is very small, namely, the difference between the signal voltage and the output voltage. For most practical purposes the input capacitance may be considered to be equal to the grid-to-anode capacitance.

The output impedance of the cathode follower is almost independent of the value of the load impedance, and is approximately equal to the reciprocal of the mutual conductance (in amperes per volt) of the valve employed in the circuit. By considering the basic circuit in Fig 1, it can be seen that the effect of drawing a current from the output terminals will be to reduce the cathode potential. This will enable the valve to pass more current, and the extra current passed by the valve will tend to restore the cathode potential to its original value.

The principal application of the cathode follower is that of an impedance-matching device (or "buffer" stage), but the circuit can be readily adapted for operation as an output stage, where the low output impedance will provide excellent damping for the loudspeaker, while the large negative feedback will render the stage practically distortionless.

The circuit recommended is shown in Fig. 3. The output valve is a Mazda AC2/pen. connected as a triode. The potential divider connected across the HT supply provides the grid with a positive bias in order to offset the excessive positive cathode bias produced by the DC resistance of the output transformer primary winding. In some cases, it will be found possible to dispense with this biasing arrangement and to connect the earthy end of the coupling transformer secondary directly to the chassis. This can be done when the DC resistance of the output transformer primary in from 100-150 ohms; if it is lower than about 80 ohms, it may be necessary to apply negative bias to the grid of the valve. The best procedure to adopt it to connect a milliammeter in the HT lead and adjust the bias until the correct value of current is flowing, not forgetting that the meter is indicating both anode and screen current. This should be 40 mA. The bias is by no means critical, and the valve will deliver a reasonably large undistorted output when the grid is overbiased. In general, it is better to overbias than to underbias the grid.

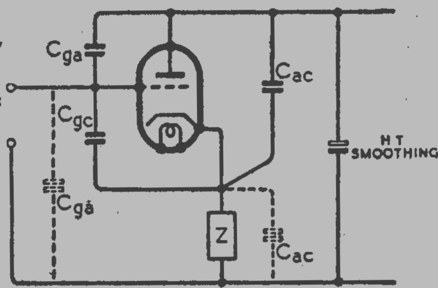

Fig 2 The inter-electrode capacitances are represented as condensers connected externally to the valve. Since the HT + line is by-passed to earth by the smoothing condenser in the power pack Cga and Cac are virtually in the positions indicated by the broken lines.

Matching Loudspeaker to Valve

When employed as a triode the AC2/Pen has a mutual conductance of 0.01 ampere per volt and an AC resistance of 2,500 ohms. In a normal amplifier with a resistance in the anode the maximum power will be delivered to the load when its resistance is equal to the AC resistance of the valve, but if the load is a resistive impedance (a transformer-coupled loudspeaker, for instance), it can be shown that the maximum undistorted power output will be obtained when the load impedance is equal to twice the AC resistance of the valve. A suitable value of load impedance will therefore be 5,000 ohms.

In deciding on a suitable value of cathode load impedance, it should be borne in mind that the cathode impedance must be matched to the AC resistance of the valve, and not to the output impedance of the circuit. This may seem a little confusing, for, in order to obtain the maximum output from a generator, the load impedance must be equal to the output impedance of the generator, so it would appear that the correct value of cathode load impedance would be of the order of

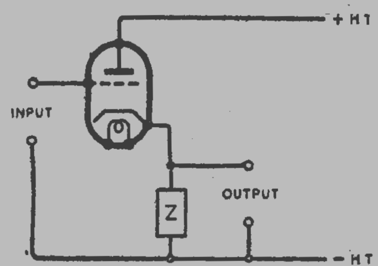

Fig. 1. Basic circuit of the cathode follower.

* *Wireless World*, July, 1941, p. 176; July 1942, p. 164.

200 ohms. This argument does not apply to the cathode follower, however, and we must not overlook the fact that, although the circuit characteristics are changed by the negative feedback, the valve characteristics are entirely unchanged. The feedback simply modifies the input between the grid and cathode of the valve, and this attenuated input is subjected to the full amplification of the valve, just as it would be in a normal amplifier. The apparently low output impedance is due to the fact that a decrease of output resulting from the application of a load of low impedance to the output terminals results in a reduction of the opposing signal fed back, which, in turn, results in a larger input appearing between the grid and cathode of the valve. When viewed from this angle it is seen that the valve still requires the same load impedance as it does when functioning without negative feedback.

It can be argued, of course, that if the wrong value of load impedance is employed, the input will automatically adjust itself and so offset to a large extent the effects of incorrect matching. While this is perfectly true, there is no point in deliberately mismatching the load to the valve, and the following example will demonstrate the effects of incorrect values of load impedance.

In the circuit under discussion, the valve passes a steady current of 40mA, and if a load impedance of 5,000 ohms is employed, the AC power in the load will be 5,000.I² (since W = I²Z). If the power is 3 watts, then $I^2 = \frac{1}{5,000}$, and I = 24.5 mA (RMS). The peak value of this current will be 34.5 mA, so the HT current fluctuations will be from 5.5 mA to 74.5 mA—it will be possible for the current to swing about its mean value of 40 mA without the valve running into the cut-off or saturation region of its characteristic. The anode voltage swing can be calculated in a similar manner.

$W = 3$ watts $= V^2/Z = V^2/5,000$

$\therefore$ $V = \sqrt{15,000} = 122$ V (RMS) = 173 V (peak). If the HT voltage is 250, the maximum theoretical voltage swing of the cathode will be 500 V, and the peak-to-peak cathode voltage swing (346 V) can occur without the valve cutting off.

Now consider the effect of matching the load to the ouput impedance. If the load impedance is 200 ohms, then W = 200.I². If the no-signal current through the valve is 40 mA, the maximum peak-to-peak current swing will be from zero to 80 mA, so the peak AC component will be 40 mA = 28.3 mA (RMS); the power will be $(0.0283)^2 \times 200 = 0.16$ watt! If the input voltage were increased to bring the output up to 3 watts as before, then the peak-to-peak current swing would be 346 mA. Since the current cannot fall below zero, this means that the current would have to swing from zero to 346 mA; the negative half-cycles would have an amplitude 40 mA and the positive half-cycles an amplitude of 306 mA. The distortion introduced would be nearly 50 per cent. without taking into account distortion of the positive half-cycles due to saturation. This distortion would be reduced by the negative feedback, but with a load of 200 ohms the internal gain of the circuit would be only 1.9, and, therefore, the distortion would be reduced to just less than 17 per cent.

With the higher load impedance, the internal gain of the circuit would be approximately 17 and the distortion introduced would be reduced to 1/18 of its original value, so even 50 per cent. distortion introduced by overloading the valve would be reduced to less than 3 per cent.

The "gain" of the stage (without

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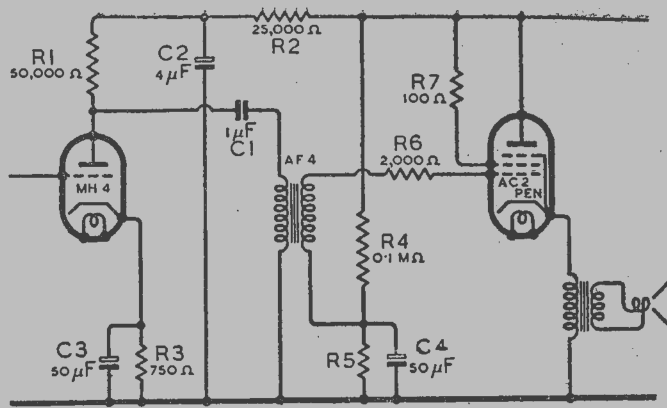


Fig. 3. Circuit of output stage and pre-amplifier. The biasing potential divider R4, R5 consists of a 100,000 ohm resistor in series with R5. The value of the latter depends on the DC resistance of the output transformer primary.

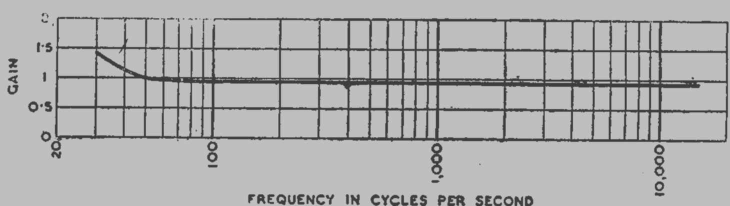


Fig. 4. Frequency characteristic of output stage. The increase in gain at the lower frequencies is due to phase shift.

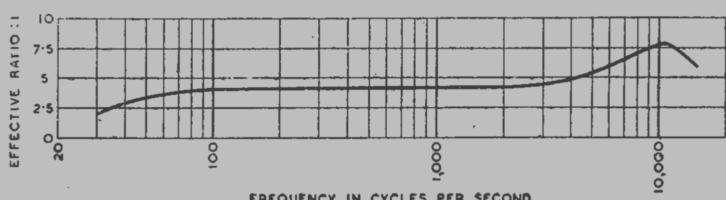


Fig. 5

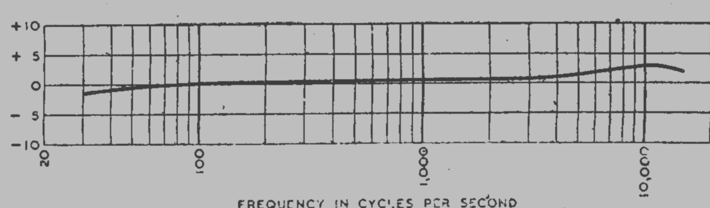


Fig. 6

CATHODE FOLLOWERS

(Continued from page 11)

the intervalve transformer) remains level at about 0.95 from 100 c/s to 15 kc/s, above which frequency the circuit could not be tested owing to the lack of a suitable oscillator. Below 30 c/s there is a considerable increase in gain, and this is due to phase shift which reduces the effective value of the negative feedback, but over the rest of the frequency range phase shift is negligible.

It may surprise the reader to notice that an intervalve transformer is used instead of resistance-capacitance coupling between the output valve and its pre-amplifier, but unless there is a very large high-tension voltage available it will not be possible to provide a sufficiently large voltage swing to drive the output valve; the input voltage is larger than the output voltage, and is, in fact, the normal input voltage plus the output voltage. A good intervalve transformer parallel fed should not introduce appreciable distortion. The transformer employed in the circuit shown in Fig. 3 is a Ferranti AF4, the frequency characteristic of which is shown in Fig. 5.

Good Reproduction

When the amplifier was tested on a radio programme, the reproduction was remarkably good. Speech was reproduced with as good fidelity as the narrow band of transmitted frequencies permit, and consonants such as "t" and "k" were clear and distinct; the absence of bass resonance tended to give the impression that orchestral items would lack bass, but this impression was false, for in musical items the bass was well maintained, although not exaggerated by mechanical resonances. These improvements are due to the large negative feedback and to the exceptionally heavy damping of the loud speaker by the low effective output impedance of the circuit. Distortion could not be detected until the valve was delivering its full output of 3½ watts, after which further increases of input resulted in a marked increase in distortion. One remarkable feature of the circuit is the unusually large output which can still be obtained when the valve is over-biased. Quite a good undistorted output can be obtained when the cathode current is reduced to half its normal value; this is due to the fact that distortion produced in the valve is reduced in the same proportions as the gain, and when operating with a 5,000-ohm load this reduction is 18 to 1.

It is not essential to use a pentode or tetrode in this circuit, and any valve with a high mutual conductance should give good results. A greater output can be obtained with a PX25, provided that the preceding stage is capable of providing a sufficiently large voltage swing to drive it. It should be borne in mind that, whether the valve has a filament or an indirectly heated cathode, the LT winding supplying it should be isolated from the common LT supply, otherwise the large cathode potential fluctuations may damage the heater insulation.

Speech-on-light System

The German Army is said to be using a "speech-on-light" beam signalling system, which employs a modulated light beam as the transmitting medium for speech. The advantages claimed for this method, originally developed in about 1935, is that, unlike radio, it cannot readily be intercepted and it dispenses with line field telephone systems.

This German apparatus comprises a send-receive head, which contains a lamp, modulating device, transmitting lens (80 mm.), colour filters, receiving lens, photo-cell (Thalofide type) and its amplifier and built-in telescope (for aligning the instrument with distant terminal), the whole unit standing on a strong tripod. The separate send-receive AF amplifiers and batteries are housed in a box, which is placed on the ground near the tripod. The apparatus, complete with accessories, weighs about 54 lb.

The instrument can be operated on white, red or infra-red light, merely by turning a knob. By using the infra-red filter, the possibility of enemy interception is prevented and secret communication in darkness ensured. The average effective range, dependent on atmospheric conditions, is about five miles at which distance the practically parallel beam of light is about 90 ft. wide. Reception is by means of headphones.

★

New York Viewers.

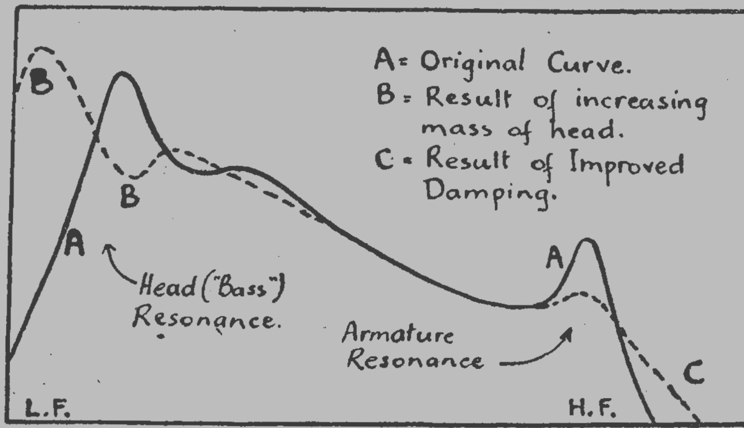
A recent survey of television receivers in the New York area, undertaken by the National Broadcasting Company, shows that only slightly over 80 per cent. of the 4,600 sets in the area are at present in working order. The survey further revealed that there was "a responsive television audience of 40,000 in the New York area."

★

Copper-covered steel wire for high frequency communication lines has been developed and found as efficient as solid copper wire.—"Science News Letter."

PICK-UP PRINCIPLES AND PRACTICE

PART 1



IN this article, which is actually a series of lessons in the theory and practice of electro-acoustics (the conversion of electrical energy to sound and vice versa), the data given applies in most cases not only to pick-ups but also to loudspeakers, microphones and even to such non-electric devices as pendulums, the riding of a motor car and the sound-proofing of buildings! Few amplifier enthusiasts are aware that pick-up theory can be as exact as

An article in three parts dealing with the theory of vibrations and damping, design details of electro-magnetic pick-ups, and the choice and use of filters.

By

J. W. STRAEDE, B.Sc., A.M.I.R.E. (Aust.) *

that relating to railway engine design, that there are no hidden mysteries and that it is just a case of combining the theory of mechanical vibrations with a little elementary knowledge of alternating currents.

The science of vibrations includes so many things, such as acoustics, balance wheels in watches, shock-absorber and spring design in motor cars, and the same rules and formula apply to all of these. An alternating electric current is a form of vibration, so anyone who can understand A.C. can understand the production and absorption of vibrations.

Most radio enthusiasts know the meaning of "resonance." A pendulum vibrates at a certain rate, current oscillates at a certain frequency in a circuit consisting of an inductance and capacity, the balance wheel of a watch swings to and fro.

All these **rates of vibration** or resonant frequencies, in addition to the resonant frequencies of a pick-up or loudspeaker, can be calculated from simple related formula:

For a pendulum $f = \frac{1}{2\pi\sqrt{LC}}$

where L = length of pendulum in centimetres

C = the mass that the earth attracts with unit force (approx. .001 gram).

For a **loudspeaker cone** or for the **bass resonance** of a pick-up or for anything at all that vibrates to and fro:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where L = the mass (weight) of the cone **or** pick-up head in grams.

C = distance (in cms.) that the cone or pick-up head can be moved by unit force.

(C is called the "complance" —it is the opposite or reciprocal of stiffness.)

Unit force is one "dyne", approximately the weight of one milligram.

For the **needle resonance** of a pick-up or for the oscillation of a balance wheel in a watch (or anything which pivots):

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where L = the "moment of inertia" (or flywheel effect) of the moving part

C = the angle that the moving part can be turned through by unit "couple" (or twisting leverage).

Unit couple is the leverage exerted by one dyne (see above) acting one centimetre away from the pivot).

Now it will be noticed that the resonant frequency in every case depends on two factors. Actually there are only two main types of vibration that we need consider: "Back-and-forwards" vibration and "Twisting about a Pivot" vibration.

Back-and-forwards vibrations usually have comparatively low resonant frequencies whilst the twisting vibrations have fairly high resonant frequencies.

A loudspeaker has only one main resonance, the bass resonance, depending upon the mass (weight) of the cone and the compliance (or freedom of movement) of the "spider" so loudspeaker design is not so troublesome (as regards major resonances) as pick-up design.

There are two very pronounced resonant frequencies in a pick-up and the farther apart these frequencies are, the better the tone of the pick up.

Now, so far all we've discussed are the resonant fequencies. In practice, a pendulum doesn't go on swinging for

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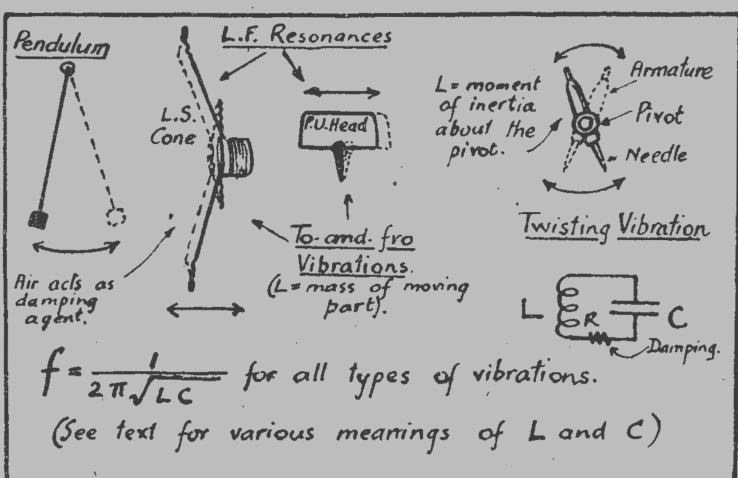

*Lecturer in Electronics at Melbourne Technical College

PICK-UPS

(Continued)

ever, a motor car doesn't bounce forever after traversing just one bump. What stops things from vibrating perpetually at their resonant frequencies? The answer is, of course, that some of the energy is converted to heat, either directly by friction or by some indirect method. This removal of energy is called "damping". By increasing the amount of damping the amplitude (or size) of the vibration at resonance, can be reduced considerably, but damping usually results in a loss of efficiency (except, of course, where a loudspeaker cone is acoustically damped by an efficient speaker horn). A magnetic pick-up with very little damping has a shrill unnatural tone due to certain high notes (around the resonant frequency) being over-emphasized.

Now what forms of damping have we available for pick-ups? There are various forms of gas, liquid, solid and electrical damping. Air-damping has not been applied to pick-ups because we do not wish to hear any extra sound at the resonant frequencies. Oil damping has been used but has one or more drawbacks. Either a large vane has to be attached somehow to the armature thereby increasing its moment of inertia and increasing the need for damping or the oil must be situated in some awkward place where it may rot rubber, corrode iron or copper or destroy insulation. Solid friction is most undesirable because there is an abrupt change between static and kinetic solid friction resulting in **discontinuities** in the wave-form and really horrible tone.

Most commonly employed as a damping material is rubber, but it is far from perfect. It is, in fact, a semi-solid consisting mainly of a colloidal mixture. Even rubber is not bad as a damping material (it does absorb some energy though not as much as people think!) but most pick-up designers also employ the same piece of rubber as an anti-poling device.

Electrical damping does not seem to have been used much so far for moving-iron pick-ups, but can easily be tried by winding the bobbin on a non-magnetic metal former. Just winding a few extra turns on the bobbin and short-circuiting them is of some, but not much, use as they are too far away from the armature to absorb much energy in the form of eddy currents. Moving-coil meters employ electrical damping to obtain a "dead-beat" effect (to bring the needle to rest sooner) by using a copper or aluminium frame for the coil. There is no reason why this cannot be used for a moving coil pick-up providing the coil and former are light. There is yet another form of damping—negative feedback. By applying inverse feedback over a **reversible** device such as a loudspeaker, microphone or pick-up, the response can be evened out. This negative feedback system of "damping" works best when the device is a reversible one of high efficiency. It's no good applying it to a pick-up which has a weak magnet with the pole pieces a long way from an armature of poor quality steel. Electrical damping is also of most use in high-efficiency reversible devices.

Record Wear.

Record wear depends mainly on three factors: the downward thrust on the needle, the stiffness of the needle in its suspension, and the presence or otherwise, of resonances. Bad tracking, of course, will also cause wear—this is discussed in a later part.

The downward thrust can be reduced by counterbalancing or by use of a spring. The latter is not to be recommended on any account—in fact, one famous American manufacturer actually employs excessive counterbalancing together with a spring that applies pressure to the record! Counterbalancing has several advantages: The thrust does not depend on record thickness, the counter-balance weight increase the moment of inertia of the arm and lowers the bass resonant frequency, it is much easier to measure the thrust on the record and dropping the pick-up accidentally causes less damage. A certain amount of downward thrust is necessary for three reasons:

First the pick-up must not jump from one groove to another, second the pressure between record and needle has a desirable damping effect on high-pitched needle vibration, and third a fair thrust is sometimes needed to prevent "chatter", especially if the pick-up needle is nearly vertical as in some high-fidelity pick-ups.

In ordinary pick-ups the stiffness of the needle, plus armature, is bound up with the amount of damping so not much can be done about it. Possibly, after the war there will be available a material which, although viscous (and damping) is not stiff or elastic like rubber.

Improving Cheap Pick-Ups.

Generally the cheaper moving-iron pick-ups can be improved by a little careful treatment. First let us see how to improve response and reduce resonance: To lower the bass resonance frequency the pick-up head can be loaded and this extra load balanced by a weight on the other side of the pivot. An adjustable counter-balance is desirable. The high-frequency resonance depends on the moment of inertia of the armature and the stiffness. We can reduce the moment of inertia by carefully filing off part of the tube into which the needle fits, and a tiny bit of the top of the armature. Using a **shorter** needle helps, as does a permanent needle which enables the large needle holding screw to be replaced by a small set-screw.

If the output can be sacrificed, more of the armature can be removed.

(Part 2 will deal with design details, armature suspensions, moving coil pick-ups, and includes a photograph of old and new type armatures.)

★

An improved method of electric contact heating has made the process practical for a wide range of uses, principal among them being the heating of the bolt or firing mechanism on machine guns, of the hydraulic actuating mechanisms on airplanes in the stratosphere, and of storage batteries in Army tanks in below-zero temperatures. The new heaters have the advantages of light weight, of operating at low wattage, of being safe in the presence of explosive vapours, of operating without deterioration of the heating element, of withstanding severe vibration and of maintaining exact temperatures within close limits.

"NOVACORD"

(Continued from page 9)

ates problems of wear associated with other forms of foot pedal controls.

Audio Amplifier

The audio amplifier consists of two 56 triodes feeding 4 push-pull parallel 2A3 output tubes.

Power Pack

It is interesting to note that the power pack uses vacuum tubes in a novel arrangement whereby the tubes replace the usual filter condensers in standard types of power packs. The action of such filtering is as follows. Referring to Fig. 6 it can be seen the 5V4 rectifier supplies 250 volts between terminals 1 and 5 with the filtering by the following three tubes. Filtering takes place like so. If a small ripple appears in the 250 volt line it will appear at the cathode of the first 6J7 tube, through the condensers and is amplified by the following 6J5. The amplified ripple appears across R1 and will drive the next tube which is the actual filter, and the plate current of this tube will change so that it opposes the original ripple in the line and is of such value that it cancels out. Any high frequency ripple introduced by the oscillators into the power supply is also filtered out by this system. Tubes 5, 6 and 7 operate in the same way on the 65 volt tap on the voltage divider network.

Because the voltage regulation of the 5V4 and supply transformers is poor, the filter tube plates can really be regarded as operating as variable loads or voltage regulators rather than to supply a 180° out of phase hum bucking voltage.

In conclusion the Novachord is the first commercial purely electronic musical instrument having a full keyboard on which chords may be played.

CATHODE-FOLLOWER AMPLIFIER DESIGN

By
F/L. IAN C. HANSEN
62 Squad., R.N.Z.A.F., N.Z.A.P.O. 366, Overseas.

A RECENT article in the technical press (1) gave details of a cathode follower output stage. The main advantages of this circuit were mentioned as

(a) low output impedance, thus providing excellent speaker damping, and

(b) low distortion, due to the large percentage of negative feedback.

A further advantage, not stressed in the article, lies in the fact that the tube used in this way is not critical to loads within certain limits.

It is the purpose of this article to illustrate how this latter effect can be put to practical use in audio amplifier work.

Let us assume that we wish to construct an amplifier for a small school to supply five classroom speakers with one watt of power each. A suitable choice of power tubes would be a pair of 2A3's or their six volt equivalents, used as a class A stage with a plate voltage of 250.

Under these conditions the output would be approximately seven watts, allowing a margin of two watts for losses in lines and output transformers.

It can be shown that, when used as a cathode follower power output stage, tubes should work into their normal load impedance for maximum power output. Thus for the tubes in question the following operating conditions apply:—

Plate voltage..Ep.250
Grid bias voltage..Eg.–45
Plate current..Ia..120 mills. (2 tubes)
Cathode to cathode load.Rc.5000 ohms
Power output..Po..7 watts

The tube constants for reference, are:—

Mutual conductance...Gm..5250 micromhos
Amplification factor..........u...4.2
Plate resistance...Rp..800 ohms

The peak voltage developed across the load is

$$\sqrt{2 \times Po \times Rc} = \sqrt{2 \times 7 \times 5000} = 264 \text{ volts}$$

Now stage gain M′ for a cathode follower stage is

$$\frac{u\,Rc}{Rc\,(u+1) + Rp} = \frac{4.2 \times 5000}{(5000 \times 5.2) + 1600} = \cdot 76$$

(Note that Rp for a push-pull stage is twice the Rp of one tube.)

Therefore, peak input voltage to output tube grids is

$$264 \times \frac{I}{M'} = \frac{264}{\cdot 76} = 350 \text{ volts approx.}$$

This peak audio voltage would be difficult to achieve by resistance capacity coupling, without the use of a high voltage power supply. The solution, then, is to use an audio transformer having a step-up ratio of 1 : 5.

The peak primary voltage is

$$\frac{350}{5} = 70 \text{ volts}$$

There are several ways of feeding the primary of this transformer, and the one that would probably spring first to mind would be to use a triode such as a 6J5, either direct or shunt coupled. The main disadvantage of both of these methods is the reduction of the low frequency response and an increase in low frequency distortion. While the method of shunt feeding is preferable to direct feed, the improvement is still insufficient to be regarded as entirely satisfactory. Push-pull drivers, while reducing tube distortion, still suffer from the same troubles.

These can be overcome by the use of a cathode follower driver. The peak input voltage necessary on the driver grid, assuming an inductance of 50 henries as typical, would be, at medium frequencies, where Rc is very much greater than Rp,

$$70 \times \left(\frac{u+I}{u}\right) = \frac{70 \times 21}{20} = 73.5 \text{ volts}$$

(using a 6J5 driver tube, which has a u of 20 and Rp 7700.) This voltage can be readily obtained by using a resistance capacity coupled pentode, such as a 6J7, which, when used with the constants shown in the figure, has a stage gain of 140 and a maximum peak output voltage of approximately 100. Thus the input voltage at the 6J7 grid to give full output is

$$\frac{73.5}{140} = \cdot 5 \text{ volt approx.}$$

The linearity of the first stage could be improved by omitting the cathode by-pass condenser, and by returning the screen by-pass to the cathode. This would reduce the gain by approximately half, necessitating a peak signal input of one volt.

Having thus designed the amplifier, the question of matching the output stage to the speaker load arises. As it is undesirable to run long leads at voice coil impedance, due to line losses, a standard value of low impedance matching transformer should be fitted to each speaker, say 600 ohms. Five such transformers when paralleled at the amplifier output will present a load of 600/5 or 120 ohms. The output transformer should be wound to match 5000 to 120 ohms, and will have a ratio of

$$1 : \frac{\sqrt{5000}}{120} = 1 : 6 \cdot 4$$

The peak output voltage at full signal, across the 5000 ohm load was found to be 264 volts. The peak second-

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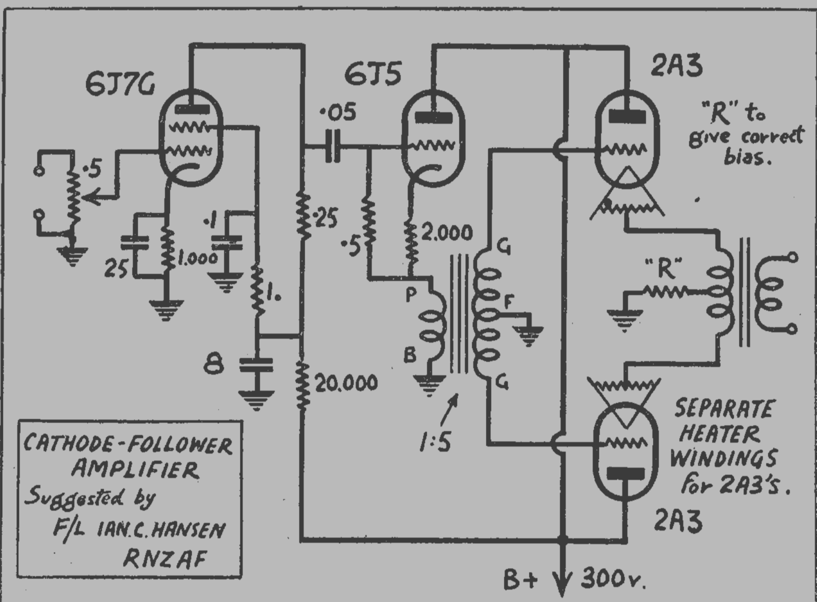

★ Inductance and Capacity Meter ★

IN the days before signal generators and service oscillators were the accepted thing, it was customary to use the old method of utilising the absorption wave meter to determine the frequency of a tuned circuit. The method consisted of holding a tuned circuit comprising a capacity and inductance near a resonant or oscillating system which was calibrated. When the indicating instrument indicated a sharp dip at a particular resonant frequency, it was then known that the circuit being measured was fairly close to the resonant frequency of the oscillator circuit. Even to-day for purposes of measuring at U.H.F. and in pre-war days adjusting the "ham" transmitter this method is still relied upon.

Upon this very same principle, this handy instrument about to be described is based. But before going into details let us see to what uses it can be put.

Uses

(1) Measurement of small capacities from under 1 uuFD to several hundred uuFD. In this connection it would be well to point out that this method is probably the most accurate for the measurement of extremely low capacities.

In fact it becomes well within the scope of such an instrument to determine the input and output capacities of valves, which for certain applications is extremely handy.

(2) Can be used to accurately match of sections of gang condensers.

(3) Will check wiring capacity of receivers.

(4) Enable the experimenter to calibrate dials accurately.

By

CHARLES MUTTON

1 Plow Street, Thornbury, Vic.

(5) Check frequency range of an unknown coil.

(6) Check resonant frequencies of RF chokes.

(7) Enable correct adjustment of aerial and RF high impedance primaries for correct resonance.

(8) Will match coils of all descriptions for correct tracking by comparison with a standard with extreme accuracy.

(9) Will give comparative value of Q for various shapes and sizes of coils.

(10) Enable the mutual inductance of primary and secondary of a coil to be checked.

With such a wide range of applications it should be apparent that such an instrument can fill a definite place in any service organization or amateur workshop.

Explanation of Operation

Turning our attention now to the circuit we find the following sections:

(1) Essentially we have a 6V6G operating as an electron coupled oscillator, using the screen as the plate of the oscillator and the normal plate serving to couple the output to the external circuit which is comprised of C3 and C5 and the external coil or inductance which connects to the measuring terminals. In the writer's case C5 and C3 was a standard H type gang. In the matter of switching C3, which is the rear section of the H type two gang; in or out of the circuit by means of S3, this is optional and is merely included in the interests of flexibility. If desired S3 can be left out and both sections of the gang may be wired permanently into the circuit. The same remarks apply to C1 and C2 and S2 in the oscillator circuit. C4 merely forms a trimmer condenser across C5 and C3 and as in the writer's case it only consisted of an R.C.S. three plate reaction condenser, it forms but a

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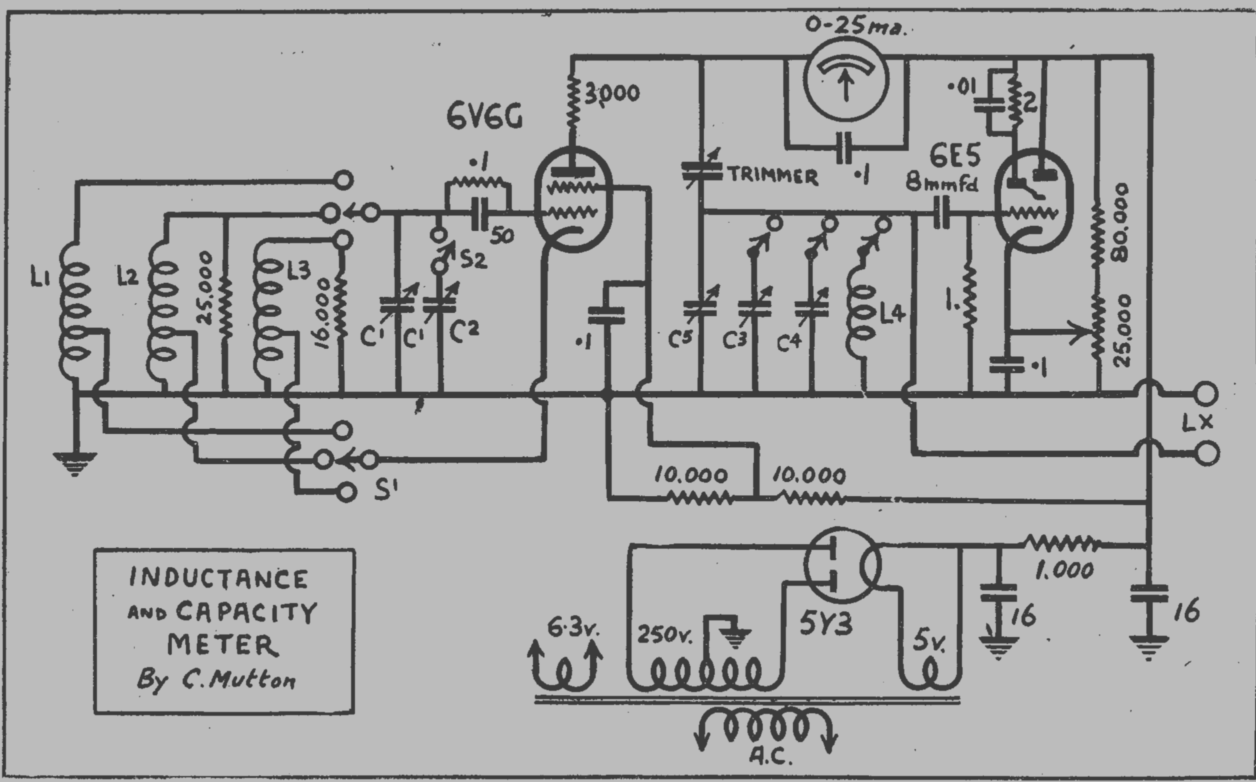
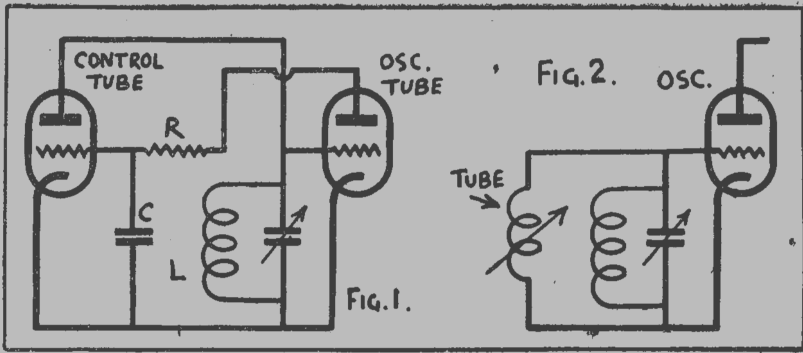




small fraction of the total capacity of C5 and C3. In actual operation this condenser (C4) is set so that the zero setting corresponds to the plates being half in mesh. Which simply means that this vernier control when turned one way represents an increase of, say, 5 uuF capacity, while in the opposite direction it would correspond to –5 uuF. It then becomes possible to measure small differences in capacity fairly easily.

Coming now to the inductances L1, L2, and L3 from the three coils which cover the range required. The author suggests as a guide, to use one to cover the mostly used intermediate frequencies one for the broadcast band, and one to cover the mostly used short wave bands. The remaining inductance L4 is only used for capacity measurements.

As shown in the diagram the instrument features the more or less doubtful advantage of having switched coils, which were used when first experimenting with this hook up. The writer, however, is not a firm believer in switched coils and the switching arrangement was merely included in the diagram in order to cater for those who favour this convenient, if not entirely efficient, method of changing from one band to another. However it must be pointed out that using a tube such as the 6V6G as the oscillator, the output packs a fair "wallop".

Under such conditions it was found that with switched coils, no matter how well the coils were shielded on from the other or what layout was used, at the higher frequencies, absorption effects occurred which adversely affected the oscillator on the short-wave range. Even short circuiting out the coils which were not in use did not entirely eradicate the trouble. The writer would firmly recommend the prospective builder of an instrument of this type to stick to the old and well tried friend, the plug-in coil. Seeing there are only three connections to each coil, it is a simple matter to rig the coils up on 4-pin amphenol plugs, and use a 4 pin socket in the instrument. Added to efficiency is the fact that additional ranges can be added at will when required. It was found that due to causes just explained the frequency range faded out about 15 mc with switched coils. Whereas the plug in range enables the range to be increased down to approx. 34 mc with a few modifications.

It may be noticed that two of the coils are shunted by resistors. These serve to limit the oscillator voltage and are purely damping resistors which control excessive oscillation which would damage the tube. A damping resistance is not required on the high frequency range.

Oscillator Circuit

The oscillator circuit formed by C1 and either L1, L2 or L3 with C2 (Δ Co) being optional as previously explained, needs to be calibrated in terms of frequency. This procedure is carried out in the usual manner by using a radio receiver, and either a service oscillator or signal generator of reliable accuracy. Use the oscillator with the modulation turned off and zero beat the signal from the 6V6 oscillator with the oscillator or signal generator signal. A resistor is incorporated in the plate circuit of the 6V6 and in series is connected a milliameter, which measures the plate current. This serves as a check on oscillation. Under oscillating conditions the plate current should be much lower than the non oscillating condition. Condenser C15 keeps the A.C. away from the metre.

The alternating plate voltage of the 6V6 is coupled via C7 to the external tuned circuit, consisting of C5 and the coil being measured. C3 designated as (Δc) may be switched across C5.

Tuning Indicator

The 6E5 "magic eye" tube serves as a rugged V.T. voltmeter which measures the H.F. voltage from the 6V6 via C8. In this application the 6E5 has negligible loading effect on the tuned circuit and makes an extremely sensitive resonance indicator. Resonance is indicated by the eye shadow closing, not opening, as when tuning a radio receiver.

Power Supply.

A small transformer serves the supply to the instrument and a simple resistance capacity filter is used. The voltage divider R7 and R8 supply the screen voltage to the 6V6. It will be noticed that this lead is by-passed twice, which is quite in order and necessary, one by-pass being needed right at the 6V6 socket. A potentiometer on the cathode of the 6E5 adjusts the bias on the grid and governs the shadow angle. Although by no means essential it is preferable to connect small mica condensers of, say, .002 to .006 across the 16 mfd electrolytics in order to ensure efficient RF by-passes.

Capacity Measurement

nductance L4 equals approximately 175 microhenries. By closing S3 and S5 this coil, together with C5 ÷ C3. will form a circuit which can be tuned to the oscillator frequency. By connecting a capacity across the measuring terminals the circuit becomes untuned with respect to the oscillator frequency, but can be retuned by decreasing the capacity C3. The value of the capacity connected is then known from the decrease in C3. C3 should be calibrated by comparing it with some sort of calibrated standard. At one time it was possible to pick up .005 General Radio condensers in a round metal container and supplied with a graph showing capacity reading against the dial numbers which ran from 0-100. These were quite accurate enough for ordinary purposes to use as a standard. Alternatively if no calibrated standard is on hand a handful of silver mica fixed condensers accurate to within 5 per cent. would suffice for most purposes, ranging in 10 uuF steps from 5 uuF up to 250 uuF.

Capacity Measurement Continued

As the capacity change with C3 is rather large for a given movement, C4 is introduced, its purpose being previously explained.

Coil Data

If the coil dimensions given here are adhered to, also the turns, the approximate inductance values will be as follows:

L1=7.5 u henries, L2=175 u henries, L3=3,500 u henries, L4=175 u henries.

All inductances are a single winding which is tapped at one point. Turns data as follows:

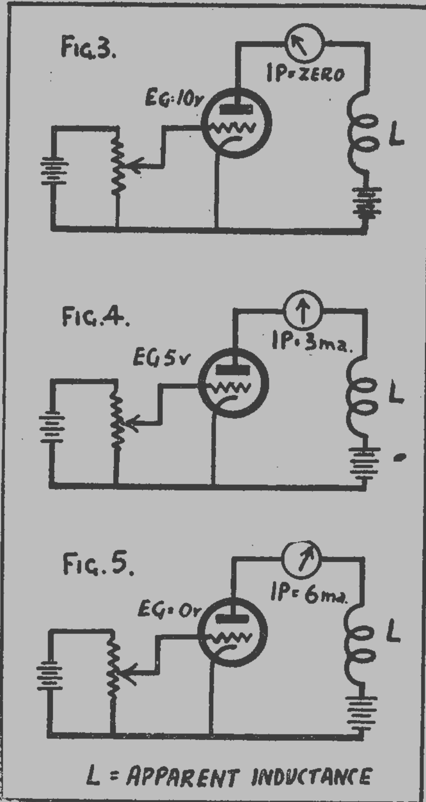
L1=18 turns of 7/41 Litz tap at 4 turns from start, L2=250 turns, 6 pies of 20 turns each spaced 1/8in. apart, tap at 10 turns from start, 7/41 Litz wire.

L3=540 turns 5 pies of 90 turns each, spaced 1/8in. apart, tap at 90 turns from start. All coils are wound on 3/4in. former, and should be doped with trolitvol or some such compound. The coils will enable the constructor to cover most of the widely used frequency bands, including intermediate frequencies broadcast band, and short-wave band. Should the constructor not like to tackle winding his own coils, it is possible to convert old I.F. transformer windings, ordinary broadcast aerial coils and ordinary S.W. coils to suit his own requirements.

Inductance Measurement

It is extremely unlikely that the average reader would have the necessary gear or standard inductances, such as a calibrated variometer on hand, so that the calibration of the oscillator circuit dial would be to most enthusiasts a snare and a delusion. However, by simple mathematics on wavelength formula, by knowing the frequency, and the capacity, the inductance may be calculated. As we have already seen the oscillator section dial may be calibrated in terms of frequency by beating against either a broadcast station or a service oscillator. Hence we come to the simple formula $\lambda 1 = 1.885 \sqrt{LX.C}$ (Formula 1). More accurate measurements can, however, be obtained when a second wavelength measurement is caried out at a different capacity value. If the tuning capacity in the circuit is increased by an amount ΔC then the circuit is tuned to a frequency $\lambda 2 = 1.885 \sqrt{LX (C+\Delta C)}$ (Formula 2). By squaring (1) and (2) and deducting (1) from (2) we get $\lambda 2^2 - \lambda 1^2 = 3.55\ LX.\Delta C$ or

$$LX = \frac{\lambda 2^2 - \lambda 1^2}{3.55.\Delta C}$$



The unknown inductance can thus be determined from these two measurements without knowing the capacity value of C in the first measurement. It is only necessary for the capacity variation ΔC to be known.

If however the inductance of the coil connected to the terminals is known which would be the case if a known standard was available. Calling this Lo and the capacity of the wavemeter circuit during the first measurement Co we get the following formula.

$\lambda = 1.885 \sqrt{Lo.Co}$ (Formula 4).

Now if we alter the capacity Co so that Co is increased by an amount ΔCo then

$\lambda = 1.885 \sqrt{Lo(Co+\Delta Co}$ (Formula 5)

From these two formulas we solve the following equation:

$\lambda 2^2 - \lambda 1^2 = 3.55\ Lo.\Delta C$ (Formula 6)

Finally from (3) and (4) we get

$$LX = \frac{\Delta Co}{\Delta C} Lo$$ (Formula 7)

At a known value of ΔC and Lo, Lx is proportional to ΔCo. This constitutes the basis for making measurements with this instrument.

The coil to be measured is connected in parallel with a condenser, and a radiation wave meter is tuned to the frequency of the circuit thus formed. A condenser of known capacity (ΔC) is now connected in parallel with this

(Continued on next page)

AN INTERESTING VALVE RELEASED IN U.S.A.

Triode for grounded grid r.f. amplifier.

R.C.A. has recently made available to equipment manufacturers a new member of the family of miniature "button-base" tubes, the 6J4. When obtainable, it should be of considerable interest to amateurs.

The 6J4 is a triode intended for use as a grounded-grid v.h.f. or u.h.f. amplifier at frequencies up to about 500 Mc. It has an amplification factor of 55 combined with the extremely high transconductance of 12,000 micromhos. Used in the "grounded-grid" or inverted-amplifier circuit, it aids in securing a high signal-to-noise ratio. The 6J4 may also be used in conventional triode circuits with ungrounded grid.

In grounded-grid service the grid of the 6J4 functions as a shield between cathode and plate, and the input signal is applied to the cathode. The input circuit therefore is between cathode and the grounded grid; the output circuit is between plate and the grounded grid. Internal shielding connected to the grid aids in reducing undesirable feed-back effects by keeping the capacitance low between cathode and plate.

The heater is rated at 6.3 volts, 0.4 ampere. Maximum plate voltage is 150 volts; rated plate dissipation is 2.25 watts maximum. The maximum permissible d.c. heater-cathode potential difference is 90 volts.—Q.S.T. (U.S.A.)

INDUCTANCE METER

(Continued on page 19)

circuit and the capacity of the wavemeter is increased sufficiently for the two circuits to be tuned to the same frequency again. The capacity variation in the wavemeter circuit (ΔCo) is then a direct measurement of the self inductance to be found.

As a "Q" Meter

This instrument is in some respects very similar to its much more expensive brother the Q meter less a lot of refinements, but the mode of operation is very simlar. Although absolute measurement of Q cannot be made, the instrument here described has sufficient scope to enable tests to be made for finding shorted turns, low Q etc., in all types of RF coils. For instance, take 2 similar broadcast aerial coils, one of which you suspect to have some fault which all routine tests for resistance, etc., have failed to find the trouble. By connecting the good coil and tuning the oscillator section to the resonant frequency and resonating four wavemeter circuits you get a certain capacity reading and the magic eye indicton opens say about half-way. Now leaving the set up as it is, disconnect the good coil and connect in its place the suspected coil. Making allowances that no two similar coils can be wound to have exactly the same characteristics, and therefore the resonance point may have to be shifted slightly to coincide with the same set of readings given with the other coil. Now if the Q factor is alright and no shorted turns are present, then the width of the opening on the tuning eye should be the same as before, indicating that the amount of RF voltage developed across the two coils is the same. But, supposing the shadow angle is almost closed or a great deal more narrow, then this is a definite indication that something is wrong.

Shadow Angle

From this is can be seen that the greater the width of the shadow angle at a given frequency, when measuring a number of similar coils the greater is the Q factor of the coil. Similarly, sections of gang condensers may be accurately matched and testing mass production of coils becomes very simple with this instrument. In fact if it is desired to pre-align coils for receivers before actually incoporating them in the receiver the following procedure could be adopted. Making sure that a receiver is perfectly aligned and comes up to a standard of measurements as regards sensitivity and selectivity, then the coils in the receiver can be removed and used as standards of comparison. Then it merely becomes a routine matter to adjust the iron cores so that the shadow of the resonance indicator opens the same amount as with one of the standard coils. It can be clearly seen, however, that minor adjustments will need to be made when using the production coils due to added wiring capacity and trimmer capacity, etc., but at least all coils can be tested for substantially the same characteristics before they go into receivers, a procedure which has a lot to recommend it. Many may say that the above procedure is only a comparative one and perhaps unnecessary, but practical experience has shown that it saves hours of head scratching.

ICONOSCOPE — THE ELECTRON "GUN"

MOST amateurs have the urge to experiment with new developments in the field of radio, There are those who will wish to explore the possibilities in the use of television on the amateur bands after the war is over. Since there are large parts of the country not covered by commercial television signals, it will often be necessary for the amateur experimenter to build his own television transmitter as

By

B. W. SOUTHWELL

(Reprinted from "Q.S.T.", U.S.A.)

well as a picture receiver. "Q.S.T." has published articles on the construction of a video camera and transmitter using a Type 1847 pick-up tube for operation in the 112-Mc. band.*

In this article an attempt will be made to give the amateur experimenter a clear understanding of what happens within the iconoscope tube. The word "iconoscope" comes from a combination of two Greek words—eikon, meaning "image," and skopein, meaning "to observe." Various types of iconoscope tubes have been manufactured. Fig. 1 shows a sketch of a typical tube of this type.

Mosaic

The essential element in the evacuated tube is the mosaic. The base of the mosaic is a flat mica plate which is used because of its high electrical insulation, good surface and its uniform thickness. The thickness of the mosaic plate is on the order of about 1 mil (0.001 inch). One side of the plate is coated with a thin, finely sifted coating of silver-oxide powder. After the mica has been coated it is baked in an oven, which reduces the silver oxide to pure silver. The silver congeals in the form of extremely minute globules less than 0.001 inch in diameter. Each globule is separated and insulated from its neighbours by the mica.

The silver globules are then made photosensitive by the admission of caesium vapour to the tube and by passing a glow discharge through the tube in an atmosphere of oxygen.

Before it is placed in the tube, the reverse side of the mosaic is coated with a thin signal coat of colloidal graphite. This coating serves as the electrode through which the signal is transferred to the external circuits during the process of scanning. Silver plating sometimes replaces the colloidal graphite as the signal coat.

The mosaic is mounted in the iconoscope in such a position that the electron beam strikes the photosensitized side at an angle of 30 degrees from the normal, and the optical image to be transmitted is projected normal to the surface on the same side. The scene to be transmitted is focused through an optical lens on to the mosaic, as if the latter were the film of an ordinary photographic camera.

The mosaic may be thought of as a great number of minute photocells, each of which is coupled by an electrical condenser to a common signal lead, as shown in Fig. 1. When the mosaic is illuminated these condensers are positively charged, as a result of the emission of photoelectrons from its surface. The fundamental action of photoelectricity is in this way performed, and the optical image is thus translated into an electrical image.

Electron Gun

There now remains the task of dissecting the electrical image obtained on the mosaic into an orderly series of horizontal lines. This is accomplished by means of an electron gun, which is also contained within the iconoscope tube. The electron gun produces a very narrow stream of cathode rays which serve as a commutator for the tiny photocells on the mosaic. The gun may be thought of as an electron projector which concentrates the electrons emitted from the cathode of the gun in a very small spot on the mosaic. The electron optical system consists of two electron lenses formed by the cylindrically symmetrical electrostatic fields between the elements of the gun, as shown in Fig 2.

Details of the gun construction are of considerable interest. The cathode is indirectly heated with its emitting area at the tip of the cathode cylinder, which is mounted with the emitting area a few thousandths of an inch in front of an aperture in the control grid. A long cylinder with three defining apertures, whose axes coincide with that of the cathode and control grid, serves to give the electrons their initial acceleration. This cylinder is known as the first anode, or the accelerating anode. A second cylinder, of somewhat greater diameter than the first and mounted along the same axis, serves as a second anode which gives the electrons their final velocity. The second anode generally is formed by applying a metal coating to the neck of the iconoscope bulb.

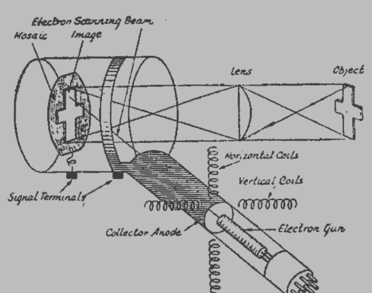


Fig. 1 — Sketch showing the basic construction of the iconoscope and how an image of the object being viewed is focused on the mosaic plate

Scanning

The electron beam is aimed initially at the extreme upper left-hand corner of the image and is then moved horizontally, from left to right, across the upper edge of the picture, to trace out the first scanning line. As it passes

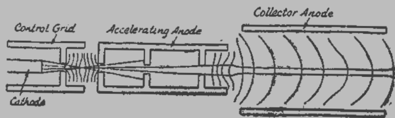


Fig. 2 — Sketch showing the principal points of the "electron gun."

over each silver globule of this line the beam contributes electrons to each globule in succession, thereby cancelling the positive charge created by illumination and restoring for an instant the charge to the value it possessed before illumination—the equilibrium charge. This change in charge results in the generation of a minute voltage across the small capacity between the globule and the signal plate. This voltage is then transferred to the signal terminals and amplified to the necessary degree for modulation. As each charge is restored the image plate potential changes, resulting in the potential of the plate assuming a rapid succession of different values, each value depending upon the amount of charge restored at that particular instant. The deflection of the electron beam for scanning the mosaic is accomplished by means of deflection coils arranged in the form of a yoke which slips over the neck of the iconoscope.

As the electron beam completes its motion across the first scanning line, it is blanked out and instantaneously returned to the left-hand edge of the picture. During the scanning and return motions the beam is moved vertically downward at a comparatively slow rate, so that its position is somewhat below the initial starting position of the previous line. The beam then traces out a new scanning line across the mosaic, parallel to the preceding one but separated from it by the width of one line. The beam therefore scans

(Continued on page 22)

* Lamb, "Television Camera-Modulator for Practical Amateur Operation," *QST*, October, 1940, p.11.

the mosaic in a succession of alternate lines. The empty space between lines is later filled in by a second interlacing field.

Interlacing

When the beam reaches the bottom of the mosaic, the slow vertical motion is stopped. The beam is then extinguished and returned while in that state to the top of the picture. Here the beam again begins its scanning motion, but this time it is positioned to scan the spaces between the lines previously scanned, thus filling in the gaps in an interlacing fashion. When the beam again reaches the bottom of the picture it has covered every point on the mosaic in two series of alternate lines.

The picture mosaic is scanned at the rate of thirty complete pictures per second. There are various methods of scanning, but the interlaced method just described has been adopted as standard in the United States.

A picture element has a height equal to the distance between centres of adjacent scanning lines. The number of picture elements depends upon the number of lines by which a complete picture is scanned. The greater the number of lines, the greater the number of picture elements, and hence the higher degree of definition obtainable.

In the Type 1847 iconoscope the inner signal electrode (the conductive film on the mosaic) is a band of conductive material on the inner surface of the tube. Another band of conductive material is placed on the external surface of the tube, directly over the internal band. The capacitance between the two bands, in series with the capacitance between the signal electrode and mosaic, provides the coupling between the signal-electrode terminal and the mosaic.

Storage vs. Non-Storage Types

Image pick-up tubes may be divided into two groups; namely, storage pick-ups and non-storage pick-ups. In the storage type, which is the one described in this article, the photoelectric current from on element of the picture charges an individual condenser for a period of time equal to the scanning time of one complete picture. This condenser is discharged once during the scanning time of a complete picture, the time of discharge being only the time of scanning of one picture element. In the non-storage pick-up the current from the photoelectric cell flows only during the time of scanning, does not charge a condenser, and therefore no storage of the charge caused by the photoelectric effect takes place.

Widespread use of television promises to be one of the earlier post-war developments. The experimentally inclined ham therefore should have more than ordinary interest in this explanatory discussion of the "eye" of the television transmitter—the inconoscope.

Shortwave Review

CONDUCTED BY
L. J. KEAST

NOTES FROM MY DIARY—

TIME, GENTLEMEN, PLEASE!

So there will be no daylight saving this summer. Well, thinking selfishly, that saves me a lot of alterations to schedules, etc. But talking of time, what a great check we get from the Short Wave stations without any suggestion of indulging in My Lady Nicotine. The Yanks say, "It is 15 seconds before . . . Pacific War Time, . . . hours Greenwich Mean Time" or coincidentally as I write KROJ 'Frisco 16.89 metres, has adopted a new expression, "at the sound of the tone it will be . . ." But then, there is that great old broadcaster, Big Ben, who has a style all his own and just in case you want to check that boy-proof watch or what have you, here is a paragraph from the B.B.C. Year Book which will help:

"The time signal, which gives the time to a normal accuracy of one-twentieth of a second, is sent out from Greenwich Observatory to the transmitters, and a sequence of signals is broadcast all over the world throughout the day. Each signal consists of six dot seconds—the 'pips'—the first at five seconds to the hour, and the sixth exactly on the hour. The hour is therefore given by the last 'pip' of the time signal. The times at which the signal is broadcast in the B.B.C.'s Home and Overseas programmes are subject to alteration. It may be necessary, occasionally, for a signal to be suppressed if superimposition on a current programme is inadvisable on artistic grounds. The time by Big Ben is given by the first stroke of the hour, but when Big Ben strikes the quarter hours, it is the first stroke of the chime which gives the time.'

OUR CANADIAN COUSINS

Most reporters are delighted with the splendid signals from CBFX, Montreal on 9.63 mc. from 9.30 pm made possible by All India Radio having thoughtfully withdrawn their transmitter which for quite a while had been operating on the same frequency. When I reported this station in May issue of "A.R.W." as having first heard same on March 28th, listening was difficult with Delhi right on top. Nevertheless, I was able to compile a satisfactory report and last week received a verification from Canadian Broadcasting Corporation. Accompanying this very beautiful card was a letter informing me that CBFX was installed three years ago at Vercheres, near Montreal, to increase the coverage of CBF transmitter, the French outlet of the CBC in Montreal. It is primarily intended to provide French programmes to the large French population living in the western provinces of Canada, but from 9.30 pm until 2 am it broadcasts in English for the benefit of listeners in Australia and New Zealand. When reporters hear that the station only employs 7½ kilowatts of power, they can conjure up great thoughts regarding the two 50 kilowatt transmitters now being erected at Sackville, New Brunswick, for International broadcasting and expected to be ready to operate at the end of the year.

AH WELL! LET 'EM ALL COME.

Remember the fun we had trying to sort out WLWO from WLWK? It is just a year ago ("A.R.W.", Oct. '43). Well, now, the Crosley Corporation have added some more letters to their transmitters, RL and X having been heard, but even with Basic English there are still 21 more that CAN be used, so "wait fir it", wait for that station announcement, "'cos if you guess, you may be wrong, honey." Then, just to still further keep us on the qui vive, the National Broadcasting Company have a sort of Radio Quiz with WNRA and WNRI. Maybe if you heard I on . . . I heard A there, too, but the time may have been different. But it all means hearing the news more often with the East Coast slant, and a still further opportunity of brushing up our foreign languages.

However, the two outlets referred to do give them an index, so if only to permit of more precise recording in our Log Book, I wish the All India Radio would attach a tab to their many and still increasing number of transmitters.

FAIRER AND WARMER

That suggests surfing, but to us it forecasts the return of night reception and already daylight stations seem to have an inkling it's time they packed up, and even some of the 'Frisco transmitters get very faint long before they are due to make their prescribed exit. And so whether our sets are to be in the future designed for Frequency Modulation, Television, News Strips, Comic Strips or Strip-tease, at present they need to be very selective to provide the full enjoyment from the many and varied programmes offering, after coffee and cigars.

I am sure all regular readers of these pages will be very grieved to hear that the wife of Mr. Leo Edel passed away on Sunday, 10th September. Our deepest sympathy goes to Mr. Edel in his great loss.

ALL-WAVE ALL-WORLD DX CLUB

Application for Membership

The Secretary,
All-Wave All-World DX Club,
243 Elizabeth Street, Sydney.

Dear Sir,

I am very interested in dxing, and am keen to join your Club

Name ....

Address ....
(Please print both plainly) ....

....

My set is a ....

I enclose herewith the Life Membership fee of 2/- (Postal Notes or Money Order), for which I will receive, post free, a Membership Certificate showing my Official Club Number. NOTE—Club Badges are not available.

(Signed) ....

(Readers who do no want to mutilate their copies can write out the details required.)

Shortwave Notes and Observations

OCEANIA

Australia

VLC-4, Shepparton 15.315 mc and VLI-2, Sydney 11.87 mc, commenced on Monday 18th September, by arrangement with the Department of Information, the sending of messages from relatives to Australian Prisoners of War in Asia. Duration is 9-10 am. At 10 o'clock VLC-4 is used by Gen. MacArthur's H.Q. for a fifteen minute news service to the Philippines.—L.J.K.

VLC-4 19.59 m. No doubt about this station from 10-10.15 am. "She's a Cracker" (Perkins). Heard well at 11 am (Cushen).

VLC-6, Shepparton 9.615 mc. 31.2 m. Very good in Philippine hour (Cushen)

AFRICA

Algeria

Algiers is heard in English News at 6 am over 49.79, 49.67 and 33.48 m. (Gillett).

Belgian Congo

RNB, Leopoldville 9.78 mc. 30.66 m. Heard daily relaying BBC at 2.30 pm. (Gaden, Cushen).

French Equatorial Africa

English periods are: 4.45, 6.45 and 9.45 am over 25.06 m. (Cushen).

FZI, Brazzaville 15.595 mc. 19.25 m. Good from 8.45-9.15 pm. (Matthews).

Mozambique

CR7BD, Lourenco Marques 15.235 mc. 19.69 m. Heard at 3.30 pm with an R6 signal (Young).

Senegal

Radio Dakar, Dakar 11.41 mc. 26.29 m. Good strength 5.15-7.20 am (Cushen).

CENTRAL AMERICA

Ecuador

HC2ET, Guayaquil 9.19 mc. 32.64 m. Heard morning, noon and night. Not so loud in afternoon as at night, but less noise (Gaden, Gillett).

Guatemala

TGWA, 15.17 mc. 19.78 m. Heard a few times only; very patchy. Not nearly as good as on 9.685 mc which is reasonably consistent (Gaden).

TGWA, 9.685 mc. 30.96 m. Heard till 3 pm on Sunday (Cushen).

U.S.A.

San Francisco, unless otherwise mentioned.

KWID, 17.76 mc. 16.89 m. Is splendid, best at closing, 9.45 am (Gaden).

KROJ, 17.76 mc. 16.89. Much stronger than KWID (Gaden, Perkins). (KWID is directed to the Americas to the South, whilst KROJ is intended for Australia.—L.J.K.)

KGEX, 15.33 mc. 19.57. Splendid all morning and till closing at 3 pm. (Gaden, Perkins).

KGEI, 15.29 mc. 19.62 m. R6 around 2.30 pm (Perkins).

KGEI, 15.13 mc. 19.83 m. Very good in afternoon (Gaden).

KWIX, 11.90 mc. 25.21 m. Worse than it was once on 11.87 mc in am (Gaden). (Can hear for about 30 minutes before closing at 2 pm.—L.J.K.)

KES-3, 10.62 mc. 28.25. Not much good (Gaden). (Too much morse down here.—L.J.K.)

KROJ, 9.89 mc. 30.31 m. Very good all evening (Gaden).

KWIX, 9.855 mc. 30.44. Splendid from 6-8.30 pm (Gaden).

KWID, 9.57 mc. 31.35 m. Carries Latin-American transmission till 2.45 pm (Cushen, Gaden).

KGEI, 9.53 mc. 31.48 m. Opens at 8.45 pm with KES-3. Signal O.K. if not overpowered by WGEA.—L.J.K.) Very often 50/50 with WGEA (Gillett).

KRCA, 9.49 mc. 31.61 m. Does its best in parallel with KWV from 4 pm, but has bother from WCBN and particularly GWF. However, makes up for it from around 11 pm by excellent signal and entertaining programme.—L.J.K.

KES-2, 8.93 mc. 33.58 m. Not much good (Gaden). Like its sister, steeped in morse.—L.J.K.

KEL, Bolinas 6.86 mc. 43.73 m. A great favourite in late afternoon (Gaden).

KGEX, 7.25 mc. 41.38 m. Excellent at night in programme to Philippines

NEW STATIONS

WLWL, Cincinnati, 15.20 mc. 19.73 m.: First heard 9th September, at 9.40 am in French, followed by Italian at 9.45. When closing at 10, announcer said, "This is station WLWL, The Crosley Corporation, Cincinnati, Ohio, U.S.A. We have been broadcasting in the 19 metre band on 15,200 and 15,230 kilocycles. We are leaving the air at this time and will renew our broadcasts in exactly one hour from now on 9,897.5 kilocycles, 30.35 metres. We invite you to rejoin us at that time."

The wave-length mentioned is what we always call 30.31 metres.—L.J.K.

WLWL-2 15.23 mc. 19.69 m.: See reference above. If on, cannot hear.—L.J.K.

WLWR, C'nnati, 12.967 mc. 23.13 m.: One of three more operated by the Crosley Corporation. Heard around 9 am. Good signal.—L.J.K.

WLWR, C'nnati, 9.897.5 mc. 30.31 m.: Opens at 11 am but can only just be heard . . . impossible to copy owing to morse. First heard September 9th.—L.J.K.

WLWL, C'nnati, 7832.5 k.c. 38.30 m.: Heard well at 4.45 pm. Closes at 5.—L.J.K.

WLWX, C'nnati, 9.74 mc. 30.80 m.: This Crosley reported by Wally Young and Rex Gillett, of Adelaide, and Dr. Gaden and Roy Matthews, as being heard around 5.15 pm. Not audible here owing to morse.

WNRI, New York, 13.07 mc. 22.95 m.: A new outlet of the National Broadcasting Co. First heard 2nd September, at 10.05 pm with news in English. Carries usual East Coast "V. of A." programmes and is in parallel with WKRD on 23.13 m. at that time. Signal R7 Q4. Heard also around 9.15 am.—L.J.K.

WNRI, New York, 9.855 mc. 30.44 m.: Another frequency for the N.B.C. First heard last week in August at 9.15 am, and also in afternoon from 2 till 5. Signal from 4 pm is R7 Q4.—L.J.K.

WNRA, New York, 9.855 mc. 30.44 m.: This seems to be the call when closing at 9 am and 9 pm.—L.J.K.

WNRX, New York, 7.56 mc. 39.66 m.: And here is another one from NBC. First heard early in September at 3.40 pm in parallel with WNRI, 30.44 m. and WNRA, 49.15 m. Sig. R7 Q4.—L.J.K.

(Continued on page 25)

(Gaden, Cushen, Gillett, Perkins). (I would say one of the very best signals on the air all evening.—L.J.K.)

Other than California

WLWL, C'nnati 15.20 mc. 19.73 m.: Better than 'Frisco in the morning (Gaden).

WNRI, New York, 13.07 mc. 22.95 m. Very fair at night (Gaden, Gillett, Young, Edel).

WNRI, New York 9.855 mc. 30.44 m. Carries "V of A" programmes till sign off at 5 pm. Very good signal now that GRH is off the air in Pacific Service (Cushen). Heard strongly at 9.30 am (Gillett, Matthews).

WNRA, New York, see "New Stations."

WLWX, C'nnati 9.74 mc. 30.80 m. Heard in late afternoon (Gillett, Gaden, Young).

WLWL, C'nnati 7.832.5 mc. 38.30 m. Heard till signing at 5 pm with V of A programme (Cushen).

WCBN, New York 9.49 mc. 31.61 m. Heard through KRCA till closing at 5.30 pm (Cushen). (What about GWF?—L.J.K.)

WOOW, New York 7.82 mc. 38.36 m. Heard at 3.30 pm (Cushen).

WGEA, New York, 7 mc. 42.86 m. Heard from 2 pm till sign off at 5 (Cushen).

WOOC, New York 6.12 mc, 49.02 m. Heard at 3.30 pm (Cushen).

WGEA, New York 6.01 mc. 49.92 m. Heard as early as 2 pm (Cushen).

(Continued from page 24)

WNRA, New York 6.10 mc. 49.15 m.: This NBC was first mentioned under "New Stations in August issue but now appears to be on regular schedule. When giving news at 4 pm overpowers KROJ but at 4.33 position is reversed. Think closes at 5 pm.—L.J.K.

FZI, Brazzaville, 11.67 mc. 25.71 m.: Arthur Cushen, of Invercargill, reports this one as being heard around 5.30 am in parallel with 11.97 mc. (Looks as though they have jumped the spot vacated by their neighbour, RNB of Leopoldville.—L.J.K.)

WBOS, Boston, 14.55 mc. 20.61 m.: Mr. W. Howe, of "Universalite" reports this new one as being heard twice, starting at 10.30 am after sign off on 15.21 mc. at 10.15. (I have not heard this one, but Wally Young, of Adelaide, has heard a station on this frequency relaying WNRX and WRCA.—L.J.K.)

UNITED NATIONS CALLING FROM H.Q., S.E. ASIA COMMAND, 11.81 mc. 25.40 m.: This one, which I think is situated in Colombo, has been heard as early as 8.30 pm at great strength. Announces frequently as above giving frequency. At 9 pm gives news in Japanese, and same programme can be heard on 25.45 m. Later in the night, 11.45 to be exact, says "Colombo calling." At 12.30 am I heard a clock strike 9 and announcer said, "This is Colombo, Ceylon, calling. You are invited to drop into Colombo." A very enjoyable sing-song with piano accompaniment followed and at 12.57½ we were invited to stand by for news from London, due in little over two minutes. Signal is R8 Q4 right through.—L.J.K.

WNBI, New York, 11.71 mc, 25.62 m.: A new frequency for this old timer. Heard at very good strength till closing at 10.15 pm.—L.J.K.

SOUTH AMERICA

Brazil

PRL-8, Rio de Janiero 11.72 mc. 25.60 m. English at 5.30 am (Cushen).

Costa Rica

TI4NRH, Heredia 9.74 mc. 30.80 m. Heard in early afternoon (Gaden).

Peru

OAX5C, Ica 9.80 mc. 30.64 m. Announces as "Radio Ica Peru" signing at 3 pm. "This is the station heard and mistaken for LSE, Argentina, in July issue" (Cushen). Heard after lunch at fair strength but is NOT the same station as heard several weeks ago . . . first of call letters was definitely "L" (Gaden).

STOP PRESS

As we go to press **KROJ, 'Frisco,** announces os and from 1st October, transmission for the South Pacific, from 6 till 11 pm, will be on 6.10 mc. 49.15 m.

INDIA

Delhi unless otherwise mentioned.

VUD-, 11.95 mc. 25.10 m. Heard this one at 11.45 pm in relay with 25.45 m. (Gillett).

VUD- 11.76 mc. 25.51 m. Heard in afternoon, R6, but when giving news at 9.30 pm, R4 (Cushen).

Delhi gives news at dictation speed at 5.30 am on, 9.63, 7.29 and 6.19 mc. (Cushen).

VUD-2, 7.295 mc. 41.15 m. Heard at 8 am and 10.30 pm (Gillett).

VUB, Bombay 6.15 mc. 48.74 m. Heard announcing as Bombay at 10.30 pm giving news in English in relay with VUD-2, 48.47 m.; clock strikes 7 (Gillett).

VUD-3, 6.01 mc. 49.92 m. Heard Delhi here at 11 pm with a strong signal (Gillett).

GREAT BRITAIN

GSV, 17.81 mc. 16.84 m. and GSG, 17.79 mc. 16.86 m. are good from 8-10 pm then fades, but come back again about 11 o'clock till 12.30 am or later. (Matthews).

GWE, 15.435 mc. 19.44 m. Fair to good all evening (Matthews).

GWD, 15.42 mc. 19.46 m. Between 6 and 7 pm very good (Gaden, Matthews).

GWP, 9.66 mc. 31.06 m. Heard London calling Europe 11 till 11.30 pm (Matthews). Mr. Cushen, of Invercargill says at 6 pm he hears, with strength ranging from R6-8, GWP, GRY, GSL, GRM, GVZ, GRX, GRV, GRS, GSB. (All audible here except GSL.—L.J.K.)

Rex Gillett, of Adelaide, writes that he heard London from 5.30 am till closing at 6, on 42.56 m. He adds that he thinks it was the African session. (I do not know of any BBC frequency nearer than GRS on 7.065 mc. which is intended for Algiers and North Africa at that time, actually from 2.30-8.30 am. It occurs to me that the broadcast heard may have been a relay from ACCRA on 7.02 mc.—L.J.K.)

U.S.S.R.

Moscow unless otherwise mentioned.

Moscow heard in French at 3 pm on 11.83, 11.66 and 10.44 mc . . . the last two give news in English at 2.45 pm (Cushen). Mr. Gillett, of Adelaide, reports Moscow on 41.87 m. at 7.25 am. Moscow 15.37 mc. 19.51 m. Fair at 11 pm (Matthews).

Leningrad, 11.63 mc. 25.76 m. Fair to good at M/N. (Matthews).

WEST INDIES

Cuba

COCQ, Havana 8.84 mc. 33.98 m: Heard with Spanish programme till 3 pm (Cushen).

COBC, Havana 9.37 mc. 32.00 m. Heard well some nights at 10.30 (Matthews).

French West Indies

Guadeloupe

FG8AH, Point-a-Pitre 7.446 mc. 40.29 m. Radio Guadeloupe is back on the air but is very weak. Heard till 10 am (Howe "Universalite").

MISCELLANEOUS

ABSIE (American Broadcasting Station in Europe). News heard at 5.30 am on 7.185, 9.625, 6.00 and 11.80 mc. and at 8 am on 9.625 mc (Cushen).

CANADA

CBFX, Montreal 9.63 mc. 31.15 m. From 9.30 pm very good, now that Delhi is absent. Quality is first class and signal much louder than 6 mc. Canadians . . . less noise, too, on this band (Gaden, Edel, Matthews).

CFRX, Toronto 6.07 mc. 49.42 m. Is heard nightly from as early as 8.15 . . . signal improves from 9.30 (Matthews).

Italy

. . ., Rome 16.11 mc. 18.62 m. Rome has been heard under Allied occupation on approximately 16.11 mc. believed to be old IRY; heard from 4.15-5 am (Howe "Universalite").

British Mediterranean

Mr. Cushen reports 9.67 mc. 31.02 m. and 11.715 mc. 25.60 m. both quite fair with news at 3 pm (Cushen). Good after M/N (Matthews). News in English at 6 am with an R7 signal, subject to slight interference, is heard over 7.215 mc. 41.58 m. (Cushen). Rex Gillett reports Br. Medit. on 6.135 mc. 48.90 m. at 6 am with news in English in relay with 41.58 and 31.03. Closes at 7.15 am.

Portugal

CSW-7, Lisbon 9.735 mc. 30.82 m. Quite good at 10 am (Matthews). (Another one denied us because of morse.—L.J.K.)

Sweden

SDB-2, Stockholm 10.78 mc. 27.83 m. Morse spoils musical programme at 2 am (Edel).

SPEEDY QUERY SERVICE

Conducted under the personal supervision of A. G. HULL

G.K.H. (Darlington) wants full instruction for building a vibrator set.

A.—Sorry, but we do not have any back numbers on hand with a circuit of the kind you require. To design up a special circuit for the job is quite beyond the scope of this service. As doubtless you are aware, the manufacture of sets is controlled at the moment, also the use of spare parts for other than replacement to keep existing sets in service. Not that you would have much hope of getting the parts together, as vibrators, transformers, chokes, and even bases, are not only controlled but in very short supply, in fact, unprocurable. We strongly advise you to give up all idea of doing the job now.

●

J.L. (Croydon) is an amplifier enthusiast.

A.—Frequency response is not the whole story, by a long shot. In fact, we would go so far as to say that it is only one of several points which have to be watched. Distortion is most distressing and can be brought about by many ways. In the circuit you submit we would have the gravest doubts about the ability of the first audio valve to either accept the full signal from a crystal pick-up or to drive the output valve, without a high percentage of distortion. You can't beat using a low-gain valve over a comparitively short portion of the straightest part of its plate current-grid volts curve. In the best circles there is a steady trend towards using more and more valves in the driving stages, for example, a recent amplifier which we heard used a low-gain triode first stage, then a phase changer, then a pair of drivers in push-pull to a pair of output triodes in push-pull.

●

F.E. (Melbourne) enquires about laborotory equipment.

A.—A lab. full of G.R. equipment would be very nice to have, but few factories can afford such a luxury. Perhaps not truly a luxury, but it would be found that many instruments would cost oround £500 each and yet be used for only twenty or thirty hours per year. To run through the G.R. catalogue and pick out all the handy items and order one of each would cost about £10,000, and, of course, couldn't be done for love and money, only for 100 per cent. defence work.

●

General: In regard to frequency modulation.

To all who have written on this subject the answer is the same, viz., no back numbers are available covering f.m., but a series of articles are scheduled to commence next month.

A.R. (Ballarat) has heard a tale that you can't get a serviceman's licence without having test equipment and you can't get test equipment unless you have a serviceman's licence.

A.—This might be so, theoretically, but we feel sure that if you actually make application for a licence and state the full facts you will find that it will be considered reasonably and that arrangements can be made to overcome this apparent anomaly.

●

C.M. (Bentleigh, Vic.) enquires if we know where he can obtain an intermediate transformer with a tertiary winding to suit a variable selectivity arrangement.

A.—No, we do not think that these are available at present. The firm which previously listed these is now engaged solely on defence work.

●

W.R. (New Zealand) asks the reason why metal rectifiers are not so popular for h.t. circuits.

A.—Several times there have been attempts to popularise metal rectifiers to replace the old 80 type valve, but the valve has always won out. Possibly on account of being cheaper and more efficient.

CATHODE-FOLLOWER

(Continued from page 16)

ary voltage must then be 264/6.4 or 40 volts approximately. The RMS value of this is 28 volts.

Due to the action of the cathode follower stage, this voltage will remain constant no matter if part or all of the load is disconnected. Thus it is seen that the power output from the tubes is inversely proportional to the load, provided that the load is not reduced below 5000 ohms. In fact, the output stage can be regarded as a 28 volt A.C. supply with almost perfect regulation up to its maximum output of 5 watts. As a result, the power input to each speaker remains constant and there is no necessity to switch in dummy loads when speakers are switched out of circuit.

If it is desired to divide the power unevenly between speakers, using the existing transformer, the problem can be regarded as an Ohms law one, and treated accordingly. As an example, it is intended to feed two speakers with one watt each, and one speaker with three watts. It is required to find the speaker impedances necessary to connect to the constant 28 volt output.

$$Ra = Rb = \frac{E^2}{W} = \frac{28 \times 28}{1} = 800 \text{ ohms.}$$

$$Rc = \frac{28 \times 28}{3} = 266 \text{ ohms.}$$

The total connected load equals 120 ohms when the extra loading allowed for losses, two watts, is taken into account. From these examples, others using different tubes, in class A or B, can be worked out quite readily. No doubt, other applications of the versatile cathode follower will come to mind. The constancy of power delivered to loads with changes of loading, the avoidance of dangerous peak voltages if the load is suddenly removed, and the lack of dummy loads and multi-tapped secondaries, should make this output system very attractive for many audio apllications. Its freedom from harmonic distortion, and its satisfying low frequency response will make an appeal to high fidelity enthusiasts, who will find the cathode follower indispensable in a modern amplifier, either as a novel tone control, volume expander, or output stage as described herein.

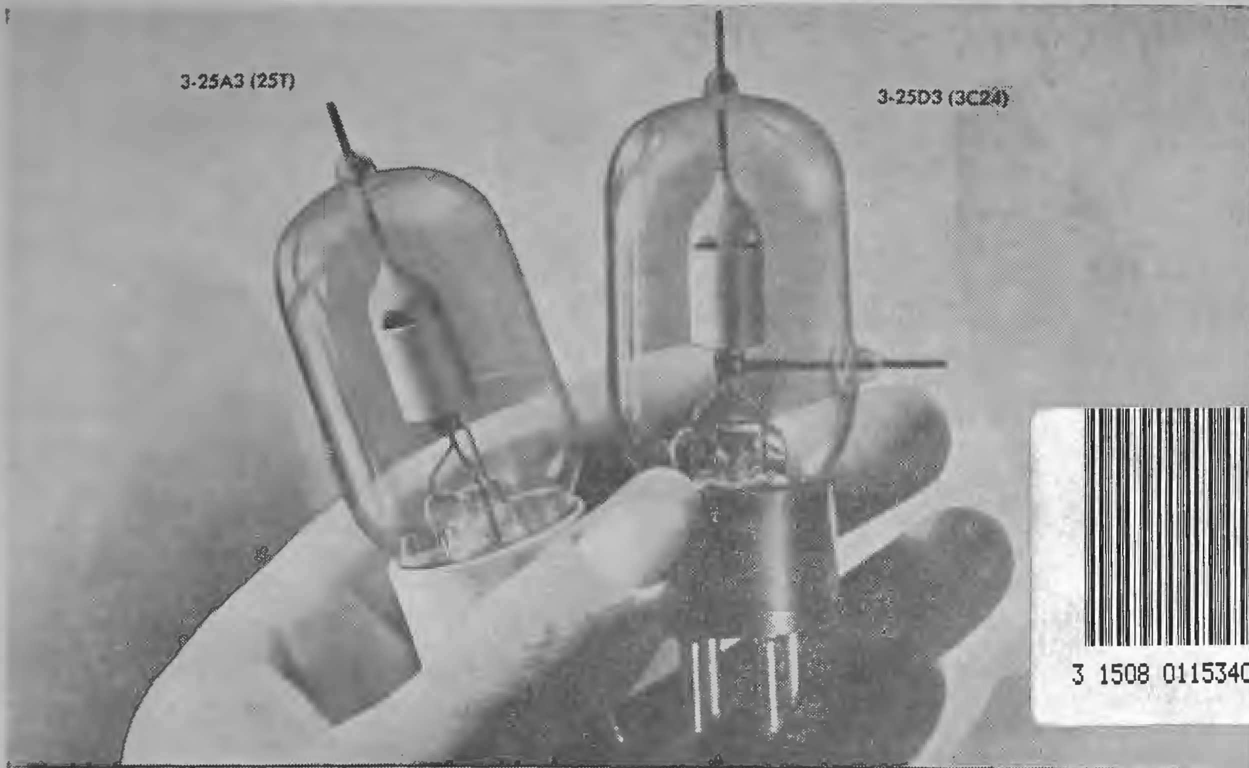
(1) *Reference.*—"Cathode follower output stage", by C. J. Mitchell, "Wireless World," April, 1944. Reprinted on page 10 of this issue.

SOMETHING FRESH

(Continued from page 6)

2A3 in the output, using the audio transformer as before, but neglecting the centre-tap, thereby getting the effect of a higher step-up ratio. The resultant amplifier came up to expectations in every way and must surely be the finest job we have ever heard with a single 2A3. The amount of overload which can be handled without distress is quite remarkable and anyone who wants greater power for ordinary household use must surely be a little on the deaf side.

We hope that it won't be long now before we have ample time to do all the laboratory work on this amplifier that we would like to do, and in the meantime we offer it to our readers as a most fertile field in which to experiment.



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Filament Current (amps)	3.0	3.0
Interelectrode Capacitances		
Grid to Plate	[illegible]	[illegible]
Grid to Filament	[illegible]	[illegible]
Plate to Filament	0.2	0.2
Maximum Ratings		
Class C amplifier		
Plate Voltage (DC)	2000 volts	2000 volts
Plate Current (DC)	75 mills	75 mills
Grid Current (DC)	20 mills	20 mills
Maximum Plate Dissipation (watts)	25	25

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