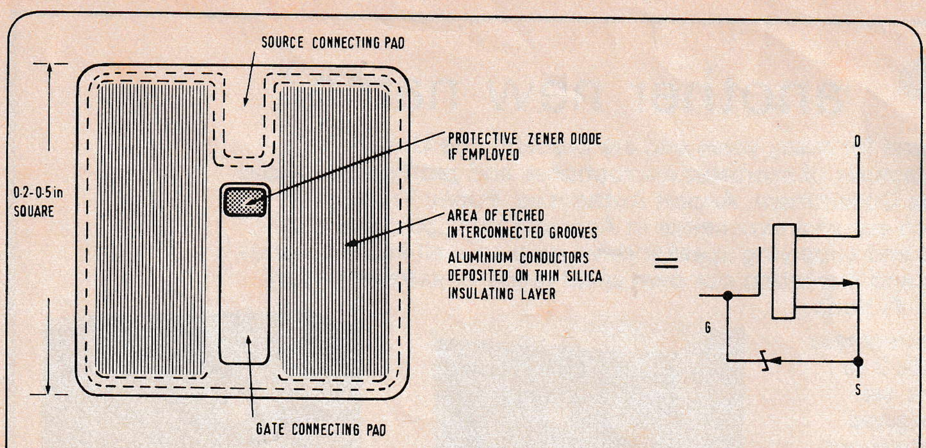

FIG.7 PLAN VIEW OF TYPICAL 'POWER MOSFET' SHOWING MUCH MORE COMPLEX CONSTRUCTIONAL FORM (COMPARE WITH FIG.3)

and turn-off times in the circuit and avoids much masking of low-level signals, where these happen to coincide in time with larger level events. In all my experiences in the use of these devices (some of which have been frustratingly brief) the common factor in the sound quality has been a greater transparency and delicacy in low-level detail, and this has been a common factor with a wide variety of circuits and a fair range of different MOSFET types. Since, in some cases, I had not sought to use the better HF response of the components to reduce the THD, this absence of 'internal memory' in the transistor seems the most likely common factor. Suffice it to say that the glimpses I have had of the possible were enough to keep me trying, in spite of many set-backs.

The second part of the problem is less easy. If the makers of the transistor have provided an internal protective zener diode, this will be formed by a diffusion into the emitter or 'source' region, as shown in fig. 6. If this is ever forced into reverse conduction, by reverse biasing the gate, the *n-p-n* arrangement of the *n*-channel MOSFET will instantly become a *p-n-p-n* silicon controlled rectifier, turned hard on, and smoke will pour out of the entrails of the amplifier. Conversely, if the makers *haven't* provided a protective diode the device may blow-up in use anyway!

It is the need to tread such a careful path through the minefield of conflicting demands and difficult requirements which has so far limited the commercial availability of this type of amplifier. However, a fortunate combination of design circumstances allows the 30 watt amplifier described in these pages in the January-March 1980 issues to be uprated to use power MOSFETs with very little circuit change. The amended power amplifier circuit is shown in fig. 8.

In this, the need to avoid the possibility of reverse bias being applied to the gate of the transistor is achieved by its use in the doublet output combination—where it is a straight swap for the power Darlington device. In this, the worst-case condition for the driver transistor merely turns it off, leaving the MOSFET with its gate and source at the same potential. If the driver transistor is turned hard-on, the external Zener diode conducts and limits the forward voltage on the MOSFET gate to 4·7 V.

Because of the absence of 'secondary breakdown' phenomena in the power MOSFET, the safe operating area of the device is rather better than that of the MJ2501/MJ3001 power Darlingtons previously specified, which will allow the HT line voltage to be increased to +80 V, giving a continuous output power rating of some 50 W. The only other changes in the circuit from the values published on page 69 of the January 1980 issue (fig. 6 of that article) are the reduction of C_6 to 47 pF, the increase of R_7 to about 680 ohms (most easily accomplished by putting a 390 ohm fixed resistor in series with it), the connection of two 4V7 Zener diodes across R_{13} and R_{16} respectively, and the increase in the value of R_{12} to 1·2 k to compensate for the small difference in speed between the *p*-channel and *n*-channel power MOSFETs used in the change-over. (Hitachi 2SJ49 and 2SK134 used in place of Motorola MJ2501 and MJ3001). Note, incidentally, that the base connections of the power MOSFETs are different from those of junction transistors.

The quiescent current for each output channel should be increased to 100 mA.

From the instrument point of view, the most remarkable outcome of this substitution is that the amplifier is unconditionally stable, on all loads, even when the internal HF compensation capacitor C_6 is omitted entirely. Unfortunately this leaves the square-wave response on reactive load less smooth than in the unmodified version; this is aurally noticeable in spite of the fact that such glitches as there are are confined to the first two or three microseconds of the rising or falling edge, which it is inconceivable that we can hear!

A measurement of the 'transfer distortion'—a direct comparison of input and output via a phase equalised attenuator—on a 30 Hz–20 kHz bandwidth limited signal (preferably pink-noise superimposed on a squarewave) suggests an optimum value for C_6 around 47 pF, a value with which my ears are happy to concur in spite of the fact that the THD at the HF end worsens from some 0·002% to 0·02% at 20 watts at 20 kHz across 8 ohms as this capacitor value is increased, giving once again the situation in which one's ears tell one one thing while the THD measurement tells one another! Even with a 47 pF compensation capacitor, the THD at 1 kHz and below is around the 0·001–0·002% at 20 watts or less, which is about the limit of detectability in the presence of the inevitable 'hum' and circuit noise. The standard 30 watt amp is in the 0·01–0·02% region under similar circumstances—an assessment made on the basis of tests made on about six of these built since publication.

From my own point of view, having listened to two of these amplifiers converted to MOSFET output (my own prototype and a subsequent 'Hart' kit) over a period of some months, there seems no doubt that this is the direction in which future audio amplifier progress will lie. I do not know which of the measurable characteristics of the modified circuit are responsible for the difference, but I have convinced myself that in terms of sonic delicacy and transparency this modified amplifier makes the nicest sound I have heard yet, closer in fact to the sort of sound one normally gets with a Class-A headphone amp.

I understand that Hart Electronic Kits are happy to supply amended 30 watt kits, or the parts necessary to convert existing units to power MOSFET operation. I also understand that Robins (Electronics) can supply ready-built units to this design●

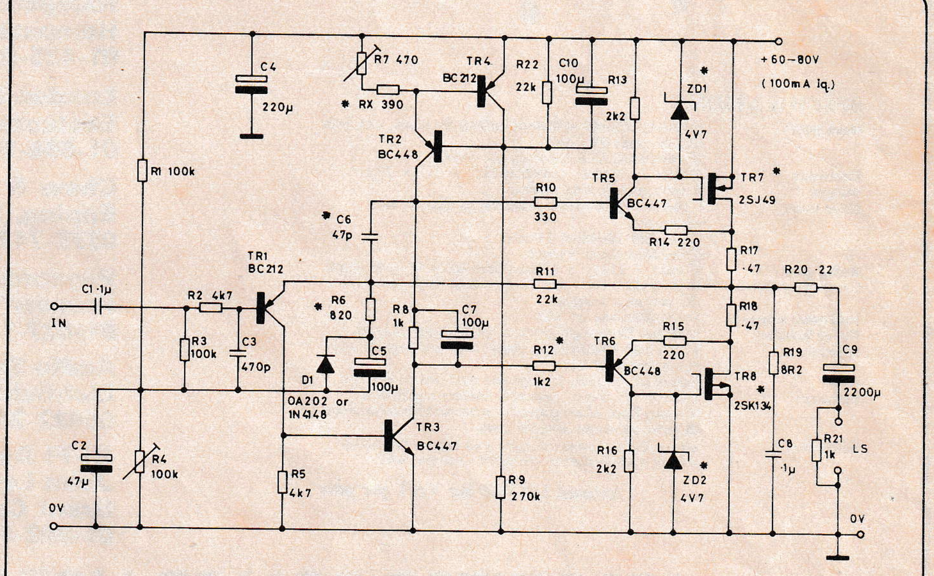

FIG. 8 MODIFIED FORM OF 'SIMPLE 30 WATT' AMPLIFIER USING POWER MOSFETS. ADDED OR AMENDED COMPONENTS IDENTIFIED BY ASTERISK