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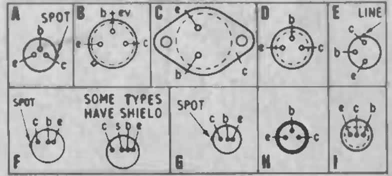
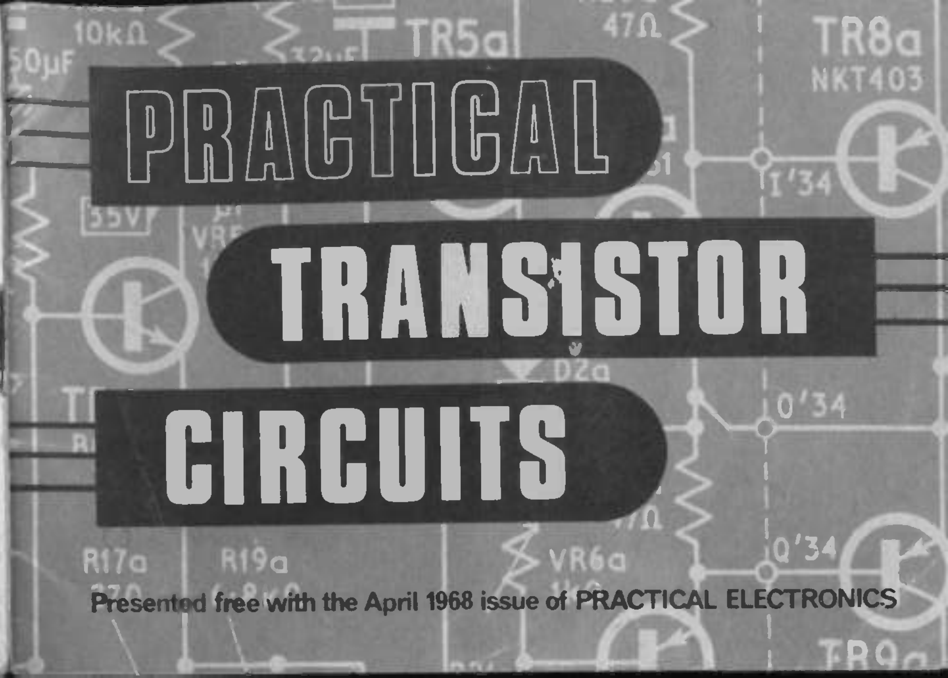
TRANSISTOR CONNECTIONS

Code letter after each type number given in text refers to appropriate key diagram below. For example: 2N2926 (I) is type number 2N2926, connections in key diagram I below (looking at the underside wire end). e = emitter, c = collector, b = base, s = shield, ev = envelope

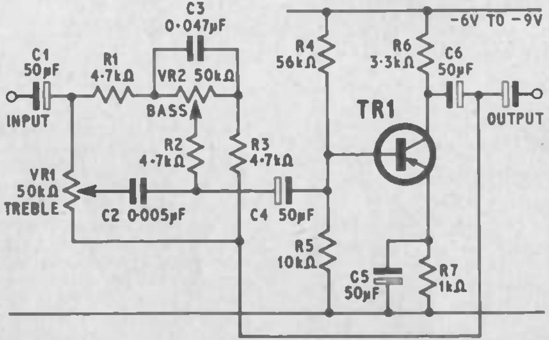




PRACTICAL TRANSISTOR CIRCUITS

Presented free with the April 1968 issue of PRACTICAL ELECTRONICS

12—DUAL TONE CONTROL



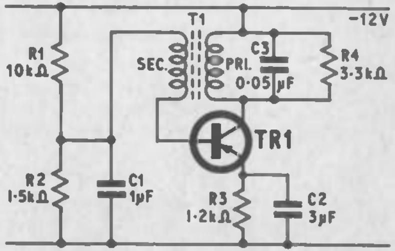
With any form of tone control the signal level will be reduced at pre-determined frequencies. If bass boost is required, the high frequencies are cut. Then the audio spectrum is amplified to bring them up to normal, while the bass frequencies will be higher than the treble. Similarly for treble boost the bass frequencies are cut. The reactance of a capacitor (X_C) is inversely proportional to frequency. When the frequency is such that X_C is equal to the associated resistor, the frequency response will be 3dB down. It will continue to go down at 6dB per octave as frequency increases for a parallel capacitor, and as frequency decreases for a series capacitor. The *C* and *R* form a frequency sensitive potentiometer.

Transistors: almost any small signal type such as OC71(G), NKT214(A)

13—TUNED COLLECTOR OSCILLATOR

Current changes through the transistor are reflected back through the transformer to the base. A continuous oscillation is produced and is tuned to the required frequency by the inductance of T1 primary and the value of C3. R4 acts as the load across the output. Frequency of oscillation is $1/(2\pi\sqrt{LC})$ where *L* is the inductance of collector winding, and *C* is the parallel tuning capacitance.

Transistor: OC84(F), NKT211(A)



14—TAPE RECORDER BIAS OSCILLATOR

This circuit is based on similar principles to those in Fig. 13. Provides 1mA bias current at 42kHz for a tape record head but is unsuitable for erase. Frequency of oscillation is much higher than the highest audible recorded frequency. Oscillator frequency should be about five times this recorded frequency. Output voltage is about 32V peak into a 250mH record head.

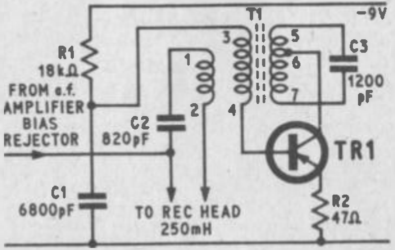
Transformer details: Ferroxcube pot core assembly LA1.

Output winding 1–2, 150 turns 34 s.w.g.

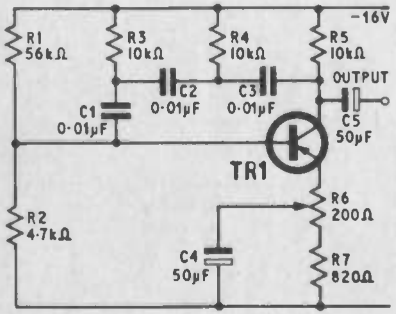
Secondary winding 3–4, 8 turns 30 s.w.g.

Primary winding: (a) 5–6, 25 turns 34 s.w.g.; (b) 6–7, 125 turns 34 s.w.g.

Transistor: OC72(G), 2G381(H)



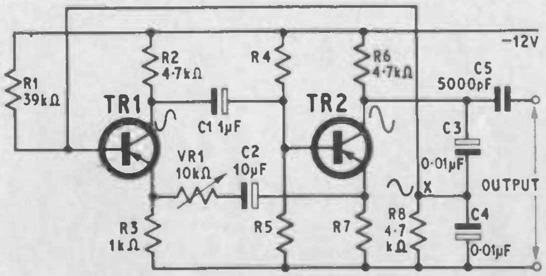
15—PHASE SHIFT OSCILLATOR



Convenient way of producing a signal without using transformers. At low frequencies, where internal phase shift of the transistor is minimal, an artificial phase shift is obtained by inserting a CR ladder network between the collector and base. At least three CR "rungs" are needed to get 180°. Impedance of the ladder will be much higher than that of the transistor. Attenuation over the ladder is 29 using three equal resistances and three equal capacitances. Frequency $1/(2\pi CR\sqrt{6})$Hz. Where $C = 0{\cdot}01\mu F$ and $R = 10k\Omega$ this gives a frequency of 650Hz but is modified by transistor impedances to 800Hz. Output impedance is high.

High gain transistor is required such as OC75(G) or AC156(E)

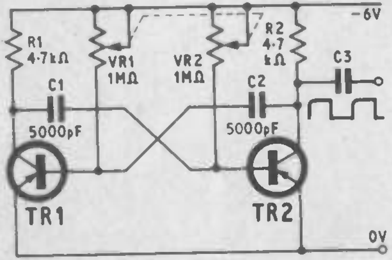
16—WIEN BRIDGE OSCILLATOR

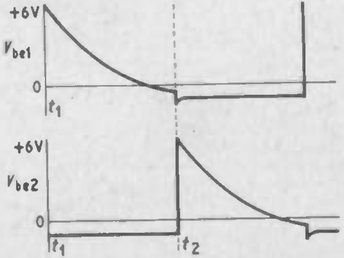


Audio frequency sine wave generator. Frequency determining components are contained in bridge network R6, C3, R8, and C4. Regenerative positive feedback from point "X" to TR1 base occurs only at this frequency. Frequency $= 1/(2\pi RC)$. Here $R = 4{\cdot}7k\Omega$ and $C = 0{\cdot}01\mu F$. Oscillator is frequency selective. Any change or mismatch in component values in the series or parallel pair of the Wien bridge will cause the feedback signal to TR1 base to become out of phase with the bridge input, preventing oscillation. If resistors R6 and R8 are made into a twin ganged potentiometer, the frequency can be varied.

Transistors: OC71(G), AC155(E), NKT214(A)

17—ASTABLE MULTIVIBRATOR

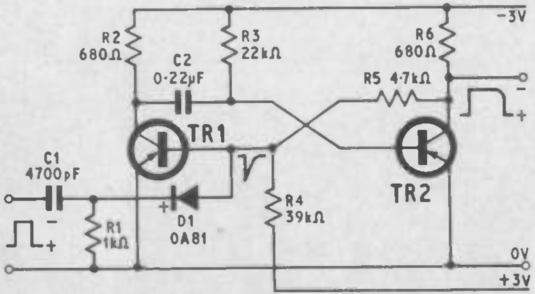


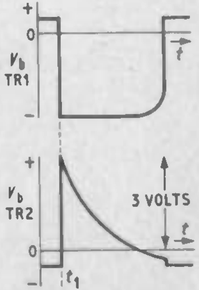


Free running square wave generator. Unbalance between two stages causes TR1 (or TR2) to conduct while TR2 (or TR1) is cut off. Cross-coupled capacitors C1 and C2 are alternately charged through base emitter junctions; discharged through VR1 and VR2. When C2 is discharged through VR2, TR1 base voltage falls exponentially to zero, when TR1 starts to conduct. TR2 is cut off. When C1 is discharged through VR1, TR2 base falls to zero, when TR2 will conduct. The small negative pips on the base waveforms are due to rapid initial recharge of capacitors. Waveform at both collectors approximate to a square wave. Frequency is adjusted by VR1 and VR2. $f = 1/(1{\cdot}4CR)$ where C is single coupling capacitance (farads) and R is base bias resistance (ohms), and where C1 = C2 and VR1 = VR2. Mark/space ratio is altered by varying the value of one capacitor.

Transistors: NKT218(A), OC83(G), AC156(E)

18—MONOSTABLE MULTIVIBRATOR

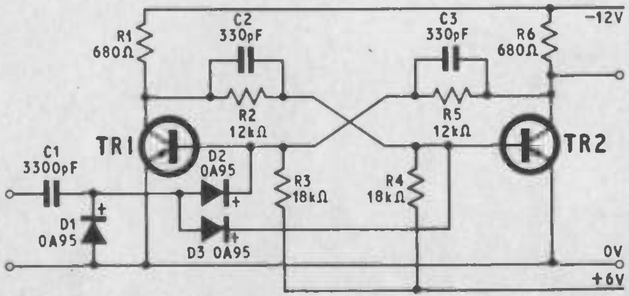




Used for pulse shaping or to provide a calculable delay period in the output pulse which is independent of the input trigger pulse period. May be employed for frequency division. With no trigger pulse applied in the circuit shown, TR2 would normally be switched on. Base bias is provided by R3. TR1 is off as a positive bias potential is applied via R4 and R5. C2 is charged to −3V. When trigger pulse is applied via the diode shaping circuit to the base of TR1, this transistor starts to switch on. The positive going TR1 collector voltage switches off TR2. This cumulative effect on the base voltages is shown at time t_1. With TR1 bottomed, C2 retains its original charge with +3V applied to TR2 base. C2 discharges through R3 and TR1, bringing TR2 base towards 0V, and the point where TR2 switches on again. The output pulse period is determined by C2 and R3. An approximation of this period is $0{\cdot}7C_2R_3$ seconds.

Transistors: OC71(G), AC155(E), NKT214(A)

19—BISTABLE MULTIVIBRATOR

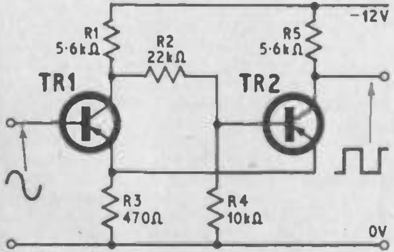


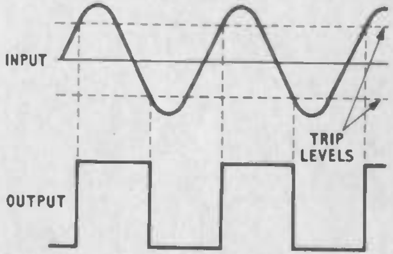
Commonly used for counting and generating square waves from pulse inputs.

When the supply is applied the circuit assumes a stable state with one transistor bottomed and one cut off. When a positive pulse is applied via the differentiator C1-D1, the transistors reverse their switched state and the circuit assumes its second stable condition. D2 and D3 route the pulses for the correct switching sequence—each diode being reverse biased when its connecting transistor is cut off. Outputs may be taken from either collector.

Transistors: NKT224(B), AC113(E)

20—SCHMITT TRIGGER



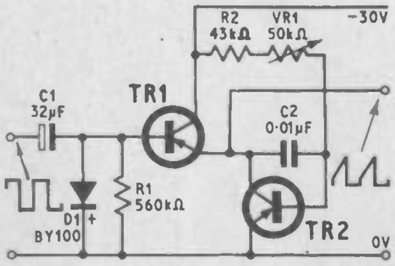


The Schmitt or emitter coupled bistable, can be considered as a fast acting switch, the action of which is precipitated by a pre-arranged d.c. level, the trip voltage (see waveforms). Often employed as a voltage level detector.

When the input is below the triggering level TR2 is switched on by its base divider network R2 and R4, with TR1 switched off. If the input voltage is made to exceed the emitter voltage (neglecting the small base-emitter drop at TR1) this transistor begins to switch on and TR2 switches off. Since there are no coupling capacitors in this circuit, reversion to its original condition of TR2 on can only be achieved by reducing the amplitude of the input signal below the trip voltage. The switch on and switch off voltages differ in level and this property is often used to square, or clip, waveshapes.

Transistors: NKT274(A), AC154(E)

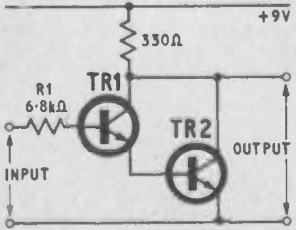
21—MILLER SAWTOOTH GENERATOR



Alternatively known as the Miller integrator or linear sweep generator, this circuit is often encountered where sawtooth waveforms are required. C1, D1, and R1 clamp the input positive peaks to 0V. When the input goes negative TR1 is switched on and almost all the supply voltage is applied to TR2 the emitter load. Since the base is almost at zero volts, C2 charges to this potential. As the pulse input goes positive, TR1 is cut off and C2 commences to discharge via TR2 and the base bias resistors R2 and VR1. The discharge of the Miller capacitor C2 is characterised by an initial small step in the output, after which the base voltage of TR2 remains constant and C2 continues discharging linearly on a long time constant producing a sawtooth output.

Transistors: 2S321(H), OC203(F)

22—SUPER-ALPHA PAIR



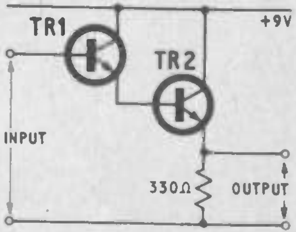
Alpha is the term originally used to indicate transistor current gain. Super-alpha pair derives its name from the combined gain of two transistors, these being multiplied. Otherwise the characteristics are as in a grounded emitter stage.

Transistor: *npn* type—2N2926(I)

23—DARLINGTON PAIR

Has a very low output impedance and high input impedance. Input impedance is approximately equal to the combined current gains of the transistors multiplied by the output impedance. Otherwise the characteristics are as in a grounded collector (emitter follower) stage.

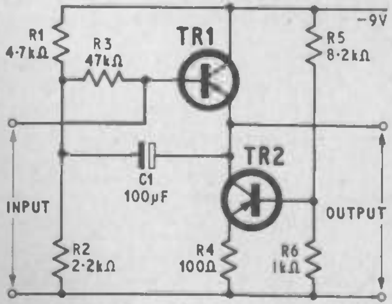
Transistor: *npn* type—2N2926(I)



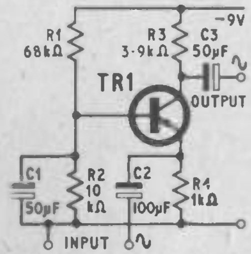
24—BOOTSTRAP AMPLIFIER

A technique used to achieve high input impedance where base bias resistors are likely to shunt the input, is known as bootstrapping. Here almost equal and in-phase voltages are applied to either end of resistor R3. The impedance of this isolation resistor can be considered as very large, as only a small current flows. TR2 is the emitter load of TR1 which acts as an emitter follower. As is usual with this type of circuit, the input impedance is high, but the bias divider R1–R2 would reduce the impedance "seen" by the signal if the bootstrapped resistor R3 was not included. C1 couples negative feedback from the emitter load to implement this bootstrapping.

Transistors: TR1 AC107(G), TR2 OC71(G)



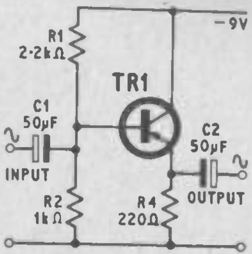
1—GROUNDED BASE



Low input impedance to emitter; high output impedance from collector. C1 acts as short circuit to a.c. while blocking d.c. Therefore, the base is grounded to a.c. and common to both input and output signal circuits. Used for matching low impedance source to amplifier stages. Phase shift zero; a.c. current gain < 1; a.c. voltage gain high.

Transistor: OC71(G)

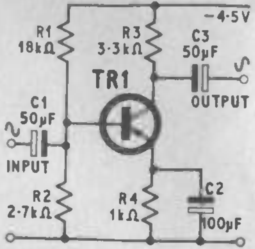
2—GROUNDED COLLECTOR



High input impedance; low output impedance. Often called an emitter follower. Decoupling capacitor is sometimes connected across supply lines to reduce power line impedance. Collector is common to input and output circuits. Used to match amplifier to low impedance load. Phase shift zero; a.c. current gain high; a.c. voltage gain < 1.

Transistor: OC35(C)

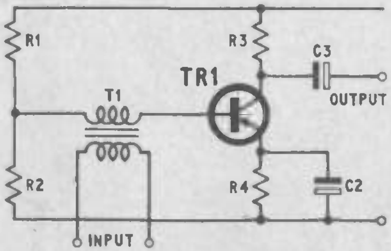
3—GROUNDED EMITTER



Medium input impedance. Medium output impedance. Battery positive supply line is common to both input and output circuits. Decoupling capacitor C2 short circuits emitter to positive supply line as far as a.c. is concerned. Therefore, emitter is common to both input and output circuits. Phase shift 180°; a.c. current gain high; a.c. voltage gain high.

Transistor: OC71(G)

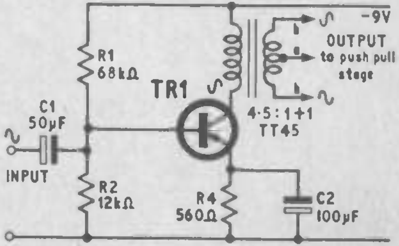
4—BASE CURRENT DRIVE



Low input impedance; source can be coupled in series with base instead of in the emitter circuit, where high current gain is required and where the normal common base circuit is unsuitable. Transformer can be used to match almost any impedance to the base. A.C. signal is superimposed on very small base bias current, determined by values of R1 and R2. Values of components not given because they depend on the characteristics of the transformer and signal source impedance.

Transistors: OC71(G), NKT214(A), AC155(E)

5—DRIVER STAGE



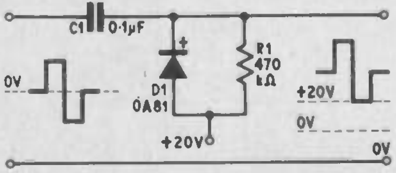
Common emitter stage with a collector current of about 3mA. The collector load is the transformer primary coupled to a class B push-pull pair. Special packages containing all three transistors (matched) can be obtained. If the characteristics are dissimilar, severe distortion is likely. Ideally the two halves of T1 secondary should be bifilar wound, i.e. both halves wound at the same time so that the wires lay side-by-side. Commercial types are available (e.g. Repanco TT45).

Transistors: 2G381(H), OC81(G), NKT271(A), AC154(E)

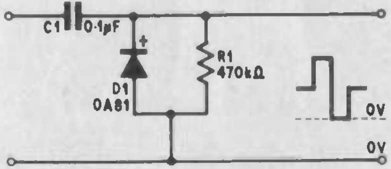
25 & 26—D.C. CLAMPS TO A REFERENCE VOLTAGE

Clamping is the technique of shifting a waveform so that either its positive or negative peaks are fixed at some reference level. If a train of pulses is passed through a capacitor the mean d.c. level is blocked. In the clamp circuits the diodes DI restores the d.c. level so that the peaks are clamped to the reference voltage. In the examples given below these peaks are negative.

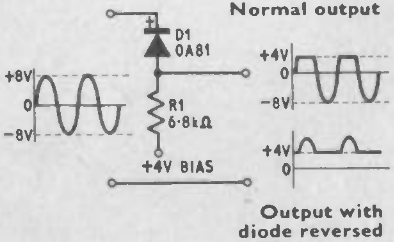
25—D.C. CLAMP TO POSITIVE VOLTAGE



26—D.C. CLAMP TO ZERO VOLTAGE

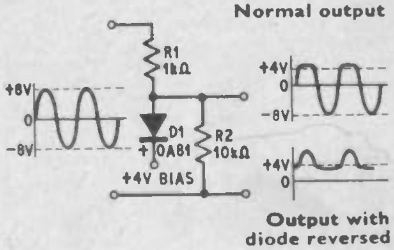


27—SERIES DIODE LIMITER



Clipper or limiter circuits are used when a particular waveform, not necessarily sinusoidal, is required which lies above or below some reference level. Since the forward resistance of a diode is low, and its reverse resistance high, when the input voltage raises the cathode level above the bias potential, DI does not conduct and the output remains at the bias potential. During the remainder of the cycle, the diode conducts and the output voltage almost equals the input. With the diode reversed, conduction only occurs when the positive peaks exceed the bias potential.

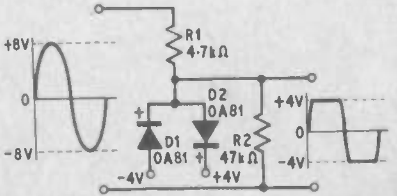
28—SHUNT DIODE LIMITER



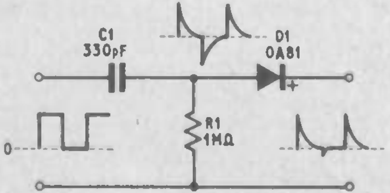
The shunt diode clipper uses the diode to short-circuit the output above the 4V bias. When the input voltage is less than the bias potential the output waveform is almost identical since the diode is not conducting. When the input voltage exceeds the bias potential the diode conducts and shunts the load resistance so that the output voltage only slightly exceeds the bias potential. With the diode reversed, the peaks are clipped at the bias voltage.

29—DOUBLE PARALLEL CLIPPER OR SLICER

In the slicer the two biased diodes combine to trim the input peaks alternately when the positive and negative half cycles exceed the respective diode bias potentials. The diodes act as shunts for the peaks above ±4V (bias voltage).

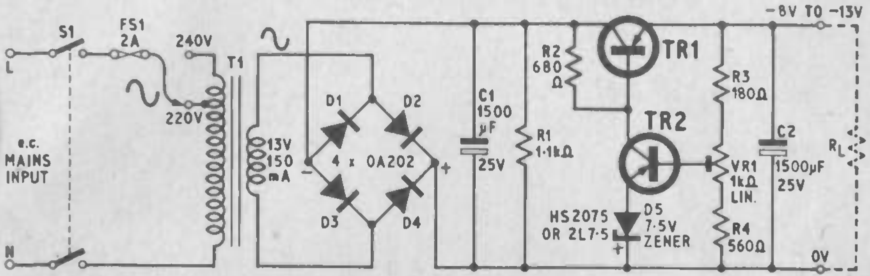


30—TRIGGER PULSE SHAPER



Most switching sources produce rectangular waveforms which generally have to be shaped to provide an effective trigger for other pulse circuits. In the shaper shown, C1 and R1 form a differentiator which converts the rectangular wave input into positive and negative going spikes, the width of each being dependent on the time constant C_1R_1. The diode effectively removes the lower spike so that the output provides one positive going narrow pulse for one input cycle. Almost any small signal diode can be used. The remaining small negative pip is due to the reverse diode resistance.

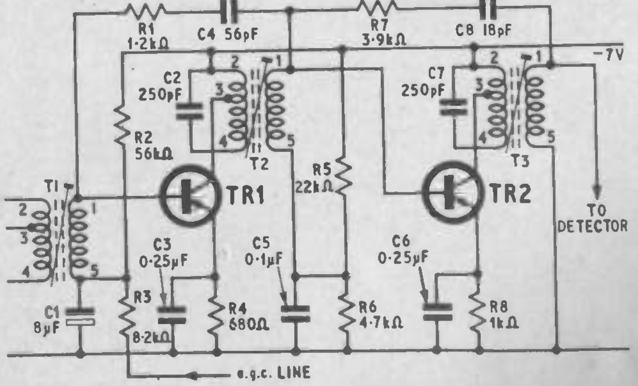
31—STABILISED TRANSISTOR POWER SUPPLY



Of the three main types of rectification, the bridge rectifier shown here (D1, 2, 3, 4) offers the lowest impedance source for d.c. supplies, an important factor when using amplifier circuits to achieve a.c. stability. Ideal source impedance is zero but is not practicable. Very high values of smoothing capacitor are used to reduce impedance to lowest figure. If a voltage stabiliser is connected to the output from the bridge circuit, any fluctuation of load resistance (R_L) is used to control the voltage output from TR1. If R_L falls, the output voltage tends to drop. A d.c. voltage is picked off by the potential divider R3, VR1, R4 to control the current through TR2 and hence TR1. TR2 base goes more negative, TR1 emitter voltage rises thus restoring the output voltage. C1 reduces the impedance across the bridge and smooths the d.c. C2 reduces the impedance at the output terminals and reduces the ripple to less than 5mV at 10V output. Maximum current capacity 150mA. D5 is a Zener diode to fix TR2 emitter voltage at 7·5V.

Transistors: TR1 NKT304(D), TR2 NKT217(A)

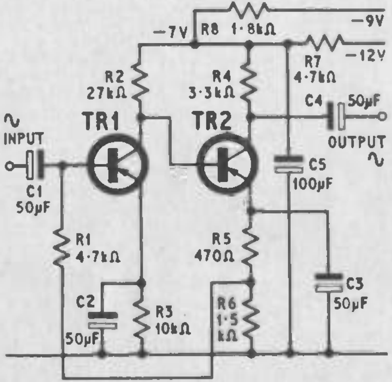
6—465kHz I.F. AMPLIFIER



Tuned amplifier with transformer primaries tuned to the i.f. High frequency transistors essential. Base voltage is determined by potential divider (R2 and R3) in conjunction with a.g.c. voltage. Base of TR1 is current driven by T1; primary is connected to the r.f. mixer (not shown). Second stage is similar but with higher current drain. Feedback is provided by R1, C4, R7, and C8. The transformers shown can be Repanco type XT26 for T1 and T2; XT27 for T3.

Transistors: NKT142(B), 2G301(H), OC45(G)

7—DIRECT COUPLED SMALL SIGNAL AMPLIFIER



Grounded emitter configuration; base bias is taken from TR2 emitter to TR1 base. The bias on TR1 base is directly controlled by TR2 collector current, which automatically sets the working point of TR1, and hence TR2 through the potential divider R1, R6. The bias point of TR2 is set by the controlled current through TR1 collector load. Direct coupling between TR1 collector and TR2 base is essential for this operation. The input impedance is 1kΩ for a 50dB gain. Decoupling of the supply line by R7 and C5 enables this circuit to be used in front of that shown in Fig. 8. R8 indicates decoupling resistor value for −9V supply.

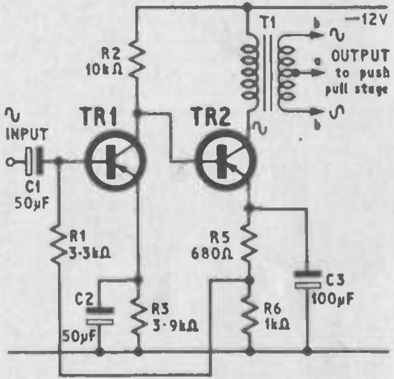
Transistors: OC71(G), NKT214(A), AC155(E)

8—DIRECT COUPLED DRIVER

Same principle as applied in Fig. 7 but handles larger signal prior to the push-pull output stage. Can be coupled to circuit shown in Fig. 7 if used with 27kΩ resistor and 0·005μF capacitor in parallel connected in series with the input.

Transformer details: Bobbin $\frac{3}{8}$in × $\frac{3}{8}$in bore; Primary 1,900 turns 42 s.w.g. enam. L = 8·2H, D.C.R. = 217Ω. Secondary two bifilar windings 950 turns each 40 s.w.g. enam. L = 2·05H, D.C.R. = 105Ω for each half. Laminations 15 mil mumetal.

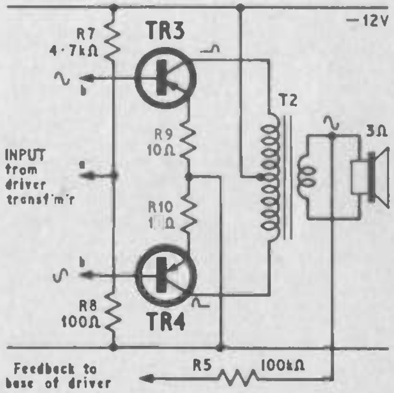
Transistors: OC71(G), NKT214(A), AC155(E), OC81D(G), NKT272(A)



9—CLASS B PUSH-PULL OUTPUT

The bases are 180° out of phase (determined by driver transformer connections). Bias is provided by R7 and RB. Crossover distortion can result from the slight non-linearity at very low base currents, so transistors are given a small bias to partly offset this. Each transistor conducts on alternate half cycles which are recombined in the output transformer. Transformer details: Bobbin $\frac{3}{4}$in × $\frac{3}{8}$in bore; Primary two bifilar windings 178 turns each 31 s.w.g. enam. L = 190mH, D.C.R. = 3·3Ω for each half. Secondary 29 turns 20 s.w.g. enam. L = 5·25mH, D.C.R. = < 1Ω. Laminations 15 mil mumetal. Power output 500mW into 3Ω loudspeaker when coupled to circuit in Fig. 8. Heat sinks must be used, 35sq cm 18 s.w.g. aluminium.

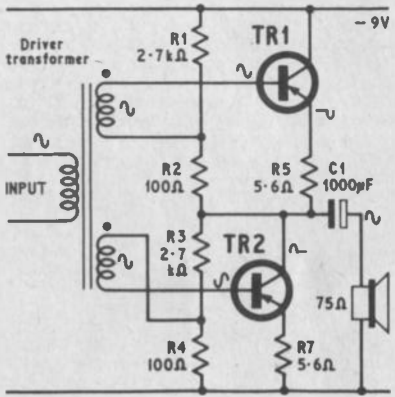
Transistor: OC81(G)



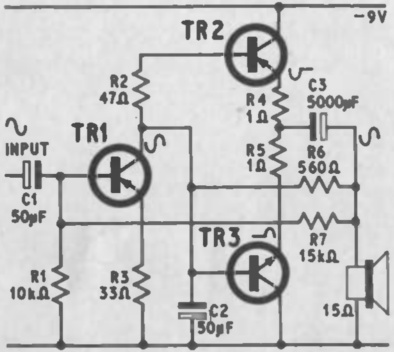
10—SINGLE ENDED PUSH-PULL OUTPUT

TR1 and TR2 can be considered as two separate class B operated stages. Bias is provided by R1 and R2 for TR1, and R3 and R4 for TR2. Since the negative and positive supply lines are common to a.c., TR1 conducts for one half-cycle while TR2 conducts for alternate half-cycles. The output is taken across the two stages which are in parallel for a.c. No output transformer is needed. Output 200mW into 75Ω with 2·7kΩ feedback resistor from output back to emitter of driver. Driver transformer (Fortiphone L442), turns ratio 7:1 + 1; Primary $L = 5$H at 1·5mA d.c., D.C.R. = <750Ω. Secondary d.c.r. <100Ω per winding.

Transistors: OC72(G), NKT212(A)



11—COMPLEMENTARY SYMMETRY



No output transformer is used in this circuit as the two transistors are operated under similar conditions to that shown in Fig. 10. No driver transformer is used as the signal is provided direct from TR1. Notice TR3 is an *npn* type so that it can operate in opposite phase to the conventional stage without transformers. The output is taken from the emitter circuits. Both TR2 and TR3 act as emitter followers. D.C. stabilisation is provided by R1, 2, 6, 7 for all three transistors. Heat sinks are recommended—35sq cm 18 s.w.g. aluminium.

Transistors: TR1 2G371(H), TR2 2G381(H), TR3 2G339(H)