SPECIAL PRODUCT REPORT

FETRONS

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THE field effect transistor (FET) is currently being used in the front end of a.f. and r.f. circuits, as well as being developed into simplified forms of logic circuitry for micro-miniature applications such as wrist watches and pocket calculators. Aside from the manufacturers of such luxury items, our attention is turned here to more domestic matters such as television receivers, radio transmitters and receivers. Where thermionic valves are still being used, there is some reluctance to effect a total conversion to semiconductor techniques. We can have the best of both worlds because we can now replace valves in some circumstances with direct equivalent improved performance transistors. Particular areas of application also include unattended relay stations, and telecommunications terminals, as well as domestic receivers.

TRIODE EQUIVALENT

These transistors, called "fetrons," have emerged from the military applications stable and are being made available for other applications, although very little is generally known about the performance so far. The fetron is basically an arrangement of two n-channel field effect transistors (Fig. 1) connected to provide the equivalent working characteristics of a triode valve but with a much better frequency response at both ends of the spectrum. This is because the fetron has an extremely low channel resistance and inter-electrode capacitance. Furthermore, since there are no heaters, operation is immediate on switch-on.

OTHER FEATURES

The life of the fetron is likely to be much greater than the thermionic valve under normal working conditions and the degradation of operational characteristics is minimal. Other important features include a higher amplification factor (almost ten times that of a valve) and a lower noise figure. Since no heaters are used, power requirements are simplified to just one high tension supply.

PENTODE CHARACTERISTIC

Both the thermionic valve and the FET are voltage controlled devices, hence design equations are virtually the same. Although the pentode anode voltage-current characteristics are similar to the drain characteristics of the fetron, the latter are more clearly defined at the cut-off region or "knee" and exhibit stable current drain for various drive conditions (Fig. 2).

Since the main purpose of the fetron is to act as a direct replacement for the triode valve, it is essential that it should withstand high voltages and have a matched gm. The single junction FET cannot do this, but when two specially selected FETs are cascaded the problem is overcome. It is also possible to reduce the Miller (gate to source capacitance) effect by using a low capacitance, small signal, high gm FET at the input circuit, coupled with a high voltage output FET.

With the arrangement shown in Fig. 1, the output FET acts as a voltage dropper for the input FET and the Miller effect capacitance of each is in series. The output impedance is also greater than in a valve pentode, resulting in the excellent characteristics shown in Fig. 2. Since the input gate circuit is effectively a reversed bias junction, it presents a very high resistance load to the signal source.

Fig. 3 shows the transfer characteristic of a fetron which has been made

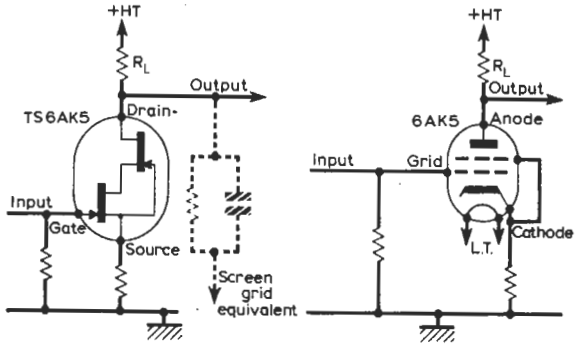


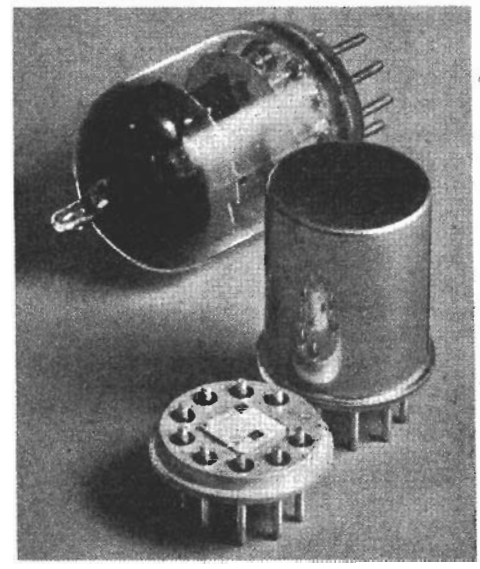
Fig. 1: Basic arrangement of two field effect transistors in one package to form a fetron, and the symbol of the 6AK5 valve.

TABLE 1:

TYPICAL PENTODE DEVICE CHARACTERISTICS— Rk=200 Ω, Eb=120V		
PARAMETER	6AK5	TS6AK5
Plate voltage breakdown	350V	350V
Plate resistance	0·5MΩ	5·0MΩ
Transconductance	5,000μmhos	4,500μmhos
Plate current (Rk=200Ω)	7·5mA	7·0mA
Grid voltage for Ib=10μA	−8·5V	−5·0V
Amplification factor	2,500	22,500
Input capacitance	4·0pF	6·5pF
Output capacitance	0·02pF	0·02pF
Useful frequency limit	400MHz	600MHz

TABLE 2:

TYPICAL TRIODE DEVICE CHARACTERISTICS (EACH SIDE)—Rk=2—70 Ω, Eb=130V		
PARAMETER	12AT7	TS12AT7
Plate voltage breakdown	400+V	350V
Plate resistance	15kΩ	250kΩ
Transconductance	4,000μmhos	3,000μmhos
Plate current (Rk=240Ω)	5·0mA	9·0mA
Grid voltage for Ib=110μA	−7·0V	−7·0V
Amplification factor	60	750
Input capacitance	2·2pF	25pF
Output capacitance	1·5pF	3·5pF



up from selected FETs to approximate closely that of a particular valve (shown dotted) operating within the same limits. If special requirements include partial operation beyond this FET cut-off then clearly a more appropriate FET device must be selected for this, perhaps providing a higher current for the same control voltage. The gm or transconductance ratio of the fetron gives a true square law property with consequent harmonic distortion figures of an extremely low order. In fact, harmonics beyond second order are claimed to be negligible.

Although the simulation of the "screen grid" principle can be effected within the fetron package, the similarity of the transfer curves to those of a pentode must not be taken as an assumption that the fetron is an ideal replacement for the pentode, even though the noise figure may be lower. The fetron has a markedly improved performance over the triode due to square law operation.

POWER REQUIREMENTS

Power supplies can be greatly simplified: first by the elimination of low voltage lines; secondly by the use of less stringent h.t. regulation. Current requirements are similar to or slightly higher than for a triode, but surge currents of up to about 1,000 times can be tolerated. Due to the lack of heating requirements the fetron will operate at more confortable temperatures around 65°C. The case is ruggedised by using a deep-drawn steel cap welded to a large diameter header, using the same pin arrangement for connections.

Fetrons that have been made so far include replacements for the 6EW6, 6JC6, 6AK5 and 12AT7 but with ready made FET junctions currently available it is expected that the majority of common types can be simulated. More familiar types such as 6V6 and 6AQ5 are next on the list. The type number given to fetrons consists of the equivalent valve number but prefixed TS. Hence the fetron for replacing the 12AT7 is TS12AT7.

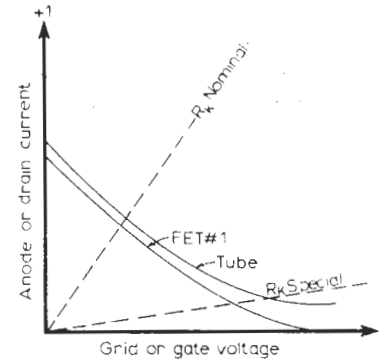


Fig. 3: Transfer characteristic of a fetron compared with a valve.

The manufacturer who has announced these activities in fetrons is the American company Teledyne Semiconductors, who are selling in the U.K. via the distributors GDS Sales Ltd. of Slough. Prices are higher than for valves but this is offset by the long term performance advantages described. GDS Sales quotes £8 for the TS12AT7 and £6·50 for the TS6AK5 for orders of 1 to 99, these being the first available in the U.K. Although this price is high the long term advantages of reliability and performance are compensatory. Small orders for these devices are being handled by the subsidiary company *Best Electronics (Slough) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks, SL1 3UZ.*

Elsewhere in this issue we are taking a closer look at some of the valves that still have a unique role to play in radio and electronics. Look out for our special feature "Special Valves for Communications".

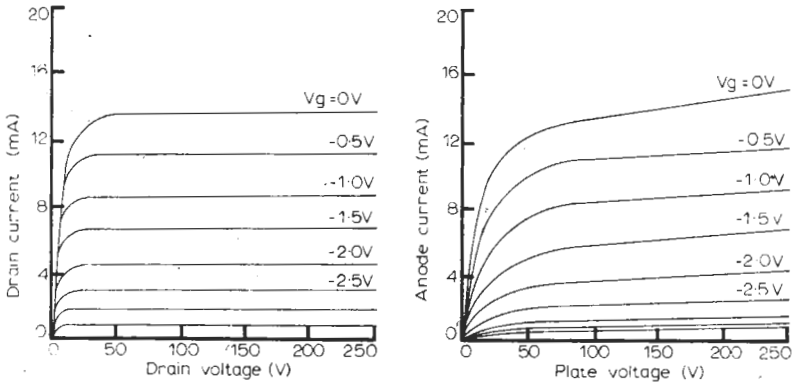


Fig. 2: Comparison of output drain characteristics with those of the 6AK5 anode.