**Synchronous signal splitter.** There is a limit to the speed at which the diode or transistor signal splitter will transfer the signal path between the sub-amplifiers. If a synchronous signal splitter is used the time taken can be reduced to a few nanoseconds. This makes true class B operation possible at frequencies far higher than the audio spectrum. The system diagram is shown in Fig. 8(a). Instead of using the characteristics of the devices, as in the signal splitter which separates the two halves of the waveform, switches $Tr_1$ and $Tr_2$ are turned on and off at the required time by another amplifier labelled ST. This is a high-gain amplifier with a small amount of hysteresis, and as soon as the input exceeds a predetermined level the output from the trigger (amplifier ST) will change its polarity and turn on $Tr_1$ or $Tr_2$, depending on the signal direction, Fig. 8(b). This therefore gives almost the ideal signal splitting characteristics but the added complication might spoil its commercial possibilities.

## Performance of the new design

The transistor signal splitter and the output stage circuit have a combined characteristic shown in Fig. 9 which demonstrates the excellent gain linearity. It is only when the bias of the sub-amplifiers is decreased below its optimum, allowing the output signal excursions to trace the non-linear region of the characteristic, that distortion begins to rise sharply. Further studies of these curves reveal that increasing the quiescent current through the output devices *does not* degrade, or for that matter improve, the crossover performance of the output circuit. Keeping this in mind it is therefore possible to design a class B amplifier *without any bias adjustment*. This assumes that the designer can guarantee that spreads in active devices and resistance values do not permit the quiescent current to fall below the level where the mutual conductance of the amplifier begins to decrease.

In this discussion about the performance of the design as a whole it would be fitting if the sub-amplifier design is mentioned. With conventional designs this two- or three-transistor element is fraught with compromises, one of the most serious being the decision on the inclusion of a base-emitter 'turn-off' resistance for the power transistor. Such a combination generates what can be called 'dead zone' distortion, mainly due to the change in slope of the transfer characteristic at zero crossing. One example of this is shown in Fig. 10 where, as predicted, the lower the value of resistance the more pronounced is the effect. It is very tempting to exclude this resistance altogether, especially if the current drive approach has been adopted, but the penalty would be a poor high-frequency performance coupled with overload recovery problems. This dilemma is aggravated if the designer decides to use homotaxial base powder devices (chosen for the robust nature of their construction and freedom from secondary breakdown) because the input diffusion and depletion capacitance is very high, hence the gain-bandwidth product of the device is relatively low (e.g. silicon planar $f_T \approx 90$MHz, homotaxial base $f_T \approx 1$MHz). In the latter case it is essential that the resistor is included. However, if the approach suggested in this article is adopted the sub-amplifier will never enter this non-linear region, thus the base-emitter turn off resistance can be included in the circuit to improve the performance without undue complications.

Once the decision has been taken to use the new approach the best circuit configuration has to be found and here again nature's swings and roundabouts create a difficult situation where compromise seems necessary. One of the criteria I used was that of thermal performance, following an initial consideration of the electrical properties of each configuration. The power transistor chip can change its temperature by tens of degrees centigrade during a power cycle, this being reflected by a corresponding change in the base-emitter voltage ($V_{BE}$) of the device. If the voltage bias to the sub-amplifier is applied directly to the power device (Fig. 11a), any change in the $V_{BE}$ will cause a considerable change in quiescent current and in turn an

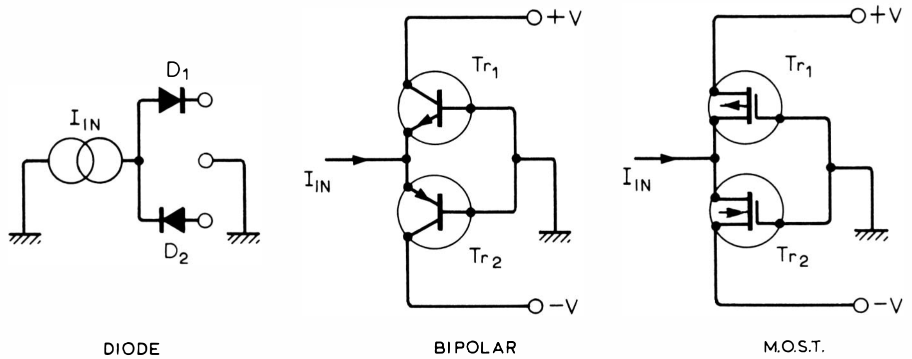
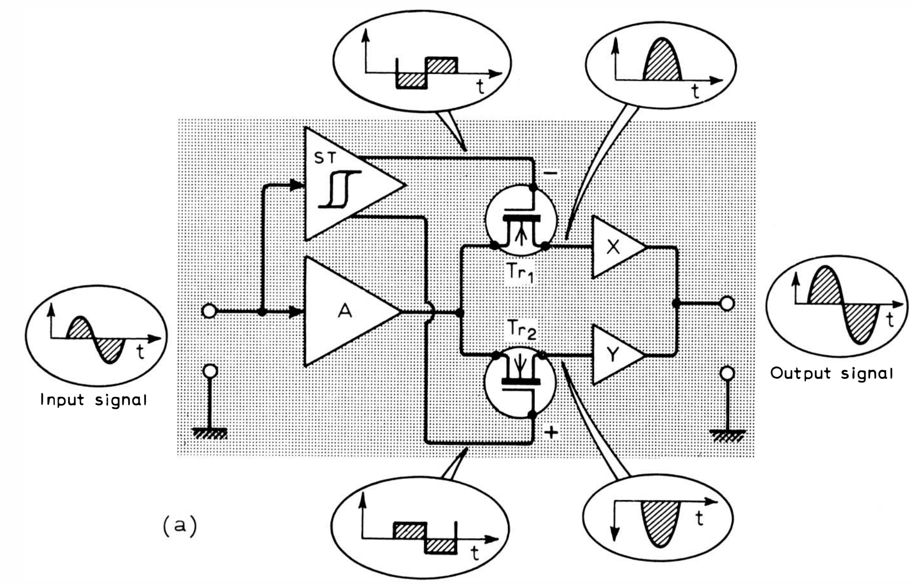



*Fig.7. Types of signal splitter. Transistor type has the advantage of level shifting.*



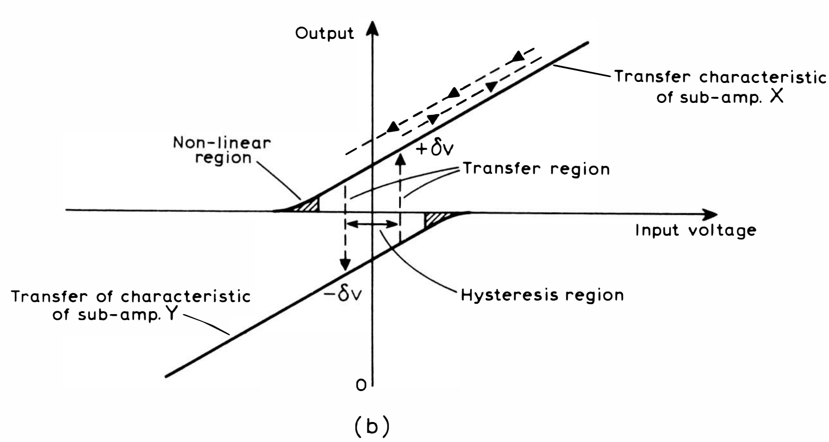




*Fig.8(a). Synchronous signal splitter, with fast switching time, allows new approach to be used at frequencies well above audible range.*

*Fig.8(b). Operation of synchronous splitter of Fig.8(a). When input level exceeds a pre-determined level, output changes polarity and turns on $Tr_1$ or $Tr_2$.*