shaping circuit correctly. No restriction exists on the ratio of the amplitudes of the noise pulse and the incoming signal.

In a recent article, Nicholson[2] suggests that frequency modulation offers little advantage over amplitude modulation if the two systems are compared under similar operating conditions. He himself describes a new noise limiter by means of which an amplitude modulation receiver may be made superior to one for frequency modulation in its ability to discriminate against impulse noise. The circuits described here achieve a similar object and will normally entail the use of less additional components in the receiver. It is probable that the overall cost of an amplitude modulation receiver, incorporating these circuits, would be less than that of the equivalent frequency modulation receiver.

[2] "Comparison of Amplitude and Frequency Modulation," M. G. Nicholson, *Wireless Engineer*, July 1947.

ELECTRONIC CIRCUITRY

Selections from a Designer's Notebook

By J. McG. SOWERBY (*Cinema Television, Ltd.*)

Some Notes on Phase Splitters

PHASE splitters are widely used in audio amplifiers and were treated in some detail in this journal[1] some time ago. The notes that follow are merely disconnected jottings on a few points which, although not original, may be of interest to some readers.

One of the most widely used phase splitters is known as the "concertina" and is shown in Fig. 1(a). In this circuit a triode, V, has equal anode and cathode loads and these are effectively in series. Consequently, any signal current in the valve passes through both resistors and so equal output signal voltages are obtained at anode and cathode. The arrangement gives a gain of little less than one (usually about 0.9) between input and either output. It has the advantage that the balance of the output voltages depends only on the maintenance of equality of anode and cathode resistors. At (a) the bias for the valve is determined by R_b which is small compared with R_k. Consequently the cathode of V is positive to earth by anything up to 100 or more volts. This being so it seems logical to couple the grid of V directly to the previous anode as shown at (b), then the cathode potential of V will be very nearly the same as the anode potential of the previous stage. Besides saving three components the coupling eliminates any phase shift at low frequencies and this is often advantageous if V is within a feedback loop, as in Mr. Williamson's amplifier[2]. To a sufficiently close approximation the current in V can be taken as $i_a = V_a/R$ where V_a is the anode potential of the previous stage. The anode-cathode voltage of V is nearly $V_{ak} = (V_b - 2V_a)$ where V_b is the supply h.t. potential. From this we see that it is reasonable to design for $V_a = V_b/3$ or less. Even so, it is wise to ensure from the valve curves that no grid current flows in V even when V_a is 30% more than the design figure, making due allowance for the resultant reduction of V_{ak}. This arises because some variation in V_a is to be expected with time and with valve replacement.

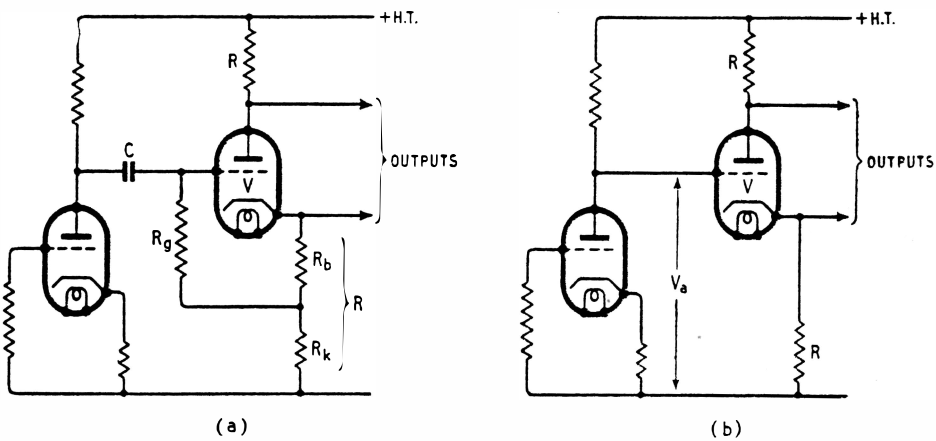

Fig. 1. "Concertina" phase splitter : (a) a.c. coupled, (b) direct coupled.

Fig. 2(a) shows a cathode-coupled phase splitter in which the usual positive bias is supplied from a fixed potentiometer across the h.t. supply. A more economical arrangement is shown at (b using fewer components, in which the positive bias is the anode potential V_a of the previous stage. Both grids are obviously maintained at the same standing potential, but the signal is applied only to the grid of V, as the

[1] W. T. Cocking. *Wireless World*. Jan., Feb., March, April and May, 1948.

[2] D. T. N. Williamson. *Wireless World*. Aug. 1949, p. 282.

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" smoothing " circuit CR prevents the signal reaching the grid of V_2. Similar time constants are used in the two circuits, and at medium and high frequencies the performances are identical. At very low frequencies, however, CR in circuit (a) merely leads to attenuation of both outputs, whereas (b) reverts to a push-push output of low gain as the frequency approaches zero, because the grids of V_1 and V_2 both follow the anode potential of the previous stage, and are in phase with one another.

may have undesirable results on subsequent stages.

In designing the circuit of Fig. 2(b) the anode current of V_1 or V_2 may be taken to be $V_a/2R_c$ and the anode-cathode potential of each valve will be $V_{ak} = V_b - V_a(1 + R_a/2R_c)$ nearly. Previous remarks concerning grid current in the circuit of Fig. 1(b) apply here too.

Some designers are disinclined to use the " concertina " and cathode-coupled circuits as both involve operating the cathode of a valve at a considerable potential to earth. A commonly used

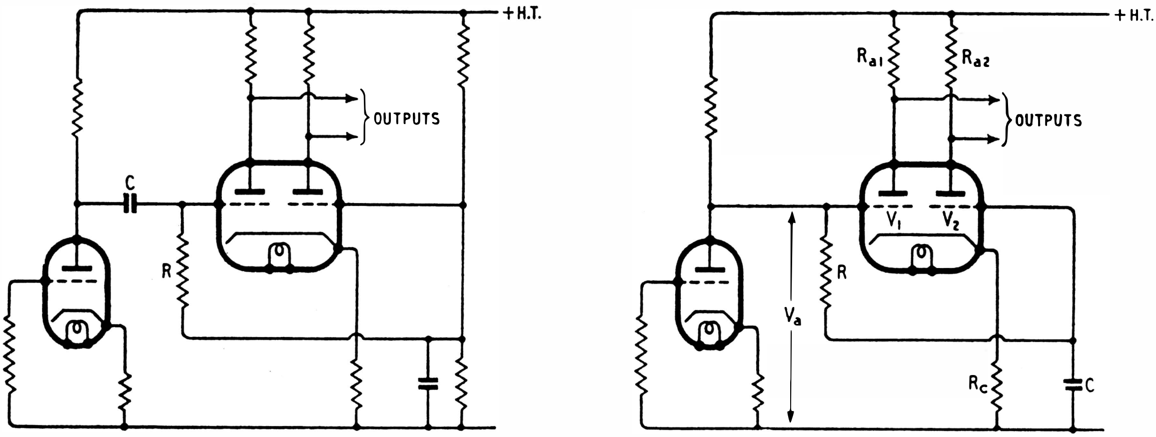
necessary to make R_{a1} less than R_{a2} to obtain equality of output *voltages*. On analysis it turns out that

$$R_{a1} = R_{a2}\left[1 - \frac{r_a + R_{a2} + 2R(1 + r_a/R_{a2})}{r_a + R_{a2} + (\mu + 1)R}\right]$$

where μ = amplification factor, r_a = a.c. resistance, of either valve

for equal signal output voltages.

In practice it is convenient to



(a) (b)

Fig. 2. Cathode-coupled phase splitter with two types of coupling.

An advantage of circuit (b) compared with (a) is that a large value of C can easily be used—say 2μF or more. Such condensers are usually of the paper-block-in-metal-can type and if used in the circuit at (a) may lead to loss at high frequencies due to the additional stray capacitance at the grid of V_1. One such condenser measured by the writer recently had a condenser-can capacitance of more than 100 pF, and if such a condenser is fixed to an earthed metal chassis and used as a coupling condenser in (a), that 100 pF will appear between the grid of V_1 and earth. In the circuit at (b) this condenser-can capacitance will only add to C, and so be slightly beneficial.

The circuit of Fig. 2(b) has a disadvantage inasmuch as variations in the h.t. supply potential may lead to a large push-push output from the splitter, and this

alternative is the " see-saw " circuit. Another circuit which might be regarded as a combination of the cathode-coupled and see-saw arrangements if available, however, and is shown in Fig. 3. It will be remembered that the cathode-coupled circuit of Fig. 2 tends to maintain equality of signal currents in the two valves, and that exact equality is approached as R_c is increased, eventually becoming exact when R_c is infinite. The circuit of Fig. 3 behaves in exactly the same way, provided that we substitute R for the R_c of Fig. 2. However, in this case there must always be some signal voltage across R (to operate the grid of V_2) and this signal will be in phase with that obtained from the anode of V_1. Consequently, however large R may be made to achieve equality of signal *currents* in V_1 and V_2, it will always be

make R_k the common bias resistance for the two valves; this largely controls the direct current through the two valves and hence through R. Next, R is made as large as possible having due regard for the voltage drop across it. R_{a2} is then fixed, and R_{a1} calculated. The time constant $C_1\ R_{g1}$ is calculated as for a normal amplifier stage, and it is preferable to make $C_2\ R_{g2}$ several times larger than $C_1\ R_{g1}$ to maintain a phase displacement of 180° between the output signals at low frequencies.

The gain from input to either output (when R_{a1} is properly chosen by means of the preceding equation) is

$$A = \frac{\mu R_{a1}}{r_a + R_{a1} + \dfrac{R_{a2} - R_{a1}}{R_{a2} + R} R}$$

Substitution of practical values indicates that this circuit yields a gain approaching twice that for the ordinary cathode—coupled circuit of Fig. 2 when $R_c = R$, and the other constants are the same in both circuits. In this respect the splitter of Fig. 3 is more like the see-saw from which a correspondingly increased gain can also be obtained, and it also suffers from the disadvantage that any disturbances on the h.t. line are fed preferentially to one grid, so that the arrangement should be used only with a well-smoothed supply.

In using the circuit of Fig. 3 and see-saw circuits one point needs watching. A common bias resistor is quite in order as long as it is bypassed. If it is not, then as there is feedback from both anodes to one grid, and feedback from one valve to the other via the cathode resistor, an unfortunate accidental combination of stray capacitances may easily turn either circuit into a cathode-coupled multivibrator[3] at high frequencies. A relatively small cathode bypass capacitor will stop this trouble completely, but may also lead to a non-uniform frequency response. By using a capacitor of more usual value—10 to 100 μF—these faults are

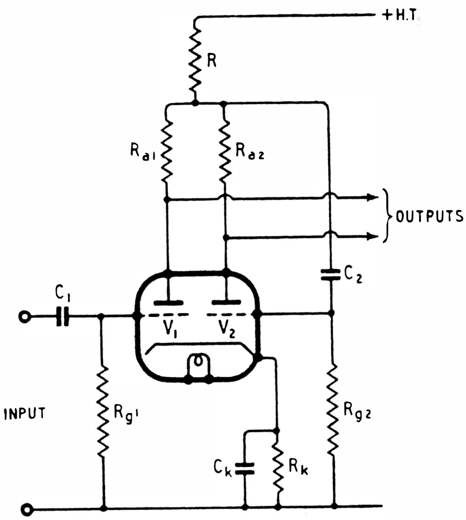


Fig. 3. Common-anode-coupled phase splitter. Typical values : V_1, V_2, = 6SN7, $R_{g1} = R_{g2} = 1 M\Omega$, $R_k = 1.8 k\Omega$, $R = 39\ k\Omega$, $R_{a1} = 80 k\Omega$, $R_{a2} = 100 k\Omega$, $C_1 = 0.05\ \mu F$, $C_2 = 0.25 \mu F$, C_k = 20-50μF, h.t. = 350V. Gain (input to one output) = 17 (approx.).

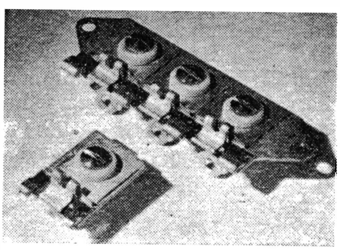
both removed. If this is omitted and "multivibration" takes place, the amplitude may be quite low and of quite high frequency—100 kc/s or more—and so difficult to find except with an oscilloscope, of low input capacitance, or a high-impedance valve voltmeter.

[3] "Electronic Circuitry." *Wireless World*. July, 1948, p. 249.

NEW PRODUCTS

Mica Trimmers

THE new "M" type trimmer introduced by the Plessey Company, Ilford, Essex, is of particularly robust construction and very stable in operation. The construction of the multiple units simplifies mounting and permits economy in space where a common earth is acceptable. Single capacitors are also available.



Single and multiple units of the Plessey "M" type trimmer.

Best quality mica, with a power factor of approximately 10×10^{-4} measured at 1 Mc/s, is used and the insulation resistance is greater than 1,000 MΩ at 500 V d.c. Capacitance range is 5-65 pF.

P.M. Focus Unit

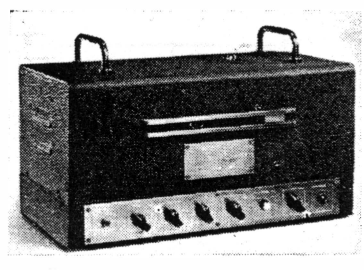
THE Elac permanent magnet focusing unit replaces the commonly used electro-magnet for focusing the electron beam of a cathode-ray tube. It comprises a ring-type permanent magnet with fixed end cheeks and an inner core tube which is adjustable by three screws. Equal adjustments to the screws move the core tube along the axis and so vary the air gap between the tube and the front end cheek. In its turn this varies the leakage field used for focusing. Unequal adjustment to the screws tilts the core tube and so moves the picture on the tube and provides a shift control.

Because focus and shift are carried out by the same three screws the two are interdependent but, in practice, the adjustment is by no means difficult. The focus obtainable on a test was as good as with an electro-magnet and is free from "warming-up" drift. It is not, of course, free from any change brought about by variations of the tube e.h.t. supply. The magnet has a much larger external field than the usual electro-magnet and it may be necessary to take this into account if valves are mounted very close to it.

There are three types of magnet; the R17 at 21s for tetrode tubes, the R20 at 22s 6d for triodes at medium e.h.t. voltages and the R25 at 25s for triodes operating at high voltages. The makers are Electro Acoustic Industries, Ltd., Stamford Works, Broad Lane, Tottenham, N.15.

Portable Radio-Amplifier

DESIGNED for use in small factories, schools, etc., the "Hadley" portable radio-amplifier is housed in a metal case 18in × 9in × 9in and provides facilities for relaying radio programmes, gramophone records and microphone announcements.



"Hadley" portable radio-amplifier.

There is a choice of four preselected radio programmes, and both radio and gramophone are automatically cut off when the microphone is switched on. A self-contained oscillator provides a push-button-controlled tone for time signals or fire alarms.

A small built-in loudspeaker unit with independent volume control is provided for monitoring.

The power output is 20 watts and the mains consumption is 120 watts at 200-250 V, 50-60 c/s. The price, including tax, is £52 7s 9d and the makers are Hadley Sound Equipment, 587-9, Bearwood Road, Smethwick, Birmingham, 17.