Inside the Ferguson TX80 Chassis

J. LeJeune

Innovative and yet somehow familiar in its concept, the TX80 is the last of the old Ferguson designs to reach the market. The chassis shows some Thomson influence, but its Enfield origins are stamped plainly all over it. This is nowhere more so than in the power supply and line output section, which nostalgically recalls the Thorn 9000 series chassis with its Syclops circuit. The key element here is the use of a single transistor as both the chopper and the line output switching device.

Basically the TX80 is just another small-screen TV receiver for 90° c.r.t.s with screen sizes from ten to fifteen inches. It's no basic receiver however. Features incorporated as standard include microcomputer-based remote control, on-screen graphics with a simple menu system to make adjustment of the operating controls easy, a sleep timer and a child lock facility. There's considerable integration in the low-level stages, where a single LSI chip incorporates the vision and sound i.f. strips, the luminance and chrominance signal processing stages, sync separation and the timebase generator circuits. The designers didn't go i.c.-crazy however: where a single transistor is all that's necessary, that's what is used. Since the receiver has a live chassis there's no scart socket. In any case while the tube is adequate for TV purposes its resolution is not sufficient for use as an 80-column computer monitor.

Picture quality is nevertheless excellent. The Samsung c.r.t.s give a bright picture with ample purity reserve. Audio on the other hand comes from a very small loudspeaker and leaves a little to be desired. Even so it's distortion free and the cabinet doesn't vibrate at high volume levels. The cabinet design is attractive, especially the 10in. model, and blends in with most domestic schemes.

Fig. 1 shows in simplified block diagram form the main sections of the chassis.

The heart of the set is of course the combined chopper and line output stage – it's known as a Wessel circuit. Fig. 2 shows the arrangement in block diagram form. Things start with the oscillator, which produces a line-frequency sawtooth output whose amplitude is determined by the comparator transistor TP03. The comparator senses the h.t. voltage produced by the chopper, and sets the supply to the oscillator. As this supply increases or decreases, so the amplitude of the sawtooth output is varied – see Fig. 3. The pulse-width modulator transistor TP05 converts the sawtooth waveform into a variable mark-space ratio squarewave which passes via the driver stage to the base of the switching transistor TP10. This drives two transformers, the chopper transformer LP03 (Wessel transformer) and the line output transformer LP04. In case anyone is puzzled by the idea of using a variable mark-space ratio waveform to drive the line output stage, the point to remember is that the switch-off time, which initiates the flyback, remains constant. It's the switch-on time during the forward scan that varies to take into account loading and mains input voltage variations. The initial part of the forward scan is controlled by the efficiency diode in the normal way. Comprehensive protection arrangements are built into the circuit.

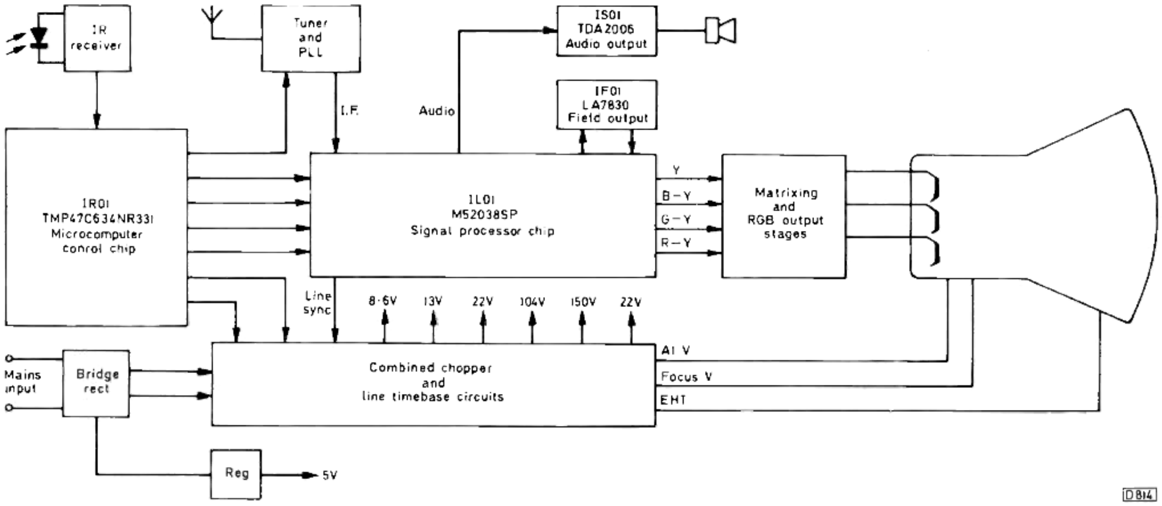

Fig. 1: The main sections of the Ferguson TX80 chassis, shown in block diagram form.

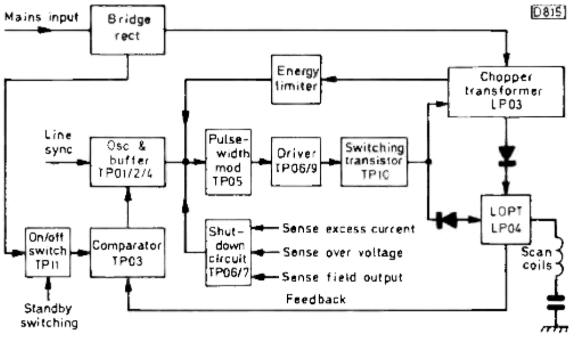

Fig. 2: Block diagram of the combined chopper power supply and line timebase arrangement.

We'll now take a closer look at the circuit action. Fig. 4 shows the complete circuit of the power supply/line output section of the receiver. Note that the receiver chassis is

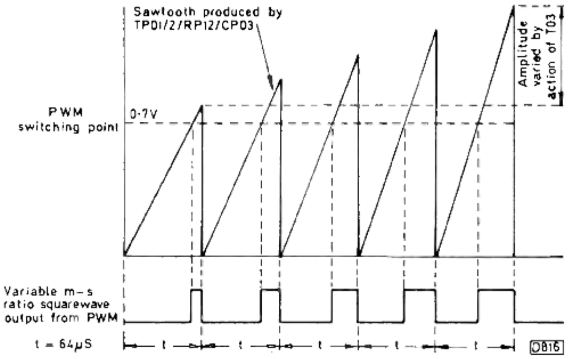

Fig. 3: Illustrating the action of the comparator, oscillator and pulse-wide modulator stages in providing a variable mark-space ratio drive waveform.

always live with respect to ground. It uses a bridge rectifier (DP26-29) to deliver three supplies, one full-wave rectified and the other two half-wave rectified. In this respect it could be said that the bridge is fully utilised. The full-wave output is smoothed by the reservoir capacitor CP31 and fed to the chopper transformer LP03 at approximately 360V d.c. One half-wave rectified supply is fed to the switch transistor TP11 whose collector feeds the comparator, oscillator, pulse-width modulator and driver stages. The other half-wave rectified supply is smoothed by RP39/CP41 and fed to a 5V regulator which in turn provides the supply to the microcomputer control chip IR01. The latter produces the on or standby command at pin 20. This is fed to TP12 which in turn controls TP11: in the standby condition TP11 is off and there is thus no supply to the oscillator etc., shutting down the Wessel system.

The main switching transistor TP10 is driven by a bootstrapped low-voltage driver stage (TP06/9) which is d.c. coupled to the pulse-width modulator transistor TP05. The input to TP05 is a variable-amplitude sawtooth which is produced by a relaxation oscillator whose timing components are RP12 and CP03. The two transistors in this circuit, TP01/2, act in a thyristor-like manner, switching off when there's insufficient current to maintain them in saturation. CP03 charges via RP12 from the voltage at the collector of the comparator transistor TP03. As CP03 charges, the emitter voltage of the pnp transistor TP02 will increase until the point is reached where it's 0·7V above the fixed base voltage set by RP26/RP05. At this point TP02 switches on and passes current to the base of TP01 which thus also switches on. The two transistors saturate heavily, rapidly discharging CP03 via RP65. Once CP03 has been discharged, TP02 and TP01 switch off and CP03 begins to charge again. The sawtooth waveform produced in this way is fed via the emitter-follower buffer transistor TP04 to the base of the pulse-width modulator transistor TP05. CP48 blocks the d.c. voltage at TP04's emitter and DP37 acts as a d.c. restorer, clamping the negative-going peak of the sawtooth waveform to chassis. TP05 conducts when the slope of the sawtooth waveform exceeds 0·7V.

The comparator transistor TP03 receives its collector supply from TP11, via RP01, RP02 and its load resistor RP03. CP01 smooths the supply and DP02 stabilises it at 18V. TP03's base voltage is obtained from the potential divider network RP08, RP61, PP01, RP07 which is connected across the 104V h.t. line: this is the main supply produced by the line output transformer, thus the conditions in the line output stage are sensed. TP03's emitter is held at 5·4V by DP46 and DP06. This combination of a zener diode and an ordinary signal diode gives a near-zero temperature coefficient.

Variations in the 104V h.t. supply are thus sensed by TP03 and inverted. A rise in the h.t. voltage will result in a fall in TP03's collector voltage and a corresponding fall in the amplitude of the sawtooth waveform fed to TP05. The action is illustrated in Fig. 3. When the h.t. voltage rises, the width of the drive pulses used to switch the chopper transistor TP10 on and off decreases. Thus TP10 remains on for a shorter period of time and the h.t. voltage is reduced to the correct figure. The action works in reverse should the h.t. voltage fall.

TP11 is used for standby switching. It has half-wave rectified mains voltage at its emitter at all times. Transistor TP12 inverts the control signal from the microcomputer chip, its base voltage going high to turn on the supplies and bring the set out of standby. When TP11 is switched on CP01 and CP13 charge via RP01 and RP17 respectively. TP03's collector and emitter voltages rise gently, so that the chopper comes to life gradually rather an abruptly. Once the chopper is running DP12 adds to the charge held by CP15. The feed to TP03's emitter circuit via RP27 provides a stable zener current to improve the regulation.

The driver stage is interesting as it employs a bootstrap circuit to ensure that the level of drive generated is adequate. The first transistor TP06 is an inverting amplifier: when it's on, the following transistor TP09 is off. In this condition DP08's cathode is at virtually chassis potential and the bootstrap capacitor CP07 will charge via DP36 from the 8·6V rail. During this time the switching transistor TP10 is also off. When the squarewave drive turns TP06 off, TP09's base voltage rises and it switches on. The negative side of CP07 is now connected to the 8·6V line via RP23 and TP09. Since CP07 is already charged to about 7V, its positive side is now at about 15V with respect to chassis. DP36 is thus cut off and the 15V appears at TP09's base via RP29. This ensures that TP09 is saturated throughout the time that TP10 is required to be conductive. When TP09's emitter voltage rises, CP08 charges via TP10's base, switching TP10 on. Diodes DP30, DP15 and DP16 conduct and limit the charge across CP08 to 2·1V. RP21 and LP02 in parallel provide some base drive current waveform shaping. When TP06 is switched on again to initiate the flyback, CP08's positive side is connected to chassis via DP08 and TP06 and TP10's base is driven negative.

The receiver's principal supply rail, from which the line output stage is operated, is the 104V h.t. line. When TP10 is switched off, the line output transformer is tuned by CP18 to produce the flyback. At the end of the flyback the efficiency diode DP13 begins to conduct and the first half (approximately) of the forward line scan is produced. TP10 can be turned on during this period, but it will have no effect on the line scan because of the isolating action of diodes DP10 and DP48. Thus TP10 doesn't drive the line output side of the circuit until DP13 stops conducting. At this point TP10 must be conducting in order to take over the supply of current to the line scan coils. The isolating action of DP10/48 enables TP10 to drive the chopper transformer before it also starts to drive the line output transformer. When DP13 switches off, the voltage at pin 2 of LP04 rises and DP10/48 switch on.

LP03 generates two secondary voltages during the flyback period. DP21 produces 22V across CP24 for the audio output chip while DP11 rectifies the output at pin 1. The cunning part of this circuit is that DP11 also serves as a boost diode, feeding pin 6 on the line output transformer

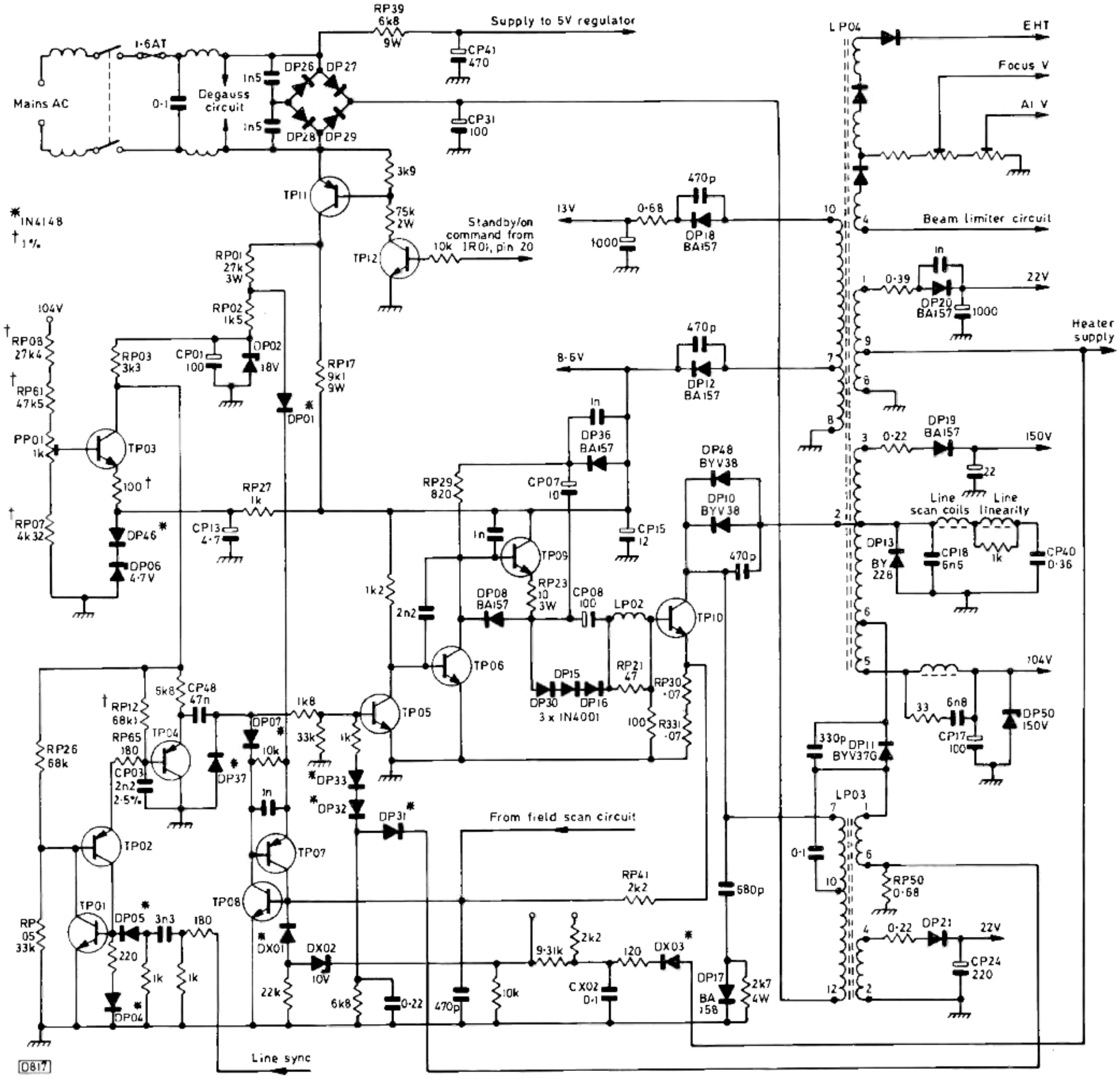

Fig. 4: Complete circuit of the power supply and line timebase sections of the chassis.

LP04. Autotransformer action between pins 6 and 5 of LP04 produces the 104V supply across CP17. No rectification is required at pin 5 as CP17 is the boost reservoir capacitor.

LP04 also produces various other supplies – the tube's heater supply, its e.h.t., focus and first anode supplies, 13V and 8·6V supplies, 22V for the field output stage and, from another overwinding on the primary, 150V for the RGB output transistors.

There are four protection systems in this circuitry. One guards against excessive voltages, which could cause the c.r.t. to produce X-rays; another guards against excessive current in TP10; a third (the energy limiter) prevents excessive current in the line output stage; the fourth protects the field scan coils in the event of the field scan coupling capacitor going short-circuit.

The shut-down circuit uses transistors TP08 and TP07 in a latching circuit that's identical in configuration to the oscillator TP01/2. Three inputs at the base of TP08 can trip the power supply. The first is via RP41 from the emitter of TP10. If TP10 passes excessive current, the voltage developed across RP30/31 will be sufficient to produce the trip action. A second input comes from the field scan current circuit. If the field scan coupling capacitor goes short-circuit excessive power will be dissipated in the scan coils. The trip action prevents damage here. The third input comes via DX01, DX02 etc., the source being the heater winding on the line output transformer. This circuit looks for excessive voltage conditions in the transformer. DX03 rectifies the heater supply and if the voltage developed across CX02 rises sufficiently zener diode DX02 switches on to initiate the trip action.

If TP08's base voltage rises because of an increase in any of these inputs, TP08 and TP07 will switch on and latch up. This action discharges CP01 via DP01. Thus the oscillator is stopped and the drive to TP10 ceases. When CP01 has been discharged, TP08 and TP07 will switch off. CP01 can then charge again, giving a soft-start action. If the problem was a transient one and has cleared, the reciever will resume normal operation. If the fault is a permanent one

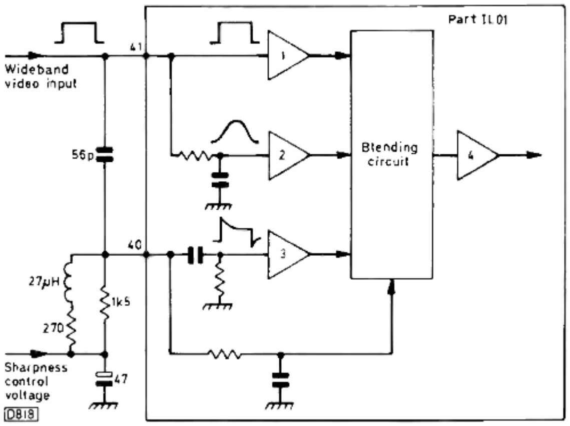

Fig. 5: Block diagram showing the operation of the sharpness control circuit.

however the power supply will trip continuously.

The fourth protection system, the energy limiter, monitors the voltage across RP50, which is connected between the earthy end of the winding on LP03 that supplies the line output stage and chassis. A rise in the current flowing in this winding, due to high current demand in the line output stage, will produce an increasingly negative voltage at pin 6. This negative bias is fed to the base of the pulse-width modulator transistor TP05, increasing its switch-on threshold. As a result it produces shorter drive pulses, reducing the power output.

Chopper power supplies operate by storing energy in the transformer as flux, releasing it during the off period of the switching device. It follows that the transformer's power output depends on the energy fed into it on the primary side. The input voltage is set by the peak value of the mains supply. The current that flows depends on the switching device's on time and the effect of back-e.m.f. in the transformer. Close regulation is achieved by adjusting the switching device's on period. The regulation loop in the TX80 starts with the 104V developed across CP17 and takes in the comparator, oscillator, pulse-width modulator, driver and output switching (TP10) stages.

Signal Circuits

We'll next take a brief look at the signal stages, most of which are incorporated in the M52038SP 52-pin processing chip IL01. This chip also incorporates the sync circuitry and produces field and line drive outputs. The latter is used to synchronise the oscillator in the power supply.

A Thomson tuner, type MTP-I-2021 for the u.h.f. bands only, is used. It features a dual-gate MOSFET r.f. amplifier stage and has excellent noise and gain figures. Tuning is effected by an integral phase-locked loop which is controlled by data and clock inputs from the microcomputer chip IR01 (42 pins this time).

Volume, brightness, contrast, colour and sharpness control are all carried out within IL01. An interesting item in this section of the receiver is VV01 which is in the circuit between the demodulated video output from IL01 and its luminance and chroma inputs. VV01 incorprates luminance and chroma separation filters, a chroma carrier trap and the luminance delay line.

Sharpness Control

The sharpness control system is another unusual feature, see Fig. 5. Full bandwidth video (luminance) is fed in at pin 41 of IL01 while differentiated video (video with a high degree of overshoot) is fed in at pin 40, which also receives the sharpness control voltage. The full bandwidth luminance signal passes via amplifier 1 to the blending circuit. An h.f. reduced signal is fed to amplifier 2 while the h.f.-emphasised (differentiated) signal is fed to amplifier 3. The control voltage acts on the blending circuit which combines the outputs from the three amplifiers in various proportions, from insufficient to excessive h.f. content at the extremities of the range with a flat response at somewhere about the centre of the range. The control works very well and can be used to good effect when playing video recordings or with satellite TV transmissions that are not all they might be. The sharpness adjusted signal then passes to the contrast control part of the chip.

Colour Decoding

The luminance output from IL01 is passed via a buffer transistor to the the c.r.t. base panel which contains the RGB matrixing and output circuits. Chroma signal decoding is carried out in the conventional way within IL01 which provides B − Y, G − Y and R − Y outputs.

Sync System

IL01 has a separate video input pin for the sync separator section. There's an external field sync pulse integrating network. The line sync pulses are fed internally to a phase-locked loop that controls a 500kHz master crystal oscillator. A five-stage binary divider (divide by 32) gives 15·625kHz. This divided down output is fed to the phase detector whose other input consists of line flyback pulses which are obtained from the line output transformer's heater winding (the pulses from this source are also used for several other purposes in the receiver).

The Field Timebase

The integrated field sync pulses are fed back into IL01 at pin 45. They are then shaped to produce trigger pulses that are used to reset the vertical counter circuit. This divides down the line frequency pulses to 50Hz. Each trigger pulse resets the counter and at the same time resets the field ramp waveform to zero. This ramp voltage is produced across an external capacitor by a constant-current source within IL01. The charging rate is modified by feedback from the LA7830 field output chip IF01 to provide fixed linearity correction. There's also a.c. feedback to provide height control and d.c. feedback to stabilise the d.c.centre point of the output from IF01.

The field output chip is operated in the conventional manner, with bootstrapping to obtain a peak-to-peak output of nearly twice the supply voltage. This ensures a rapid flyback during the field blanking period.

Audio Output Stage

The TDA2006 audio output chip provides surprisingly good results via the small, forward-facing 16Ω 2W elliptical speaker. A diode in the d.c. feedback circuit prevents excessive distortion on large output voltage excursions.

Microcomputer Control

In common with many other advanced small-screen receivers the TX80 uses a microcomputer chip, IR01, to oversee the set's operation and provide a menu-driven remote control system that's easy to follow. The operations performed by this chip can be classed in four groups as follows: (1) it provides pulse-width modulated user control outputs that are integrated by external *RC* filters to produce d.c. voltages for the signal processing chip IL01; (2) it carries out the usual key scanning to detect front panel input commands; (3) it accepts the IR remote control input, provides an I2C bus that's used principally to control the tuner, and carries out sync kill, mute, hold and reset functions; (4) it contains the system and character-generator clocks and provides graphics sync and RGB outputs.

Some Pin Functions

As previously mentioned, pin 20 provides the standby signal to toggle the power supply on and off. As there's no front panel mains switch in the initial models, this is the principal method of switching the receiver on and off. 3V at pin 20 = on, 0V = standby.

Pin 37 provides the sync killer output. This is used to defeat the sync separator circuit in IL01 during tuning operations and at switch on, to prevent spurious signals from triggering the timebases incorrectly and causing possible damage.

The mute circuit input at pin 36 is used during sweep or search tuning to tell IR01 when a valid video signal has been received. Sweep tuning is halted when this occurs.

The hold pin 34 is held high momentarily at switch off to preserve the analogue control settings in memory. This ensures that the receiver powers up next time with the previously-used settings. The reset pin 33 is held low for a short period at receiver power up to ensure that no spurious signals generated by the rising currents and voltages in the set are taken as valid commands by IR01.

The components connected to pins 28 and 29 tune the on-screen graphics read-out oscillator (pixel generator). Pin 27 takes in field sync for graphics while line sync is fed in at pin 26 (again from the heater circuit). The graphics outputs appear at pins 22-25, the latter being the blanking output that creates the black-box area in which the symbols or characters are displayed. The graphics blanking is mixed with line blanking from the heater supply then amplified, sharpened, clipped and sent to pin 22 of IL01.

Battery Converter

The 10in. model is ideal in size and performance for those on the move in caravans, coaches and lorries. It therefore has an integral battery converter to enable the receiver to be used away from mains supplies. The converter is set to operate with a 12V d.c. input and cannot be altered to work with any other voltage. The input can vary over the range 11·8 to 14·8V. It's a fairly basic d.c.-to-d.c. circuit, self-oscillating and running at about 17kHz.

In Conclusion

Although the TX80 is an intricate little receiver, packed with features, it has proved to be extremely reliable in service, not one being seen in the workshop since it started to be sold. It has but one minus point so far as the public is concerned, the rear-mounted mains switch on Models A10R and A14R. On the latest model to use the chassis, the A36R, the on-off switch is once again at the front.