TELEVISION

25p

SERVICING · CONSTRUCTION · COLOUR · DEVELOPMENTS

SEPTEMBER 1974

Modern TV POWER SUPPLY CIRCUITS PART 1

Also:

AUDIO ICs for TV

SERVICING the BRC 3000/3500 POWER BOARD

OPERATION of THYRISTOR LINE OUTPUT STAGES

TELEVISION

SERVICING·CONSTRUCTION·COLOUR·DEVELOPMENTS

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SETTING STANDARDS IN SERVICING

It is easy for us to become so engrossed in the technical side of television that we overlook the problems as the user experiences them. If you were a customer who knew nothing of the technicalities involved for example you would depend very heavily on the expertise of a service engineer when a fault occurs. In the case of colour the need for expertise is much greater.

There are variations in the standards of fault location and repair of course—it takes longer for one man than another to diagnose trouble correctly. An engineer may not make the correct diagnosis even, but it is important that he should. In a parallel but more critical situation there is public outcry when a doctor or surgeon makes the wrong diagnosis of a patient's disorder since life is at stake.

We like to think of the television set as another patient with a life. Though human emotions are much less involved the television set has a right to live from the day it is created, and to provide the pleasure for which the customer has paid.

We have heard reports of unqualified personnel setting up in business to "service" colour television sets without being able to follow even the most basic trading standards. If they get into a mess and can't cope the set is returned with the excuse that spares cannot be obtained! What can the customer then do but consult the established high street shop for help, only to be told that someone without any real knowledge of how the set works has been tampering with it?

It is a sad but all too common situation. It also creates an unfair image of the trade.

Some countries have taken steps to tidy up this problem. It is interesting to note for instance that West Germany has a register of qualified service engineers. This makes it almost impossible for sub-standard or clandestine firms to achieve the recognition or confidence of the public at large.

In the UK the Radio, Television and Electronics Examination Board has worked for some years to maintain servicing standards, in conjunction with the City and Guilds of London Institute. Now the Radio and Television Servicing Course is to be replaced by a Certificate of Competence in Colour Television Servicing.

Whilst such measures are commendable they remain very much a voluntary means of recognition and one wonders whether the standards of servicing skill will be high enough. There is also the problem of pay and conditions of employment, highlighted in recent correspondence. Coming back to the non-technical consumer, he pays for service and often complains. If the standards were made higher, perhaps with specialisation in products, the customer should have much less cause to complain. RCA have tried to go some of the way by offering servicing support facilities but so far there has been insufficient demand to keep them busy. Could this be a good omen?

—Editor

THIS MONTH

THE NEXT ISSUE DATED OCTOBER IS DUE FOR PUBLICATION ON SEPTEMBER 16

Cover: The unit shown in our cover photograph is the power supply board used in the Philips 320 chassis.

TELETOPICS

CTV SERVICING CERTIFICATE

The Radio, Television and Electronics Examination Board has since 1944 run the practical tests used in conjunction with the servicing courses of the City and Guilds of London Institute. The ability to pass these tests has come to be recognised as evidence of practical servicing ability throughout the trade. With the ending of the Radio and Television Servicing Course and the rapid growth in colour television the RTEEB has decided to establish a Certificate of Competence in colour television servicing. This will not be directly linked to City and Guilds courses. The test will be open to anyone who has passed the appropriate radio, television or electronics courses run by the City and Guilds of London Institute, to those in the forces who have qualified in an electronics trade and to mature candidates over 25 years of age, all of whom must have had at least twelve months experience in colour television servicing certified by their employer.

The test will comprise the location but not repair of five faults on at least two different colour chassis; convergence and preset control adjustments on another chassis; and in the case of candidates who do not hold the appropriate City and Guilds certificates a thirty minute written paper.

Successful candidates will be awarded a certificate which it is hoped will like its predecessors be recognised by the industry as evidence of competence in colour television servicing. A series of pilot tests is currently being held at Skills Centres of the Training Services Agency (the old Government Training Centres) and once the scheme has been validated the first test of a limited group of candidates for the certificate itself will be held. Further details will be announced at a later date.

MORE ON THE 20AX

Mullard have released further technical details of their 20AX in-line gun, slotted shadowmask, vertical phosophor striped screen tube which they now say is expected to be introduced gradually into production receivers towards the end of next year. Since the tube with its associated deflection yoke is self-converging no dynamic convergence assembly is required and the absence of this means that the tube is even shorter than the present 110° tubes. A static correction assembly incorporating four easily adjustable ring-shaped permanent magnets for adjustment of purity, raster symmetry and static convergence is clamped on the tube neck behind the deflection yoke. Depositing the phosphors on the screen in vertical stripes confers two advantages over the dot triad system. First, beam landing errors in the vertical direction have no effect on colour purity, simplifying adjustment. Secondly, the degaussing required in the horizontal direction is reduced. The degaussing coils are fitted above and below the tube instead of at the sides and the total degaussing requirement is reduced from 500 ampere-turns to 300AT (peak), enabling the material content of the coils to be reduced by 60%. The degaussing circuit is the same as that used with delta-gun tubes with the addition of an 0·1μF capacitor across the coils to short-circuit them at line frequency. In addition to the saddle-wound scan coils a four-pole toroidal winding to compensate for tolerances is mounted on the deflection yoke core.

PROJECTION TV DEVELOPMENT

One of the things that has made projection TV an expensive proposition is grinding and polishing the lenses required. Mullard Research Laboratories have now however developed a much cheaper and simpler precision moulding process involving the use of a glass base which carries a hard and durable plastic coating. The surface of the plastic coating is profiled to obtain the required lens characteristics and it is claimed that a more consistently accurate profile giving improved optical performance is possible. A number of lenses have been made using the process, including an aspherical corrector plate specifically developed for large-screen colour projection TV use.

REMOTE CONTROL SYSTEM FROM TEXAS

A couple of sophisticated integrated circuits which together comprise a remote control system for television receivers have been introduced by Texas Instruments. A complementary m.o.s. device, the TMS3835, is used for the control transmitter and has twenty channels. There are a number of analogue channels for the control of functions such as volume and brightness, and digital channels for station selection. At the receiver end a straight m.o.s. device, the TMS3700, is used. An i.c. has also been introduced for use with touch-sensitive tuners.

RELAY STATION OPENINGS

The following relay transmitters are now in operation:

Birch Vale (Peak Park area, Derbyshire) BBC-1 channel 40, ITV channel 43 (Granada programmes), BBC-2 channel 46. Receiving aerial group B.

Heyshaw (North Yorkshire) ITV channel 60. Receiving aerial group C/D.

Littleborough (Lancashire) BBC-1 channel 21, ITV channel 24 (Granada programmes), BBC-2 channel 27. Receiving aerial group A.

Marlborough (Wiltshire) ITV channel 25 (Southern Television programmes). Receiving aerial group A.

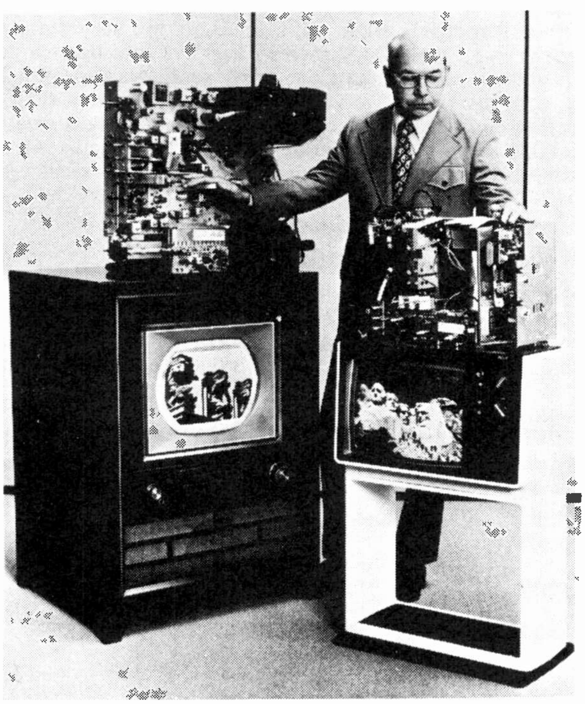
Morpeth (Northumberland) BBC-1 (NE Region) channel 22, ITV channel 25 (Granada programmes), BBC-2 channel 28. Receiving aerial group A. Note that the transmitting aerial of this station is highly directional, tailored to its particular service area. It is not intended to serve all those in sight of the transmitter.

Whitworth (Lancashire) BBC-1 channel 22, ITV channel 24 (Granada programmes), BBC-2 channel 28. Receiving aerial group A.

All these relay transmissions are vertically polarised.

COLOUR TV HISTORY

The accompanying photograph from RCA sums up the progress that has taken place in colour receivers since the commencement in the USA just 20 years ago of colour television transmissions to the RCA/NTSC standard. John Konkel who has been with RCA throughout is shown with RCA's first production model, the 15in. (round shadowmask tubes in those days!) console Model CT100, and their latest all solid-state XL100 chassis. Production of the CT100 started on March 26th 1954 when it sold for about $1,000 and employed a chassis using 37 valves. The XL100 chassis is to be used in what is understood to be the first all solid-state range of colour receivers to be introduced by a US setmaker. RCA have now gone over to exclusive production of all solid-state colour receivers—the last RCA valve set was produced at their Bloomington, Indiana plant last June 7th. The new XL100 chassis consumes 22·5-52% (depending on c.r.t. size) less energy than comparable valve sets.



The history of colour receivers—from RCA's first 1954 model to their latest all solid-state receiver.

It was 1967 before the percentage of homes in the USA with colour receivers reached the present UK level of 33% (UK colour transmissions started in late 1967—remember?). There was then what has been described as a slight hiccup in the US market before sales picked up again to reach 70% market penetration this year. This compares with 33% penetration in the UK, 24% in W. Germany and an astonishing 85% in Japan. It has been estimated that in 1975 42% of sets sold in the USA will go to first-time customers while 58% will be replacements.

In the UK a hiccup in the growth of colour TV has certainly occurred this year, with the number of sets delivered by UK setmakers during the first five months 13% down on 1973. This comes at an awkward time, with new plant coming into production. Monochrome production is also down—rather alarmingly so at 45%.

Whilst on the historic kick it is interesting to recall that Thorn/BRC adopted the all solid-state approach to colour right from the start in 1967. They were followed by Rank (Bush/Murphy) in 1969 and by Philips in 1970 with their G8 chassis which also introduced us to varicap tuners.

Looking ahead, Bernard Rogers of RRI predicted at a recent RTRA/RRI conference that three-dimensional TV using laser display techniques would be with us sometime during the next 10-15 years.

LATE SHOW NEWS

Another colour set fitted with an in-line gun c.r.t., this time from Korting. This 20in. model is fitted with a PIL tube and incorporates a chassis with 16 modules (11 direct plug-in) and a thyristor line timebase. ITT apparently have a 110° all-transistor colour chassis on the way.

Two new all-transistor 110° colour models, the 4000 and 5000, have been introduced by Bang and Olufsen. The single chassis is constructed on the modular principle with the aim of making field servicing particularly simple. A circuit feature is what B and O call PCT—permanent colour truth. The principle of this is understood to be that the three c.r.t. beams are monitored and balanced automatically at each field blanking interval.

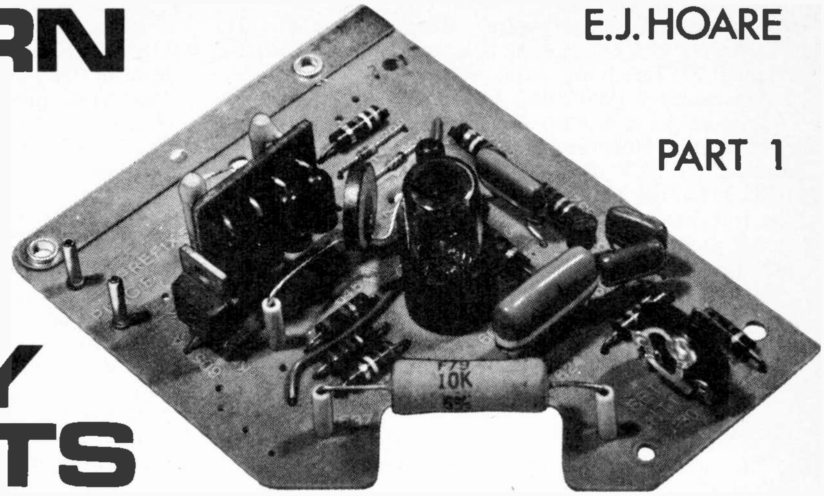
Next year's Radio and Television Trade Shows are again to be held in London hotels, the dates being May 18-22nd. There are plans for a move to an exhibition centre out of London—Birmingham's National Exhibition Centre—in 1976. The exhibition would be a combined radio/TV and appliances show.

Meanwhile Sony have announced the development of 22in. 120° and 20in. 122° versions of their Trinitron tube. And here's something that might cause confusion some time in the future: it is understood that Decca are to produce colour sets which will be marketed under the Telefunken brand name while GEC are to produce colour sets which will be marketed by Siemens.

OPTOELECTRONIC TV SET COUPLING

The use of an optoelectrical signal coupler to provide a socket outlet for TV sets—for connecting to a videotape recorder for example—with the necessary safety isolation is suggested by Hewlett-Packard who have introduced a range of couplers with the required electrical safety characteristics—tested for electrical leakage at 2·5kV for one second and rated as suitable for operation at 220V r.m.s.

MODERN TV POWER SUPPLY CIRCUITS



E.J. HOARE

PART 1

It was only a comparatively short time ago that the design of power supplies for most monochrome and colour receivers involved little more than routine care. The circuits were simple, usually consisting of a diode or two and one or more tapped dropper resistors for obtaining the appropriate h.t. and heater voltages. Matters have changed now and those days have gone for ever—or for at least as far as we can see into the future.

Most present-day receivers have stabilised h.t. lines and some use quite complex circuits. A great deal of care goes into the specification of all aspects of their performance, and the choice and detail design of circuitry has become a complex problem. Indeed the h.t. and l.t. supplies are now so closely bound up with the requirements of the line timebase that these two parts of a receiver have to be considered almost as one entity.

Clearly a great change has occurred in TV design and in these articles we are going to try to establish why this has come about and what new requirements have arisen. We can then discuss the detailed specification of a normal power supply, item by item, in order to highlight the factors and compromises that govern the choice of circuitry. Finally we shall see how the requirements are met in the case of a typical stabilised power supply design used in an up-to-date monochrome receiver.

Valve and Hybrid Receivers

To begin with let us consider the case of an all-valve receiver, or a hybrid one fitted with a mixture of valves and transistors. Hybrid chassis usually retain valves in the high-power and high-voltage output stages—particularly in the line timebase—with transistors used to varying extents in the small-signal and medium-signal stages. There are two key points to bear in mind when considering the power supply requirements. First, valves are good at handling comparatively high voltages. Even small-signal stages are happy up to about 250-300V, and it is not too difficult to design valves for stabilising e.h.t. voltages of 25kV. The second point is the problem of stabilising the field and line scan amplitudes against changes of h.t. line voltage caused for example by changes in mains input voltage. Once again valves give a satisfactory performance.

A line output valve for example will handle a high voltage at a sufficiently high power dissipation to enable the line scan amplitude to be stabilised by applying a control voltage to its grid. If the h.t. rises the extra power input to the line timebase is dissipated as heat in the output valve. In practice the stabilisation is not perfect, but the change in scan is reduced by a factor of about three times and this is adequate for all normal purposes—even in colour receivers.

Any voltages derived from the line output transformer will also be stabilised. If the field oscillator is supplied from the boost h.t. line for example the field scan will be stabilised and will track nicely with the line scan.

We thus have a tidy state of affairs and can adopt a high voltage/low current approach: the h.t. line does not need to be stabilised because the line timebase is stabilised instead. In the case of a monochrome receiver the h.t. can conveniently be in the range of 200-250V for a low-cost design. This leads to the very simple power supply circuit shown in Fig. 1. Note that since the power requirements are fairly small we can afford to drop quite a large voltage across R1 without dissipating enough heat to cause embarrassment in a small cabinet. This simple type of power supply circuit must have been used in millions of monochrome receivers over a period of many years.

Hybrid Colour Receivers

When we come to colour receiver design we have to consider the needs of the c.r.t. drive circuits. Remember that although the line and field timebases are stabilised in the type of circuit being considered the h.t. line is not. It will vary in sympathy with changes in the a.c. mains input voltage therefore.

If we assume colour-difference c.r.t. drive—this was almost universal practice in valve and hybrid receivers—the luminance signal will be applied to the three c.r.t. cathodes. With each individual c.r.t. the three drive

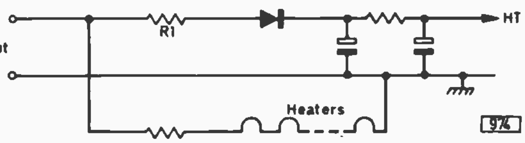


Fig. 1: A simple mains input circuit for monochrome receivers using valves.

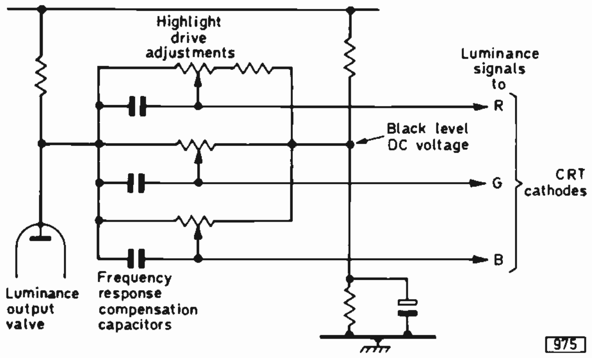


Fig. 2: Using this simple circuit, correct grey-scale tracking is maintained despite changes of h.t. voltage.

voltages will have to be adjusted in the ratios that give a correct black-and-white picture. This is the process of grey-scale tracking and a typical circuit for the adjustment of highlight tones is shown in Fig. 2.

Note that any change of voltage occurring at the anode of the luminance output valve—whether an a.c. or d.c. voltage—will be applied in the correct proportions to the c.r.t. Hence changes in level caused by changes in h.t. line voltage do not cause any discolouration of the luminance (black-and-white) picture: only a change in brightness level, which is usually acceptable. An unstabilised h.t. line, although not theoretically ideal, is capable of giving a satisfactory standard of performance therefore.

The colour-difference drives to the three c.r.t. grids come from three separate output stages—one each for R−Y, G−Y and B−Y. The only satisfactory way of ensuring that these three stages track together in the same way as the luminance drives is to clamp each signal to a predetermined level. Thus three high-voltage clamp stages are needed in addition to the three output stages. These ensure that changes in the h.t. line will have minimal effect.

For luminance drive a total voltage swing of the order of 170V from peak white to the tip of the flyback blanking pulses is required. The colour-difference drives, having both positive and negative values, need a larger swing however—usually in excess of 200V. Thus an h.t. line of the order of 250-280V is needed.

In a colour receiver the line timebase can also be conveniently driven from an h.t. line of 280V because high-voltage/high-power valves are available.

From the foregoing discussion we can see that in a valve or hybrid colour receiver it is permissible and convenient from an engineering point of view to use high h.t. values. In fact it was normal practice to use the highest h.t. line voltage that could be obtained by direct rectification of the peak of the mains input sinewave. The power supply circuit could therefore be the same in principle as was shown in Fig. 1. The value of R1 however was made as small as possible consistent with not exceeding the peak current rating of the diode at switch-on—the surge current into an uncharged electrolytic smoothing capacitor has to be limited in order to avoid damaging the diode.

We can see then that unstabilised h.t. supplies were a normal result of using valves in the high-voltage output stages. Any stabilising that was needed was carried out very cheaply in the line timebase itself or by clamp action. A stabilised h.t. line would have been an unnecessary expense and would have resulted in very little cost saving in other parts of the receiver. Thus what at first sight might seem to be a somewhat crude approach was in reality an example of efficient, cost-conscious engineering.

Solid-state Receivers

When we turn to the problems involved in designing an all-solid-state receiver we find that matters are radically different. Again the key issue is the performance characteristics of the active devices—the transistors.

Transistors do not like high voltages. The limit for high-power types is of the order of 1·5kV, which can be compared with 8kV or so for valves. If a certain critical voltage level is exceeded the result is instant death: there is no second chance.

The power dissipation level is also critical. Most of us have seen with dismay a valve anode glow red hot, only to find that the valve worked more or less normally afterwards. No one has ever seen a transistor glow red hot without it being totally destroyed in the process!

The result of these limitations is first that circuits have to be specially designed to take them into account and secondly that great care has to be taken to ensure that voltage and power limits are never exceeded—however briefly.

Transistor Line Output Stages

We have already seen that the line timebase plays a very important part in determining some of the key features of a receiver's design. Let us see how design is affected by using transistors in place of valves.

A line output valve or transistor is used as a switch. In the case of a valve in a stabilised circuit it is alternately switched between an off state (during the flyback) and a particular value of anode voltage during the forward scan. Thus a predetermined voltage is alternately applied to and then disconnected from the line output transformer primary winding. The steady-state voltage generates a sawtooth current in the anode circuit inductance during the scan: energy recovery and the generation of a large voltage pulse occurs during the flyback when the switch is turned off.

If a control voltage is applied to the grid of the valve the voltage across the primary of the line output transformer can be controlled at will—and thus the peak-to-peak amplitude of the scanning current. This means that the "switch" is never turned hard on, only partially so, and the resultant small anode voltage during the scan period causes appreciable power dissipation. The circuit has to be carefully designed so that good stabilisation of the scanning current is achieved without exceeding the voltage or power ratings of the line output valve.

Unfortunately the same kind of circuit cannot be used with transistors—at least not at the present state of the art. One of the reasons is that line output transistors capable of switching high voltages and high currents cannot be made to switch off as quickly as valves. Or to be more precise, if you take a sample batch of a particular type of transistor you will find that some transistors switch off quickly whilst others switch more slowly. The high voltage and currents present in the collector circuit cause a large heat dissipation in the junctions of the slower switching transistors.

An electronic circuit which is going to be mass produced must be designed to take into account worst case conditions. Thus a transistor line output stage must be so designed that the power handling capability of the small proportion of line output transistors with slow switching speeds and consequent high collector dissipations is catered for.

Present day types of transistor are in practice limited to collector dissipations of about 10W. Thus even with fast switching more than one transistor would be required to obtain the power handling capability needed in a line timebase of the type used with valves.

We have to face up to the fact therefore that a stabilised line scan is needed but that this cannot be carried out in the line timebase itself. Incidentally the reasons for wanting a stable scan current and e.h.t. voltage are twofold. First because viewers have learnt to expect their pictures to remain of a constant size regardless of changes in mains voltage—it is particularly useful to have this stabilisation at times of power cuts. Secondly and perhaps more importantly good convergence can be maintained only when the scan current remains reasonably constant. Small changes of picture size are permissible, but larger ones cause convergence errors. They can be corrected of course, but it is hardly practicable to do this every time the mains voltage changes!

Importance of HT Stabilisation

In all-solid-state receivers then the only way to stabilise the line and field scans is to stabilise the h.t. line from which the scan currents are derived. This gives a number of subsidiary advantages but as we shall see later there are some unexpected difficulties as well. There is also an increase in cost.

The advantages are fairly obvious. Transistors of a given type have quite large variations—or "spreads"—in their performance characteristics. Furthermore as we have already seen they are prone to instant death if critical values of collector/emitter voltage or collector dissipation are exceeded. This means that transistor circuits must always be very carefully designed to have large safety factors to ensure that the prescribed limits are never exceeded, however briefly.

If the h.t. or l.t. voltages can rise when the mains input voltage increases this clearly has to be taken into account when choosing the safety factors. They have to be larger than for nominal input conditions.

Conversely it becomes much easier to design transistor circuits if it is known that the supply voltage will remain substantially constant. This is particularly the case when integrated circuits are used. These have an input current spread for a given operating condition of typically two to one. If the supply voltage is not stabilised it is likely to vary by $\pm 10\%$ with changes of mains voltage. When this is added to the i.c. spreads life can become rather difficult for the designer.

Supplies to individual i.c.s can be stabilised by using zener diodes, but this adds to cost and circuit complexity. The importance of stabilising the input voltage of integrated circuits lies in the fact that many i.c.s are d.c. coupled to the following circuit. Part of any change of input supply voltage is usually transferred to the output, and the d.c. level of the output will thus vary in sympathy.

To take a typical case, in a monochrome receiver the video output of a jungle (or video processing) i.c. is usually d.c. coupled to the base of the video output stage. Any change of supply voltage will alter the d.c. level of the signal and hence the black level. Thus large changes of picture brightness would occur in an unstabilised receiver with changes of mains input voltage.

A further advantage of stabilising the h.t. line is that depending upon how this is achieved there may be a substantial saving on heat dissipation in the receiver. In an unstabilised set a $+10\%$ change in mains input voltage causes a 10% increase of both voltage and load current, i.e. a 20% increase in total power dissipation. Bearing in mind that the reliability of nearly all components is seriously affected by any increase in operating temperature it is clearly highly desirable to avoid any extra heat inside the TV cabinet.

This is particularly important for another reason. All modern receivers manufactured in this country are being designed to comply with the requirements of the British Standards Safety specification BS415:1972 (see TELEVISION, March and April 1974). If heat generating components produce 20% extra heat dissipation when the mains voltage is at its $+10\%$ limit then the precautions against overheating of printed boards etc. are going to be correspondingly more difficult to provide. This extra amount of heat may cause the threshold to be crossed whereby a simple problem becomes a difficult one.

Power Supply Specification

From the foregoing it can be seen that stabilising the h.t. supply confers important advantages on the performance of the receiver, and upon the task of the designer. Having said this, the next question is what sort of stabilising technique should be adopted? What are the factors that govern the choice? In short, what is the complete specification of such a power supply? It is impossible to make an intelligent choice until all aspects of the requirements have been considered and given due weight. Let us take each item in turn.

The HT Voltage

To begin with, what h.t. line voltage do we have to design for in an all-solid-state receiver? In the case of a valve or hybrid receiver the choice was simple. Valves are available specified, designed and manufactured to operate with an h.t. line of about 280V. This can be obtained very simply by direct rectification of the incoming a.c. mains supply.

In an all-solid-state design the choice of the main h.t. line voltage is governed almost entirely by the characteristics of the line output transistor. There are several different types available, but a typical example has a maximum collector/emitter voltage rating of 1,500V. This value must never be exceeded except when a c.r.t. flashover occurs—the instantanious limit is then 1,700V. So do we design the line output circuit with a peak flyback voltage of 1,500V? The answer is no, because this is an absolute limit never to be exceeded except during a flashover. We must also take into account any variations that can occur in production or during normal use.

We begin by considering spreads of h.t. voltage. It has to be assumed that in a few cases the h.t. voltage will be incorrectly set. It may be perhaps 3% too high. This is an arbitrary figure but probably not too wide of the mark. We must also assume that it will vary somewhat with changes of a.c. input voltage. Say another 3%. It is also highly probable that over a period of many years component ageing may result in the h.t. voltage drifting upwards by a further 7%. All these changes may occur in the downward direction of course, but the designer must cater for the worst case.

Now consider the production spreads of the line output transformer, its associated components, and the deflection coils. These may cause the peak flyback voltage to vary by ±10%. Another factor to take into account is that if the picture is not synchronised the line oscillator will be running free and completely uncontrolled. If it slows down, the peak line output transformer currents will rise and the peak flyback voltage will also rise. We must allow for an increase of 10-15%.

These tolerances can be added up in a variety of different ways depending upon the statistical basis used. In a typical case however we can expect a nominal flyback peak voltage of 1,100V to be chosen. It will then be safe to assume that the transistor limit of 1,500V will never be exceeded unless some unexpected and fairly drastic fault occurs.

If we then decide upon a flyback time for the line output circuit of 11-12μsecs the choice of h.t. line voltage is settled. A peak flyback of 1,100V in conjunction with a flyback time of 11-12μsecs means that the h.t. supply has to be of the order of 140V. There will be a flashover protection resistor in series with the supply to the line transformer however—this limits the peak current and voltage after a flashover occurs. The voltage drop across this resistor means that the smoothed h.t. line must be about 160V, which is what the stabilised supply must provide.

Having decided upon the line timebase h.t. supply we have to consider what other h.t. voltages are needed in the receiver. Most all-solid-stage designs use RGB drive to the picture tube because this needs a lower h.t. line than the colour-difference drive technique. This fits in better with the needs of the line timebase and makes the choice of drive transistors easier and less costly. 160V is barely adequate even for RGB drive however. Something has to be skimped a bit somewhere, and 180-200V is a much better choice for normal types of colour c.r.t.

One way of overcoming the conflicting needs of the video drives and the line timebase is to use the "anti-boost" technique shown in Fig. 3. The 40V l.t. supply derived from the line timebase for the sound and field output stages can be added underneath the line output stage. The h.t. supply required then becomes 160+40=200V and both parts of the circuit get the h.t. voltage they need.

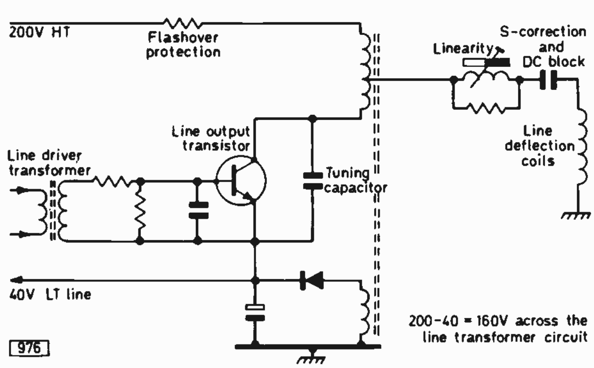


Fig. 3: Simplified transistor line output circuit using the anti-boost technique.

We have discussed this matter of line timebase h.t. supply in some detail partly because it is the key factor and partly because it illustrates the way in which a design engineer has to approach a problem of this nature. It is the engineer's job to foresee what may happen to his circuit in practical circumstances and over a long period of time, and to act accordingly. Any temptation to use book data at its face value in order to make the design process easier has to be sternly resisted. The design engineer must protect the best interest of the customer he serves.

HT Current

The current drain from the power supply does not usually present any particular problem. In a monochrome receiver it will usually be of the order of 0·3-0·4A and in a colour receiver it will more likely be 0·5-0·8A.

It is desirable to keep the current as small as possible. There are two main reasons. A low current means a low value of total power dissipation and hence less heat inside the cabinet. This reduces the design problems and improves the reliability. The second reason concerns the h.t. smoothing arrangements.

With a low current a larger value h.t. smoothing resistor can be used for a given voltage drop across it. This in turn enables a smaller value h.t. electrolytic smoothing capacitor to be used. Electrolytics are very expensive and a reduction in value can save appreciable cost—in addition to the saving in space and weight. Large electrolytics mounted on a printed board can sometimes result in cracks in the board if there is rough handling in transit.

Quality of Stabilisation

When designing any equipment it is important to be quite clear about the standard of performance you *need* in order to obtain a satisfactory product. In rare cases this standard is impossible to achieve and a compromise has to be accepted. In other cases it can be obtained quite easily and the engineer then has to make a careful choice between different circuit techniques in order to get the right overall performance at the lowest cost.

In the case of a stabilised h.t. line it is tempting to say that only the best is good enough and that we should aim at near perfect stability with changes of mains input voltage. In practice we can permit variations of about ±3% without significant ill effects. This should be maintained over a range of input voltage of ±10%, so the improvement factor is 3·3:1·0. If it so happens that the circuits available to us give a better standard of performance without any increase in cost this is a bonus which we shall accept gratefully.

HT Source Impedance

We must also take into account the effect of changes of load current upon the h.t. voltage produced by the power supply. Another way of describing the same problem is to specify the required source impedance of the h.t. line. Do we want it to be high, low or of some specified value?

To clarify this point a bit suppose that the load current increases by say 50mA and the h.t. voltage drops by 5V. The source impedance of the h.t. supply at its normal operating condition is given by $R=E/I=5\div 50/1000=100\ \Omega$. So the source impedance tells us how the h.t. supply will behave when changes of load current occur. The same supply may of course have a different source impedance if we use it to give a much higher or a lower load current. We quote the impedance at a particular working point.

Breathing

The choice of source impedance depends upon the phenomenon known as "breathing". This is the effect when the size of the picture changes as the brightness, or total beam current, changes. Suppose the brightness is turned up: the beam current increases, the e.h.t. falls due to the voltage drop across its own internal source impedance and so for a given scan current the picture size increases.

If the e.h.t. source impedance is 5MΩ and the beam current in a monochrome set increases from 0 to 300μA the e.h.t. will fall by $E=IR=300/10^6\times 5\times 10^6=$ 1,500V. If the unloaded e.h.t. is 18kV the fall of 1·5kV is 8·4%. The picture size will therefore increase by half this, i.e. 4·2%. This is quite a large change and the effect is easily visible—indeed somewhat obtrusive.

The way to overcome this difficulty is to build some source impedance into the h.t. supply. An e.h.t. current drain of 300μA at 18-1·5=16·5kV is equivalent to $16{,}500\times 300/10^6=4{\cdot}95$W. If we can choose an h.t. source impedance such that a power drain of about 5W results in the h.t. voltage falling sufficiently to reduce the scan by 4·2% we shall achieve perfect compensation and the breathing will in theory be zero.

In practice matters are a little more complicated. The drop in h.t. causes an extra fall in the e.h.t. This causes a degradation of picture spot quality, showing up as less good focusing. So, as is often the case in engineering, a compromise has to be accepted. An h.t. source impedance in the range of 100-200Ω gives a good result in the case of a monochrome receiver. A somewhat lower value is appropriate in colour receivers because the change in h.t. load current is much larger due to the higher value of c.r.t. beam current. An impedance of about 40Ω is probably typical of good practice.

BEAB Requirements

In order to obtain certification under the BEAB safety scheme it is necessary to submit models of a receiver for checking so as to prove compliance with the requirements of BS415:1972. The choice of power supply may well depend upon the cost of the precautions that have to be built into the receiver in order to pass these tests. There is a large number of safety requirements of course—these were outlined in the articles referred to earlier. One of the more important and comprehensive tests is to short-circuit and open-circuit each component in turn: this includes all electrodes of active devices.

In the case of a power supply the question that has to be asked is: if any single component fails can the h.t. rise to an unsafe level that causes any component anywhere in the receiver to overheat? In addition, do the resulting high voltages in the receiver cause any insulation to be inadequate? Also, can X-ray radiation limits be exceeded? When producing a power supply specification we have to stipulate that it must, at an economic cost, provide overvoltage protection that takes care of these requirements.

Heat Dissipation

We have already referred to the difficulties caused by excessive heat dissipation. When choosing a power supply circuit one of the more important factors to be considered is how much heat does it generate? There is no simple answer to this question because it depends upon the size of the smallest cabinet in which the chassis will be incorporated, the amount of ventilation provided, the form of the chassis structure (whether horizontal or vertical), the types of heat sensitive components used, and the skill of the designer.

Clearly extra heat causes all sorts of problems, one of which is its effect on heat sensitive components in the power supply itself. It is no good designing a power supply which is very stable on the bench if it is found afterwards that the h.t. voltage drifts upwards or downwards as the circuit heats up inside the TV cabinet. To overcome this problem special quality components may be needed, or a suitable compensating network may have to be added—at extra cost.

Disturbances on the Mains Supply

We must specify of course that the power supply will be satisfactorily immune to effects caused by disturbances on the incoming mains input voltage. This may appear to be a fairly minor problem and many viewers will be quite unaware that it even exists—apart from the occasional flicker caused by a switching operation on the mains distribution network.

In point of fact there are two types of disturbances and although they do not occur very often it is important to take them into account when choosing or engineering a power supply. One type consists of short bursts of a few cycles of a signalling waveform at a frequency of a few hundred hertz and an amplitude of up to 20V. These signals are used by the electricity authorities in a few areas of the country for remote control of unattended equipment. They usually cause a small momentary increase of the h.t. voltage.

The other type of disturbance consists of high-voltage spikes superimposed on the normal 50Hz sinewave. These spikes are of exceedingly short duration—in some cases of less than five microseconds—but they can exceed 1,000V above earth potential. They are caused by switching surges on the high-voltage mains distribution network, or occasionally by some form of lightning discharge.

Clearly voltages as large as these spikes are capable of passing through most types of stabilising networks and of causing surges on the h.t. line. These may in turn trip overvoltage protection circuits and shut down the h.t. supply.

Generating Interference

Any circuit that stabilises the h.t. voltage by some sort of switching operation—such as switch-mode or thyristor supplies—generates high-order harmonics of the fundamental switching frequency. These may interfere with the operation of the receiver itself and may also be fed back into the mains supply to interfere with neighbouring receivers.

Interference within a receiver may require a variety of precautions, such as careful layout of components to reduce to a minimum the size of loops carrying the switched currents. The power supply and synchronisation circuits may have to be spaced well apart, and great care is usually needed in designing the earth paths of all the circuits involved. In some cases it may be necessary to resort to screening, but this is expensive and bulky and sometimes an admission of defeat—or indicates the wrong choice of circuit technique.

The injection of interference into the mains is another problem. Apart from harmonics of power supply switching there will also be harmonics of the line output transistor switching. All these harmonics get picked up on the mains input leads and any components connected to them. Once again it is important to avoid loops in the input wiring, and any common earth paths. Any h.t. or mains dropper resistors should be spaced well away from the line timebase and the paths of switched currents should be kept as short as possible.

These precautions are seldom adequate on their own and nearly all receivers have a capacitor connected across the mains input to bypass interfering currents. Note that this capacitor has to be a special quality component capable of standing up to the full mains input voltage indefinitely.

Acceptable limits of mains born interference generated by a receiver are specified in British Standard Specification BS905, together with details of measuring techniques.

Cost and Complexity

We have left cost and complexity until last because up to a point it is almost too obvious to be worthy of mention. It is the engineer's duty to the society in which he lives to design equipment which represents the best possible compromise between cost and performance. The customer cannot judge this—or at least he can do so only in the vaguest terms—thus the engineer has to do it for him.

Obviously commercial motives such as profit making enter into this matter, but the fact remains that the engineer has a duty to perform, and in general he discharges it well.

The object of the kind of specification we have been drawing up—and the reminders of difficulties that lie ahead for the designer—is to provide the right guidelines to enable the appropriate compromises to be correctly chosen.

The engineer is always tempted to choose the circuit which has the best performance, regardless of cost, but he knows of course that he cannot do this. It would be the easy way, but it cannot be adopted: he has always to balance performance against cost. If a higher standard of performance does not benefit the customer significantly—and there are plenty of examples of this—then a simpler and cheaper circuit is the right choice.

Greater circuit complexity does not always increase cost, though it usually does. In any case extra complexity should be avoided wherever possible. An increase in the number of components usually reduces the overall reliability of the equipment and may make the task of the service engineer a lot more difficult.

Thus other things being equal a cheaper, well known and simpler circuit is to be preferred to a complex, new and more costly one which appears to have a slightly higher standard of performance. It is instructive to bear in mind that one of the best cars in the world uses well proven techniques engineered to a very high standard.

Continued next month

CCTV

PART 6

Peter Graves

Most CCTV equipment in this country operates on a 625-line, 50Hz field rate system though there is still a fair amount of 405-line, 50Hz field rate equipment about. For reference, Table 1 shows the comparison between the standard scanning systems in common use. Other standards may occasionally be encountered for special purposes—a very high resolution camera for instance may use over 1,000 lines.

At this stage it is important to distinguish between *field* and *frame*. In practice the two terms are often used as if they were synonymous and for many purposes the distinction is not important. In this and subsequent articles we shall take a 625-line, 50Hz field rate system as our example. In this system the time of one frame is the time taken to transmit 625 lines, i.e. the time for the scanning beam, initially at the start of the raster, to return to that position. One complete frame of information has then been transmitted: only about 585 lines convey useful information to the viewer however as the remainder occur during the vertical blanking period and are suppressed.

In standard television practice the frame is scanned in two halves or fields (we shall see how this is done later). This "cheats" the eye into thinking that the picture is flickering faster than the actual frame rate. If, for a simple example, a light is flashed on and off at a variable rate it is found that above a certain flash rate (the *critical flicker frequency*) the eye can no longer distinguish individual flashes and interprets the flashing light as being continuous. The exact critical frequency depends on a number of factors such as the brightness

Table 1: Comparison of Standard Scanning Systems

System	Field frequency (Hz)	Line frequency (kHz)	Twice line frequency (kHz)
British 405 lines	50	10·125	20·250
American 525 lines	60	15·750	31·500
British 625 lines	50	15·625	31·250
French 819 lines	50	20·475	40·950

Notes:

(1) For a 2 : 1 interlaced picture, frame frequency = ½ field frequency—e.g. for a 50Hz field frequency the frame frequency is 25Hz.

(2) $$\text{Field or line duration} = \frac{1}{\text{Field (or line) frequency (Hz)}}\ \text{seconds,}$$

e.g. at 50Hz the duration of one field $= \frac{1}{50}$ seconds $=$ 20mS.

of the light, the ratio of the on to the off periods and variations between individual observers. This characteristic of the human eye is exploited in motion pictures as well as television and for television use it is found that a flicker frequency of about 45 flashes per second is sufficient for a series of discontinuous fields to be interpreted as flicker free and continuous. The low flicker rate (about 16 flashes per second) of the early motion pictures was what gave then the name "*flicks*".

The use of fields exploits this effect to double (in a 2:1 interlaced system—see later) the picture repetition rate (i.e. the flicker rate) without increasing the bandwidth substantially. A similar method is used in projecting films where each frame is flashed on to the screen several times by means of a multibladed shutter so that the flicker frequency is increased without increasing the number of frames that need to be shown —an important economic consideration.

Interlaced Scanning

For 2:1 interlace (the most common method—2 fields make 1 frame) the two fields are called the odd or primary and even or secondary fields. Odd simply means that in this field the odd numbered lines if numbered sequentially from the top (ignoring the half line) are scanned. Fig. 1 shows how a 5 line, 2:1 interlace picture is made up: the even field follows the odd field to make up a complete frame. The odd field is then scanned again to start the next frame. This is not the only way of obtaining a 2:1 interlaced picture and Fig. 2 shows one of the alternative methods. The disadvantage of this method is that additional information must be transmitted to ensure that the field flyback returns to the correct place at the end of each field since electrically speaking the end of the odd field is identical with the end of the even field. Extra circuits are needed to process this information.

Additional information is not needed for the scanning method illustrated in Fig. 1—the ends of the fields are electrically dissimilar as there is a half-line period at the end of the odd field and a full-line period at the end of the even one. The positions of the field sync pulses, one in the middle of a line, the other at the end of a line, ensure that the beam is returned to the correct position each time.

Whatever method is used each frame is "flashed up" on to the monitor screen in two parts. If the entire frame was scanned line by line from top to bottom—i.e. *non-interlaced* or *sequential* scanning—there would be only one "flash" per frame. To double the flicker rate with this system would necessitate transmitting twice as many frames per second and this would entail a large increase in the bandwidth required—undesirable both technically and economically. The advantage of a 2:1 interlaced picture is that it has twice the flicker frequency of a sequentially scanned picture of the same frame frequency. As examination of Fig. 1 will show, a 2:1 interlaced scan must have an odd number of lines—Table 1 shows that all the standard systems follow this practice.

There is no reason why an interlace of 3:1, 4:1 or more should not be used, further increasing the flicker frequency, but complicated circuits would be needed to sort out the various fields. It is found that a 2:1 interlace with its simple circuitry combined with 50Hz (60Hz in America) field frequency gives an acceptable flicker rate.

Cameras used for specialized work may be scanned

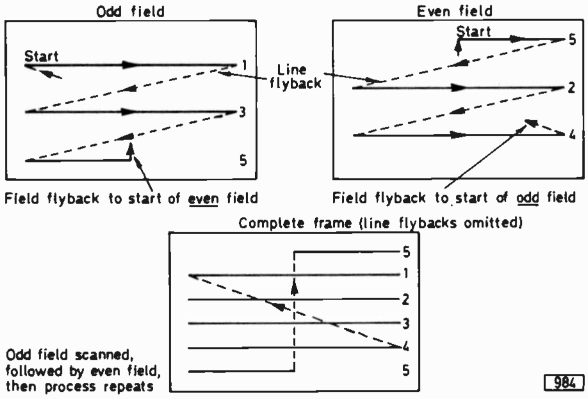


Fig. 1: 5-line, 2:1 interlaced system, showing the build up of the frame from two fields.

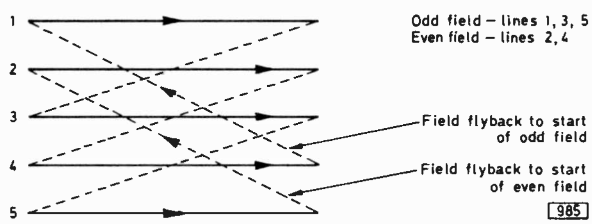


Fig. 2: An alternative method of scanning with a 5-line 2:1 interlaced system.

sequentially and have no interlace. For instance the space craft cameras used to send back pictures of the other planets store the video information on magnetic tape and send it back to Earth at a very slow rate (a frame may take minutes rather than milliseconds) in order to conserve transmitter bandwidth. No interlace is necessary as the picture is not viewed until it has been reassembled.

The field frequency is the same as the local mains frequency. This is not a necessity—clearly not so in the case of mobile equipment which (for general purposes) uses a free-running oscillator at about 50Hz so that a modified camera is not needed. However in monitors (or broadcast receivers) that are powered from the mains—as most are—there are many ways in which stray a.c. can get into the signal circuits (e.g. poor smoothing capacitors, pick up, etc.). If the monitor is not locked to the mains any hum bars (broad horizontal bands caused by modulation of the signal by the a.c.) will drift up and down the screen as the relative phases of the vertical oscillator and the mains vary. This is extremely distracting to the viewer and may cause false triggering of the vertical oscillator, giving rolling or jumping pictures. If the vertical oscillator is locked to the mains the oscillator and the mains have a constant phase relationship and any hum bars will be stationary and their annoyance value considerably diminished.

Sync Pulses

While discussing basic terms it is worth noting that confusion can arise over the term synchronising (sync) pulse. It can be used in two senses, first to describe the pulses which are added to the video output signal and are used to synchronise the monitor (strictly these are "monitor sync pulses" and are only added in the camera for convenience), and secondly to describe the pulses fed to the camera to synchronise the line and field oscillators. In this latter case they are often referred to as *drive pulses* or *drives*. It is usually clear from the context how the term sync pulse is being used.

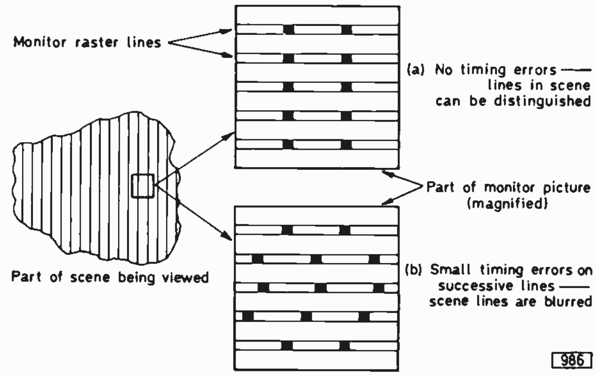


Fig. 3: Small timing errors result in detail in the scene viewed being indistinct.

Resolution

It may not be immediately apparent that the resolution of the camera (its ability to discern fine detail) depends on the accuracy with which the vidicon target is scanned. Suppose that the camera is viewing a scene consisting of fine, vertical lines (Fig. 3). The magnified sections on the right show successive lines on the monitor (which is assumed to be perfect) fed from the camera. The upper section (a) shows no error in the line scan timing. The lines in the scene can thus be discerned. The lower section (b) shows the effect of small timing errors on successive lines—the effect of these errors is that the lines are slightly displaced. In consequence the lines in the scene will not be seen—there will be just a blur. In the case of a fine line structure the errors need only be of the order of fractions of a microsecond to produce an unresolved blur. This illustrates the need for stable, accurate scanning in order to get optimum pictures. Large objects, say the side of a house, will have a ragged edge if timing errors are present—only fine detail will be completely lost. A compromise must be made however between technical excellence and cost—a simple camera used for shop lifter detection may cost £150 whereas a sophisticated camera with a built in sync pulse generator for providing high-resolution pictures from a microscope may cost £1,500!

Camera Drive Pulses

The more complicated cameras are designed to be able to work with a variety of drive pulses. The complication of the circuits is caused by the cross-linking necessary to route the pulses to the correct circuits. Some drive modes employ pulses supplied from an external source; in another mode the pulses are developed by the camera circuits. The mode selection links are semipermanent (e.g. soldered links) since the operating mode is seldom changed. Great care should be taken when changing links to ensure that the correct links and the correct links only are changed—check against the manufacturer's information. It may be necessary to add or remove terminating resistors

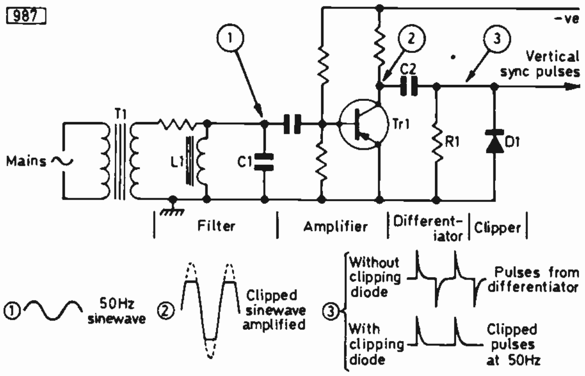


Fig. 4: Method of deriving the field drive pulses from the mains.

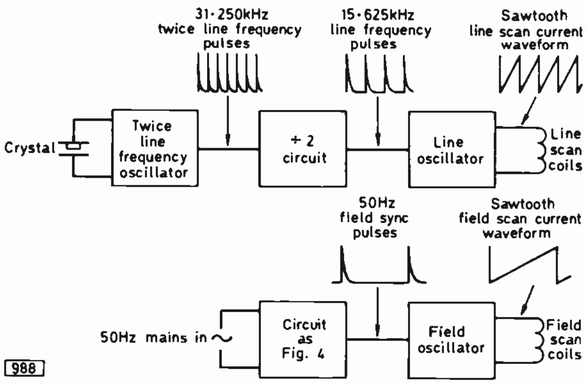


Fig. 5: Block diagram of a camera operating in the random interlace mode.

for external drives when changing to an alternative mode. We shall be comparing the various methods of driving a camera in later articles.

However the drive pulses are derived the camera requires two sets of pulses, one to drive the vertical oscillator and the other to drive the horizontal oscillator —in the last analysis a free-running oscillator is one which provides its own drive pulses. The two sets of drive pulses may have some timing relationship or there may be none. They may be generated entirely externally to the camera, entirely internally, or by a combination of these two techniques.

Random Interlace

For simple (particularly single camera) operation in non-critical applications the *random interlace* mode is used. This is by far the simplest method of driving a camera: all the pulses required, including the blanking and sync pulses for the video output, are generated inside the camera.

The pulses to drive the field oscillator are derived from the mains, or a free-running oscillator may be used. Fig. 4 shows how suitable pulses at mains frequency can be derived from a low-voltage secondary winding on the mains transformer (T1). The low-voltage (approximately 5-10V r.m.s.) a.c. input is fed through a low-pass filter L1, C1 which removes the higher harmonics of the mains frequency (100Hz, 150Hz, etc.) which could cause false triggering of the field oscillator. This is followed by a simple common-emitter amplifier using transistor Tr1 which is deliberately overdriven so that the top and bottom of the sinewave is clipped to give an approximate squarewave. The time-constant of the following *CR* circuit (C2, R1) is chosen so that the squarewave is differentiated to give the pulse waveform shown. Clipper diode D1 removes the pulses of unwanted polarity depending on which way round it is connected—in some cases the unwanted pulses will have no effect on the following circuit and D1 can be omitted. Cheaper equipment may also omit the filter L1, C1.

The line oscillator (see Fig. 5) is free-running and except for the power supplies completely separate from the field oscillator. It is usually a blocking or crystal-controlled oscillator (circuits and details of operation next month) running at twice the line frequency (31·250kHz instead of the 15·625kHz expected with a 625-line system) and is immediately followed by a divide-by-two circuit. This may sound illogical but if the camera is required to operate in other modes a twice line frequency output is necessary and this arrangement avoids the need of a selection of crystals or fiddling round with the frequency-determining components. Fig. 5 shows a block diagram of a camera operating in the random interlace mode for comparison with other modes as they are covered.

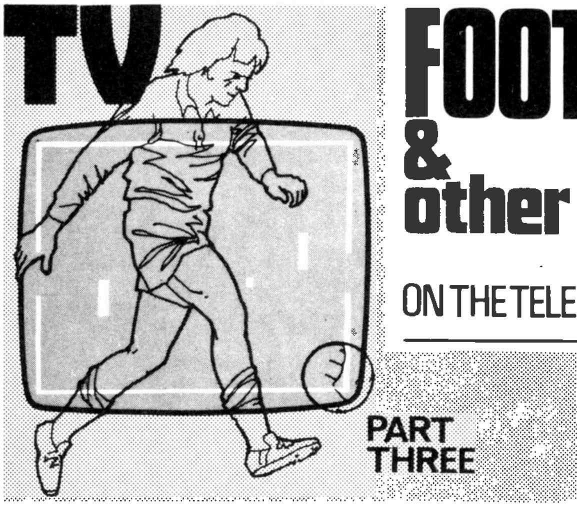
In this mode there is no relationship between the line and field oscillators, i.e. they are not locked together or mutually synchronised in any way. Each field consists of about the expected number of lines but the lines in successive fields do not have the exact timing relationship necessary for 2:1 interlace. If interlace is achieved it is a transitory thing and purely coincidental! Hence the term random interlace.

A characteristic feature of random interlace operation is a flickering white bar that appears along the bottom of the picture displayed on the monitor—the *interlace bar*. This is apparently due to charge build up on the target layer. It is difficult to eliminate it completely without increasing the complexity of the circuits —which defeats the simplicity and cheapness of this method. The amplitude of the bar and hence its annoyance value depend on tube type and age. It can be minimised by careful attention to the setting up, particularly the beam alignment. The usual "cure" is to increase the monitor height setting and thus drop the bar behind the monitor tube mask.

Despite its apparent crudity the random interlace system is widely used—in fact many cameras are designed to work in this mode only. It is simple, cheap and reliable. The resolution is not all it might be, but for many purposes (and this is the real criterion) it is found to be adequate. If two or more cameras are used their oscillators will be working independently and switching between them may result in monitor picture roll or break up until the monitor sync circuits have settled down to the new set of sync pulses. To overcome this or to allow pictures from separate cameras to be mixed together some form of inter-camera synchronisation is necessary.

Derivation of the sync and blanking pulses for the video output from the line and field drive pulses is common to the random interlace mode and synchronised modes and a discussion of the circuits used will be left until a later article. Next month we shall be looking at basic pulse generator circuits—and at how to make a bistable circuit divide by some factor other than 2!

TO BE CONTINUED



TV FOOTBALL & other GAMES

ON THE TELEVISION SCREEN

P. BUSBY* B Sc

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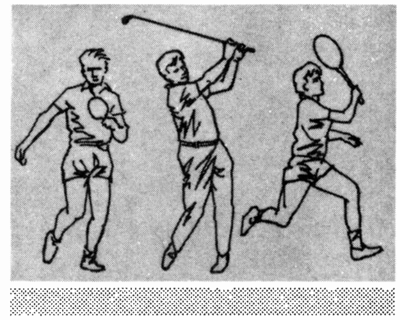


THIS month we deal with the ball control circuits for a simple TV game. Readers wishing to construct the more sophisticated football game to be described in a later part should nevertheless read through this article as the basic principles involved in both games are similar.

The Simple Game

The simple game can best be described as tennis with a remote-controlled ball. The ball travels with a constant velocity component in the horizontal direction and interception by a player reverses its horizontal velocity. The vertical component of the ball's velocity is controlled by the knob on the top of each joystick. Once a player intercepts the ball he will have sole control of the ball's direction which he can change in flight. Once his opponent intercepts the ball however the horizontal velocity component will be reversed and control of the vertical velocity passes to the opponent.

Invisible boundaries at the top and bottom of the screen reverse the vertical velocity of the ball and thus bounce it back into play. Scoring involves getting the ball past your opponent whereupon it goes out of play. To regain the ball for the next match the losing player presses the serve button on his joystick control. The ball will then reappear from his side of the screen.

You should now have a picture of what happens in the game, so we can go on to describe how this is achieved. The circuit is shown in Fig. 14.

First we must be able to recognise when a player intercepts the ball—i.e. when ball and player coincide on the screen. This is quite simple as the pulses representing man and ball will then occur at the same time. Thus all that is necessary is to feed the ball signals and signals from one of the men into an AND gate and we will get an output pulse when coincidence occurs. This is done with NOR gates IC101a and IC101b. As the input signals are zero-going pulses these in fact act as AND gates and produce positive-going output pulses at coincidence.

These coincidence signals are fed into a second pair of NOR gates IC101c and IC101d which act as inverting OR gates and give a zero output when either a coincidence occurs or a serve button is pressed. The cross-coupled NAND gates IC102a and IC102b form a latch which is triggered over by zero input to IC102a and back again by zero input to IC102b.

Coincidence between the left man and the ball will cause the output of IC102a to go positive: it will remain positive until coincidence between the right man and ball cause it to return to zero. The remaining gate IC102d is part of the display circuitry. It combines the men and ball signals before they are fed to Tr20, the c.r.t. drive amplifier.

Ball Control

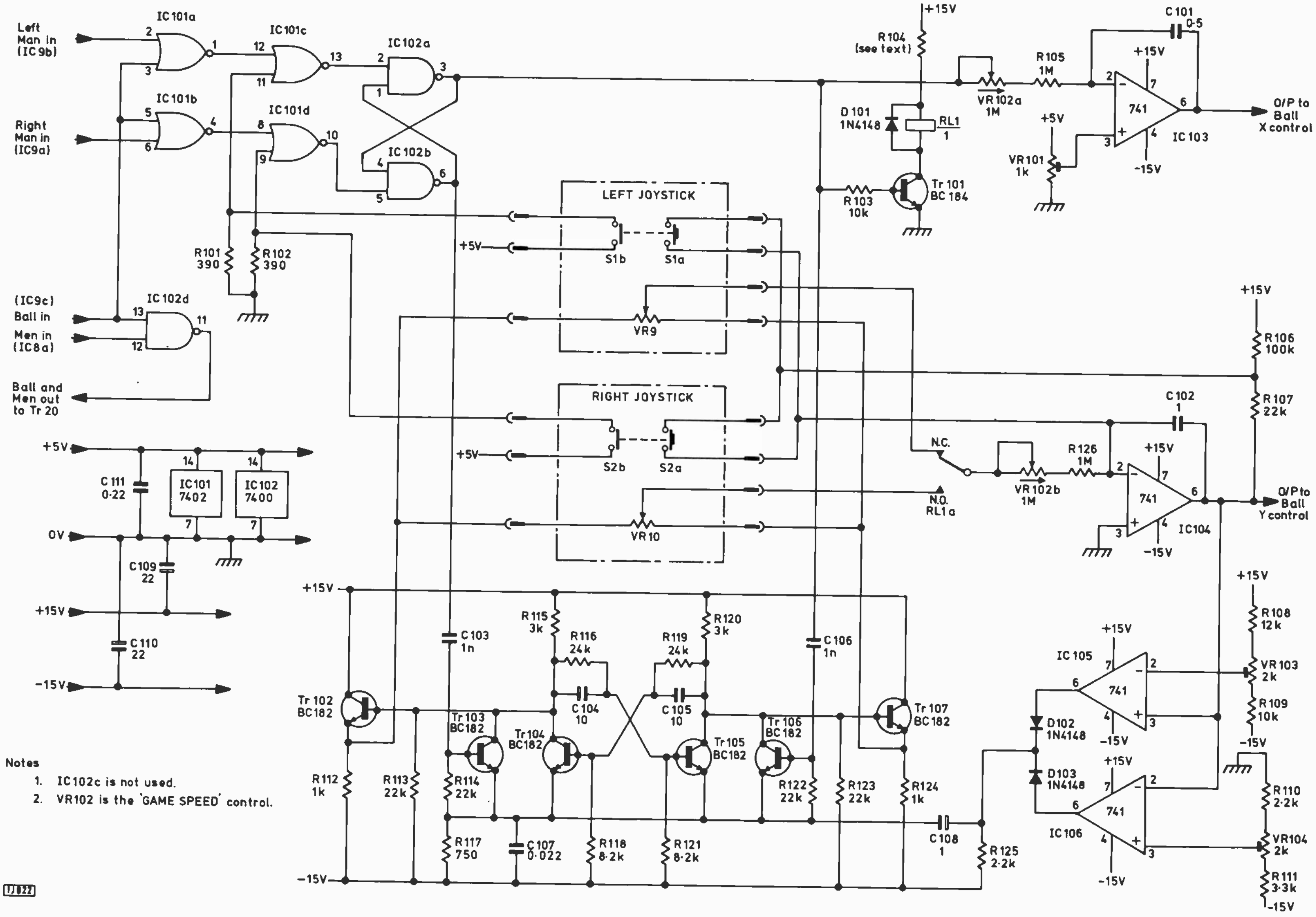
We will now deal with the ball motivation. This is achieved with two precision integrators which produce slow-speed ramps. IC103 controls the horizontal velocity which is constant in either direction. Normally a positive voltage at the input to the integrator (VR102) produces a falling voltage at the output while a negative input produces a rising output.

In the case of IC103 the input voltages are zero and +4V from the logic (IC102a). To cater for this the non-inverting input (pin 3) is taken to about +2V via VR101. Integrator IC104 controls the ball's vertical velocity, which is continuously variable from a fixed positive value through zero to a fixed negative value (by negative velocity we mean travelling in the opposite direction). The dual potentiometer VR102 allows the overall speed of the game to be varied by changing the integrator time-constants.

When the ball reaches the top or bottom of the screen it must reverse direction. The circuitry needed to achieve this consists of the emitter-coupled bistable circuit—transistors Tr102 to Tr107—and a pair of boundary comparators—IC105, IC106. The boundaries are set at the edges of the screen and correspond to voltages at the output of IC104 of about −0·5V and −6V.

Comparator IC105 forms the upper boundary detector, its output going positive when the input (pin 3) exceeds the preset voltage of −0·5V at pin 2. The lower boundary detector IC106 also gives a positive output when the input at its pin 2 is less (more negative) than the preset voltage of −6V at pin 3.

Diodes D102 and D103 form an OR gate allowing the bistable Tr104, Tr105 to be triggered over when the output of either IC105 or IC106 goes positive. Transistors Tr102 and Tr107 are emitter-followers



Notes
1. IC102c is not used.
2. VR102 is the 'GAME SPEED' control.

Fig. 14: Circuit of the simple game board. Note: C108 is a polyester not an electrolytic type.

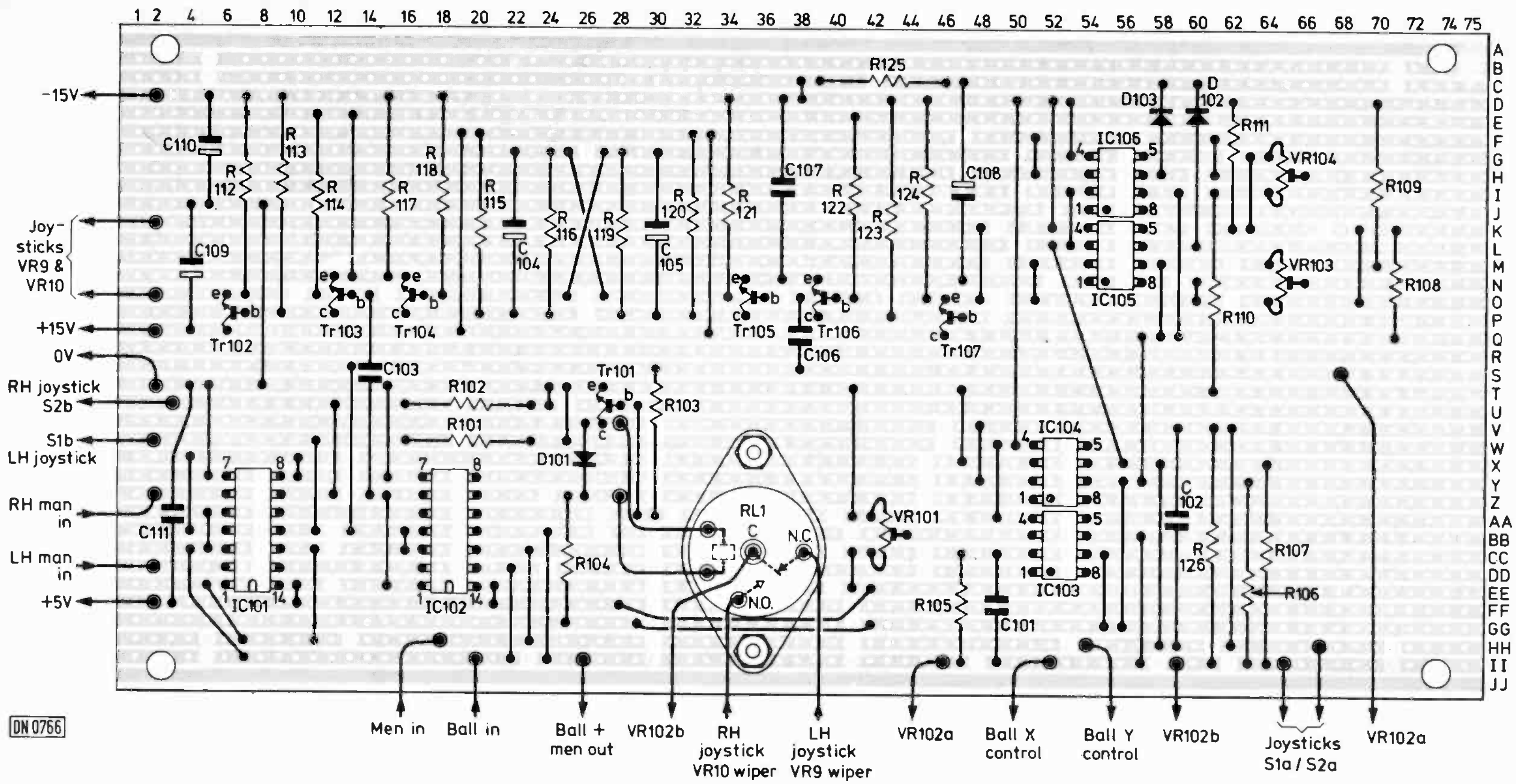


Fig. 15: Layout of the simple game board, viewed from the copper side.

★ Components list

SIMPLE GAME BOARD

Resistors: (all ±5%, ½W)

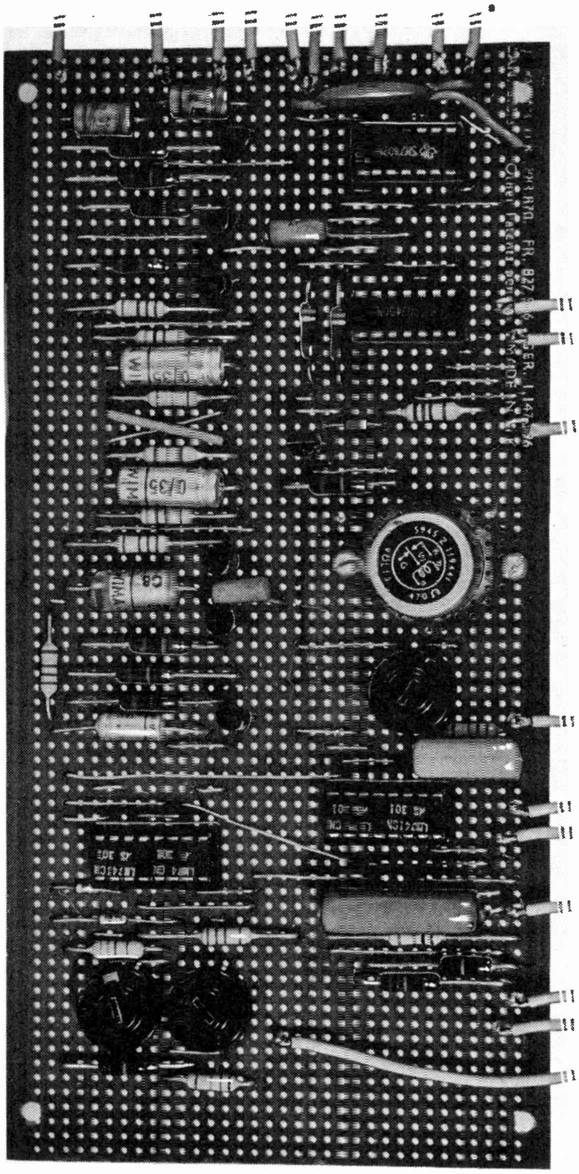
R101, R102	390 Ω	R110, R125	2·2k Ω	R118, R121	8·2k Ω	R108	12k Ω	R116, R119	24k Ω
R117	750 Ω	R115, R120	3k Ω	R104	see text	R107, R113, R114, R122, R123	22k Ω	R106	100k Ω
R112, R124	1k Ω	R111	3·3k Ω	R103, R109	10k Ω			R105, R126	1M Ω

Potentiometers:
VR101 1 k Ω preset VR103, VR104 2k Ω preset
VR102 1M Ω+1M Ω dual ganged pot

Capacitors:
C103, C106 1nF C111 20V ceramic 0·22μF C102, C108 polyester 1μF C109, C110 20V 22μF
C107 0·022μF C101 polyester 0·5μF C104, C105 35V 10μF

Semiconductors:
Tr101 BC184 Tr102, Tr103, Tr104, Tr105, Tr106, Tr107 BC182
D101, D102, D103 1N4148 (1N914)
IC101 7402 IC102 7400 IC103, IC104, IC105, IC106 741 (DIL8 version)

Miscellaneous:
RL1 SPCO—see text



Photograph of the simple game board, showing the component side.

giving a low output impedance to drive the joystick potentiometers VR9 and VR10. The bistable circuit has been designed to give symmetrical outputs of +8V and −8V across VR9 and VR10.

If we ignore transistors Tr103 and Tr106 we can now get an overall idea of this part of the circuit. VR9 can be set at any value between +8V and −8V, resulting in a rising or falling ramp at the output of IC104. This in turn causes the ball to travel up or down the screen at a predetermined velocity. Should the ball trespass over the edge of the screen one of the boundary comparator outputs will go positive and the positive-going edge will trigger the bistable Tr104/Tr105 into its other stable state. This change of state causes the voltage across VR9 to be reversed and the vertical velocity of the ball will also be reversed.

If we now return to the horizontal ball control we see that the relay RL1 changes over the joystick control each time a player intercepts the ball. In the circuit as so far described however the bistable could be in either state, meaning that the knob on the top of the joystick could equally point in the opposite direction to the direction the ball would take. To overcome this transistors Tr103 and Tr106 are incorporated to preset the bistable each time a man-ball coincidence occurs.

Construction

Construction is quite straightforward. The components should be laid out on a piece of 0·1in. pitch Veroboard, $3\frac{3}{4}\times7\frac{1}{2}$in., as shown in Fig. 15 and the photograph. Relay RL1 should be a sensitive 12V type with a coil resistance of 470Ω or greater—the prototype used a Henry's Radio type 9B. The value of R104 should be about a quarter of the relay coil resistance. Mount the game speed control VR102 on the front panel. The board should be mounted along the side of the case and all interconnections made except the outputs from the ball control integrators. The ball control inputs to the man/ball circuit board should be wired to the test potentiometers as outlined in the previous article.

Testing

Check that you now have the ball and both men together on the screen. Connect the horizontal ball control only to start with. Check that a man-ball coincidence reverses the ball direction and adjust VR101 for equal velocity in each direction.

Also check the serve buttons: contacts S1a and S2a centre the ball vertically on the screen.

Boundary Reflections

The vertical ball control should also be checked independently. Set the boundary reflections at the edge of the screen with VR103 (top) and VR104 (bottom). Next establish which joystick is controlling the velocity. You should be able to reverse the ball direction in mid flight and still get reflections from the boundaries. Test the other joystick by moving the man over to intercept the ball. The ball should move off with a new velocity in the direction indicated by the knob.

Once the ball has undergone a reflection the knob will indicate the opposite direction. Nothing can be done about this unfortunately. It should not affect the game adversely however as the ball does not undergo more than one reflection in normal play. If either of the joystick control knobs does not agree with the initial ball direction simply reverse the connections to VR9 or VR10.

Football Game

This concludes the simple game project. In the next two articles the football game will be described. This game features reflection from four visible boundaries, giving the ball interesting snooker like trajectories. Other features are that the ball can be given any speed and direction by kicking it with the player and the ball velocity decays realistically with time. All this plus the ultimate colour version!

CONTINUED NEXT MONTH

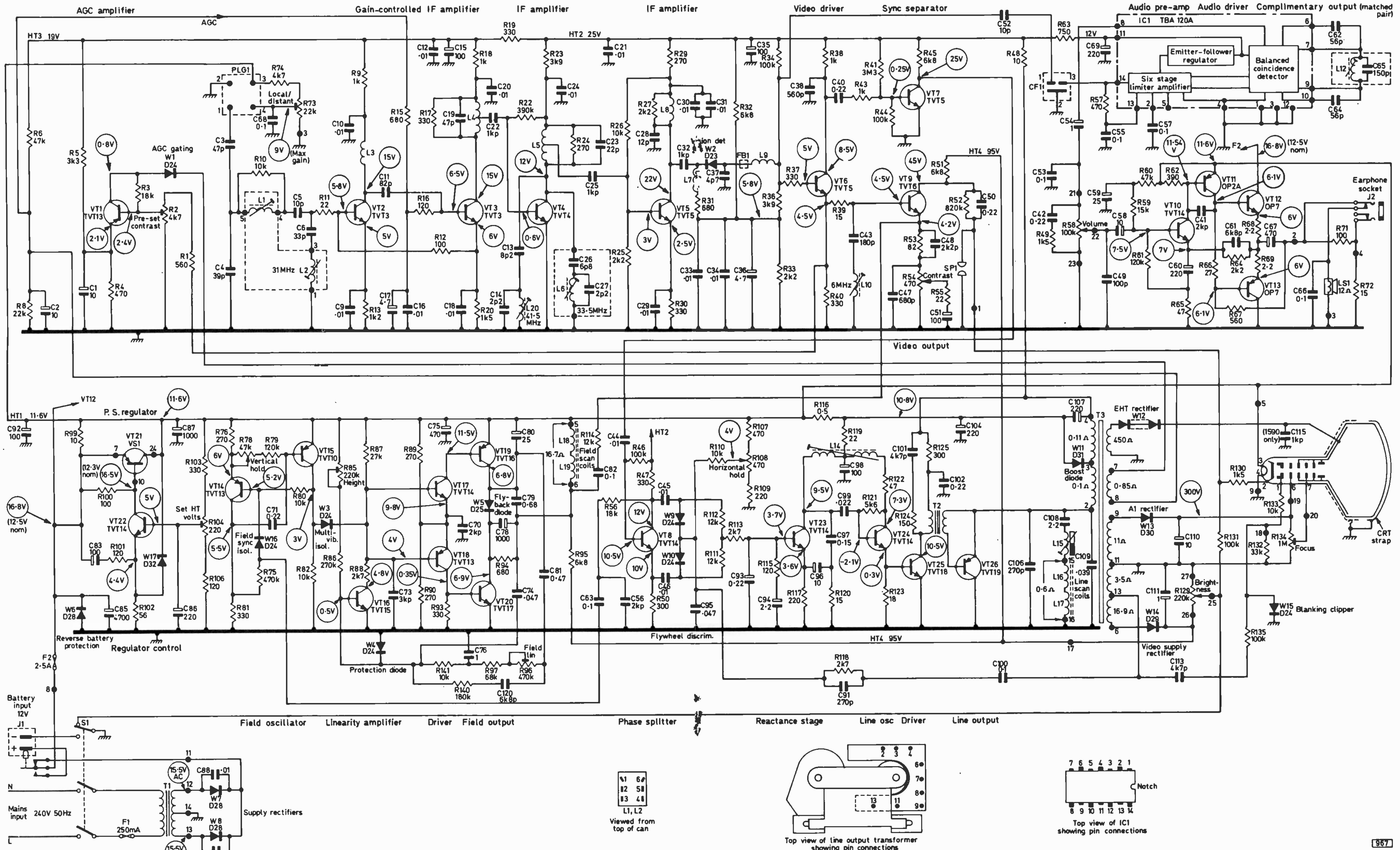


Fig. 7: Circuit diagram of the TCE/BRC 1591 chassis, schedule C. The 1590 chassis differs as follows: R131 150k Ω; C106 3,900pF; C115 fitted; C42 and R49 omitted. See also modifications on page 507.

a resistor, again upsetting the bias conditions to produce weak and croaky sound with the voltages deviating from those specified.

It doesn't take long to remove a suspect capacitor and check it on a meter where the circuit values are such as to preclude testing in situ. If a capacitor is suspected of being open-circuit it is easy to slap another across it as a quick check. Leakage will necessitate removal. Do not omit to check C54 which is the coupler from the i.c. to the volume control.

Intercarrier Sound IC

The intercarrier sound i.c. is something you can't do much about other than replace it if it is suspect. The only tuning is the quad coil (L12) whose core setting is fairly critical in order to get clear sound free of buzz. The tuning is otherwise set by the ceramic filter CF1.

The IF Strip

Fault finding in the i.f. strip becomes much easier once the positions of the four transistors have been established and also which parts of the print are the emitter, base and collector connections. Check these against the voltages given and the faulty stage can usually be located in a very short time. Low emitter voltage is not always an indication that a particular transistor is defective however. The gain of VT3 is controlled by the a.g.c. amplifier while its emitter voltage controls VT2 base (via R12). So get VT3 base voltage right first, and check the electrolytics C17, C2 and C1. Leakage through any of these will upset the whole system.

VT4 has no emitter resistor: its base is biased by R22 whose value is something which should be checked. The stage is working correctly when there is a voltage drop of some 12V across R23.

VT5 is the hard worker, having to handle fairly large signal voltages. This is the transistor which is most likely to fail. Its base voltage is held at 3V by R25 and R26 and this should produce about 2.5V at the emitter if the transistor is in order. Replacement type BF197 can also be used in the VT6 and VT7 positions.

Video and Sync Circuits

From the detector diode W2 (OA91) the demodulated signals pass to the video driver VT6 which should have 5V on its base. If this voltage is low check C36 which could well be leaky: this is far more likely than R32 or R33 changing value.

The sync separator VT7 is fed from the collector of VT6 whilst the video output transistor (VT9) is driven from VT6 emitter (the feed to the gated a.g.c. stage VT1 is also taken from VT6 emitter). There should be 4.5V across R40.

The video output transistor is a high-voltage type fed from a 95V line which is obtained from the line output stage via W14 (reservoir C111). The voltage drop across R51 should result in about 45V at VT9 collector. This voltage is dependent upon the signal and upon the correct working of the driver stage, also of course on VT9 itself.

The sync separator VT7 is followed by a phase splitter stage (VT8). Field sync pulses are obtained from its collector, antiphase line sync pulses from its emitter and collector.

Field Timebase

Neither the field nor the line timebase has given us much trouble to date (he said with his fingers, legs and eyes crossed).

In the field timebase VT14 and VT15 form a multivibrator which produces a pulse output (positive going) at VT15 collector: this drives VT17 and VT19 hard on and cuts off VT18 and VT20 to give the flyback action. The scan is produced by C74 driving VT16. As the voltage across R87 increases VT18 and VT20 are driven on while VT17 and VT19 are driven towards cut off. The voltages throughout are interdependent which makes fault tracing difficult. The writer prefers to start with a quick check on the back-to-front resistance of each transistor in turn, bearing in mind the direct coupling which prevents a high resistance reading being obtained when the test leads are reversed and which transistors are pnp and which are npn types. Readers who are unfamiliar with transistors in field timebases should read Harold Peters lovely article in the April 1974 issue —the present circuit is somewhat different to the one described there however.

Line Timebase

Antiphase line sync pulses are fed to the discriminator diodes W9/W10 which also receive a reference pulse from the line output transformer fed back via C100 and integrated by R118/C95 and a d.c. control voltage from the hold control R108. The discriminator feeds the reactance stage VT23 which controls the sinewave line oscillator VT24. Line hold troubles are normally caused by the discriminator diodes becoming unbalanced (compare the back-to-front ratio of each) or by one of the electrolytic capacitors drying up or becoming leaky. C96 is the primary suspect, more often becoming open-circuit so that another capacitor bridged across it will prove the point.

A driver stage follows the oscillator and is coupled to the output transistor by transformer T2. The output transistor itself rarely seems to fail in this chassis (others may have had different experience, we can only speak for ourselves). We cannot comment upon the fault symptoms caused by this therefore. We have had to replace the boost diode W11 however. This must be a fast-acting diode of the type specified. Thorn D31 or two BYX70 in parallel. Any other combination is likely to overheat. An XK3017 can be used however if this type is available, as can an F203. Ordinary silicon diodes are quite unsuitable.

Supplies from the Line Output Stage

Windings on the line output transformer feed rectifiers which provide the video h.t. line, the c.r.t. first anode and focus supplies and of course the e.h.t. The video h.t. and c.r.t. first anode voltages are decoupled by electrolytics. C110 (10μF) being the first anode smoother and C111 (1μF) the video h.t. smoother. A short in either capacitor will damp oscillations and render the line output stage inoperative.

SERVICING television receivers

L. LAWRY-JOHNS

TCE 1590/1591 CHASSIS—cont.

Mixer Transistor

The irritating habit of the oscillator-mixer transistor VT352 (Thorn TVT2 or AF139) is its reluctance to oscillate at low frequencies. Thus a selected button may tune in perfectly as it is unscrewed to say channel 26 but when it is turned clockwise to tune down to channel 23 the programme may start to come in and then suddenly cut off as the correct tuning point is reached. Alternatively it may tune in for a time and then cut off. "Just when it was getting interesting. I could have thrown the bloody teapot at it. If it does it again I'll chuck it out of the ******* window". Before trying a new transistor check the oscillator section tuning vanes to ensure that they are not fouling with the stator at this point. Fitting a replacement transistor is easier in this position as the screening lead is unused and is cut off short.

Audio Circuits

The main trouble spot on the printed panel is neither the signal stages nor the timebases. Due perhaps to the use of an unregulated supply for the audio output stage it is the transistors here that seem to fail. Our main circuit shows the original design–later models can vary to a marked extent and one should not be surprised to find an additional transistor in the R66 position with a variable resistor to regulate the base current of the output pair. The transistors may also be completely different from those shown and these are not interchangeable therefore. The types fitted must be adhered to.

The normal complaint is that fuse F2 fails: examination may show that resistors R68 and R69 are discoloured. If the circuit uses a Thorn OP2A (AC128) driver and OP7 output pair (matched pair with equivalents VT12 AC176K, VT13 AC128K) the writer's experience has led him to observe the following rule: if in doubt change the 128. If the output pair have damaged their emitter resistors therefore change them as a pair and also change the AC128 driver which may well have caused the trouble in the first place even if it reads right.

Faulty Capacitors

Faulty transistors are not the only things which can cause trouble here however. The electrolytic capacitors used can become defective in three ways. First they can dry up or otherwise become open-circuit resulting in very weak or no sound. Secondly they can short thus completely upsetting the operating conditions of the transistors. Completely wrong voltage readings on the output pair for example are often due to C58 shorting, thus taking the base of VT10 well down to cut off which in turn cuts off VT11 and so on. The third defect is fairly heavy leakage so that the capacitor behaves more like

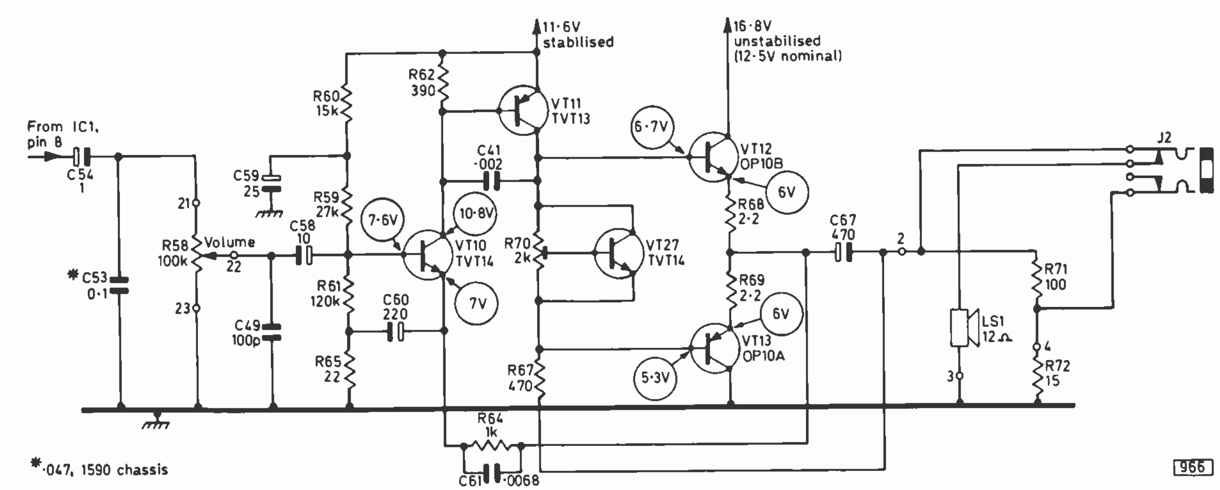


Fig. 6: Audio circuit used in later versions of the chassis.

Alternative Semiconductor Devices

If the Thorn specified semiconductor types cannot be obtained the following Mullard equivalents may be used.

VT8, 10, 17, 22, 23, 24	BC147	VT11	AC128
VT1, 14, 18	BC157	VT12	AC176K
VT4	BF194	VT13	AC128K
VT2, 3	BF196	VT21	AD149
VT5, 6, 7	BF197	W6, 7, 8	BY126
VT9	BF336	W13	BA148F

In the case of VT11, VT12, VT13, VT22 and VT25 see Fig. 6 and the modifications below however.

Modifications

As previously mentioned later versions incorporate a redesigned audio circuit using silicon driver and output transistors. The circuit is shown in Fig. 6. An extra transistor (VT27) stabilises the output stage quiescent current against temperature changes. Preset R70 is for initial adjustment of the quiescent current—it should be necessary to reset this only after replacing VT10, VT11, VT12, VT13 or VT27. The procedure is as follows: connect a meter in series with VT12 collector, turn R70 fully anticlockwise (viewed from rear of chassis), switch on, turn volume control to minimum, then slowly advance R70 for a meter reading of 4mA. With the modified output stage it is not necessary to used a matched pair of output transistors. These can be replaced individually therefore.

The field timebase circuit used in earlier production (schedule A and B) differed considerably—see Fig. 2 (last month).

In addition there have been a number of minor component modifications as follows:

C38 reduced to 390pF to eliminate cogging under certain video conditions.

C66 removed to improve the audio quality.

C80 reduced to 10μF to improve field linearity.

C111 reduced to 1μF to improve spot suppression at switch off (was 33μF in the 1590 chassis).

C116 (1,000pF, 350V) added across boost diode W11 to eliminate line tearing under weak signal conditions.

C117 (0·1μF) added across C111 to eliminate striations due to the inductance of C111.

C118 (0·01μF) r.f. bypass capacitor added from VT21 base to chassis to overcome instability on battery operation.

R3 removed and R6 reduced to 33kΩ to improve the a.g.c. action.

R10 may be 10kΩ or 18kΩ as necessary to provide the correct i.f. response.

R32 increased to 8·2kΩ, R38 to 1·2kΩ and R40 to 470Ω to improve the video performance.

R48 changed to a fusible type for increased safety and reliability.

R102 increased to 68Ω to improve the regulator operation.

VT22 changed to type TVT21 (increased rating) to improve reliability.

VT25 reclassified type TVT21 to include type BC337.

SERVICE NOTEBOOK

G. R. Wilding

Narrow Unmodulated Raster

An unmodulated 6in. wide raster and no sound was the complaint with a 20in. model fitted with the ITT VC200 chassis. In common with most other hybrid single-standard models the l.t. for the transistors in this chassis is developed from a low-voltage winding on the line output transformer. The absence of sound and picture was the result therefore of the low line output failing to produce sufficient l.t. to make the tuner's mixer stage oscillate.

A new PL504 line output valve and PY88 boost diode did not improve matters so the next step was to check the screen and control grid voltages of the PL504—a short across the l.t. circuit was ruled out since there was no sign of any overheating anywhere. −50V should be present at the control grid and 190V at the screen grid but on contacting the valve-holder control grid pin with the meter lead full width was restored together with normal picture and sound. It appeared therefore that either the grid was not returned to chassis or that excessive negative bias was being applied, the latter being reduced by the 10MΩ meter resistance (500V range at 20kΩ/V). The width control was found to be o.k., as were the 1MΩ resistors R153 and R154 (see Fig. 1), but on stabbing an equivalent resistor across the print connections to the 10MΩ resistor R159 normal width, picture and sound again appeared. On lowering the chassis it was found that R159, shown as 10MΩ on the circuit diagram, actually consisted of two series-connected 1W resistors of 5·6MΩ and 4·7MΩ, clearly a maker's modification.

Faults due to R159 are quite common on this chassis. As the two resistors were mounted close to the PL504 we decided to wire the replacements on the print side of the panel to ensure cool running. Generally speaking, the higher the value of a resistor the more inclined it is to deteriorate under high working temperature conditions.

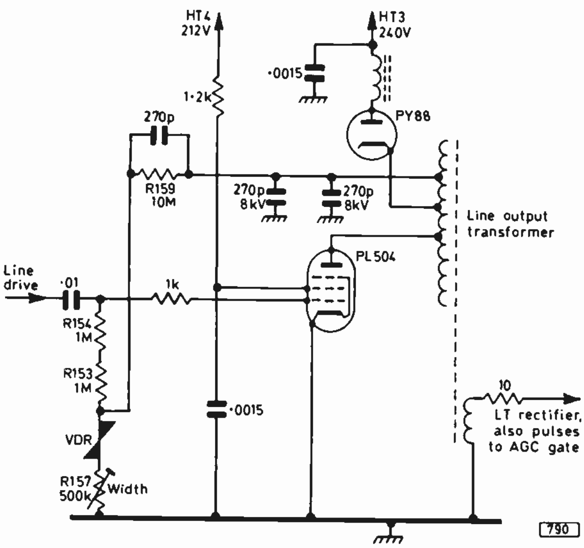


Fig. 1: ITT VC200 chassis line output stage.

LONG-DISTANCE TELEVISION

ROGER BUNNEY

IT is with pleasure that I start this month with startling news of extreme reception! Veteran DXer Ian C. Beckett of Buckingham has been active with TV-DX for some 16 years and has been very successful with all types of reception. I feel he has really reached the ultimate this time however. Readers may recall that on May 15th, 1974 at 1936-1959 BST (CET) he received on chs. E2, 3 a programme consisting of a coloured gentleman giving a talk on medicine —in English! Following Ian's research into a possible source of the signals he has now received confirmation from the Ghana Broadcasting Corporation that what he saw was from the programme "You and Your Body" and originated from the Kissi ch. E2 15kW and Jamasi ch. E3 15kW transmitters in Ghana. Our sincere congratulations go to Ian on this quite magnificent and incredible reception. The Ghana authorities also sent details of typical programme timings for their network. These are 1745 to approximately 2230 close with an earlier opening at 1600 on Sundays, all times local (GMT). Incidentally Ian also noted a newsreader as floater over the above signal, on ch. E3 at 1945! Nigeria? ? The signals were received on Ian's main Band I array (four-element ch. B1-5 wideband) and a new five-element ch. E3-F4 array at only 15ft. height.

Returning to the European area we have news that the Iraklion ch. A2 (system M) transmitter on Crete has now been received in the UK. This first occurred on June 18th at 2005 CET when Hugh Cocks (now in Devon, and of Gwelo, Rhodesia reception fame!) noted on ch. A2/E3 a weak signal with the field hold requiring resetting. The programme was an old "Ironside" USA police drama which ended at 2010 followed by a caption—a globe with white lettering on black to the left-hand side of the frame. This faded to be replaced again by "Ironside" at 2020. The signal subsequently faded under World Cup football from JRT. I feel that this is definitely the AFRTS outlet on Crete.

The second sighting of this transmitter (listed at 0.1kW!) was by Garry Smith (Derby) who received the RETMA test card "way off lock" on June 24th at 0844 BST. The main difference is that the contrast grey-scale around the card was blacked out.

Yet another possible reception occurred later the same day when Keith Hamer, also of Derby (a good DX site?) received a possible "Indian Head" test card. Keith noted a card floating on ch. E3 and assumed it was RAI spreading from ch. IA. It was then established however that RAI was carrying programme at the time. The signal was weak (as indeed were all the signals from Crete) and by the time further action was taken had faded.

It is known that Crete is using the RETMA card but at this stage we are uncertain whether the Indian Head card is also in use there. We do know that station HZ22, ch. A2 Dhahran, Saudi Arabia uses the card and must consider this a possibility although the time was rather late for their radiation of such a card (received at 1625 CET). Again our congratulations to all involved with these receptions.

The first part of June made me feel that the season had already ended since several days passed—in fact nearly two weeks—with very little of note! From about the 17th however things were really alive, with a lull only during the last two days. Sporadic E propagation has consisted mainly of longer hop signals from the south-east and east. Really strong signals have been seen at times. The TSS (USSR) signals on ch. R1 during the early morning of June 25th were so strong that they were spreading as far h.f. as ch. E3 on a narrow bandwidth receiver. The tropospherics also had a lift, notably on the 16th and 22nd.

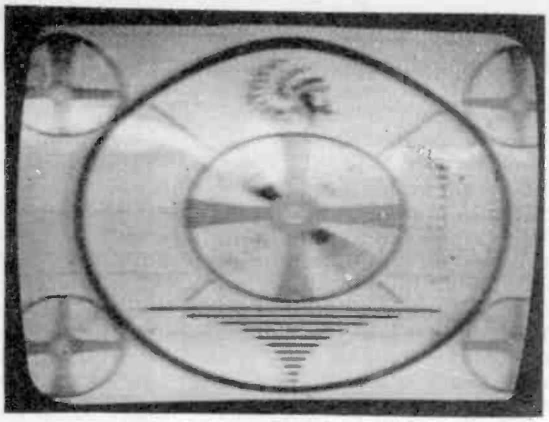
My log for the period is as follows, keeping to the "best" days due to shortage of space this month.

4/6/74	Improved trops into ORTF (France) at u.h.f.
14-16/6/74	Improved trops including ORTF; WG (West Germany); BRT (Belgium); NOS (Holland). An interesting reception here was Liege ch. E3 via trops over the local ch. B3.
17/6/74	RAI (Italy) chs. IA, IB—SpE.
18/6/74	TSS (USSR) R1, 2; YLE (Finland) E3; SR (Sweden) E2, 3, 4; NRK (Norway) E2—SpE.
20/6/74	TVE (Spain) E2, 3, 4; TVR (Rumania) R2—SpE.
21/6/74	TVE E2, 3, 4; RTP (Portugal) E2, 3; RAI IA, IB; JRT (Yugoslavia) E4—all SpE.
22/6/74	JRT E3, 4; RAI IA, IB; WG E2, 3; also unidentified signals—all SpE.
23/6/74	TVE E2, 3, 4; RTP E3; JRT E3, 4; RAI IA, IB; Albania IC; also many unidentified signals—SpE.
24/6/74	TSS R1, 2; CST (Czechoslovakia) R1; TVP (Poland) R1, 3; TVE E2, 3, 4; RTP E3—all SpE.
25/6/74	TSS R1, 2, 3, 4; TVP R1, 2, 3; DFF (East Germany) E3, 4; MT (Hungary) R1, 2; Switzerland E3; WG E4. On return in the evening conditions were still open and remained so until 2400. All SpE.
26/6/74	TVP R1; WG E2—SpE.

There have been some unusual receptions though nothing as dramatic as that reported above. The opening on Saturday 22nd at 1535-45 brought a male announcer wearing a fez! The signal was weak and fading, under heavy interference. The male announcer was replaced by a female and the signal faded completely at 1545. Since I've never seen a West European announcer on ch. E3 wearing a fez I suspect that this may at last be my sighting of Jordanian TV! The following day brought another dramatic sighting. At 1510 there appeared for a short time on ch. E4 a crosshatch/grid floating under strong signals from JRT. The time corresponds to the possible test period prior to the opening of CLT (Lebanon)! I am making enquiries as to the opening time of CLT on that day. In both cases the signals resembled trop signals and came from the south east.

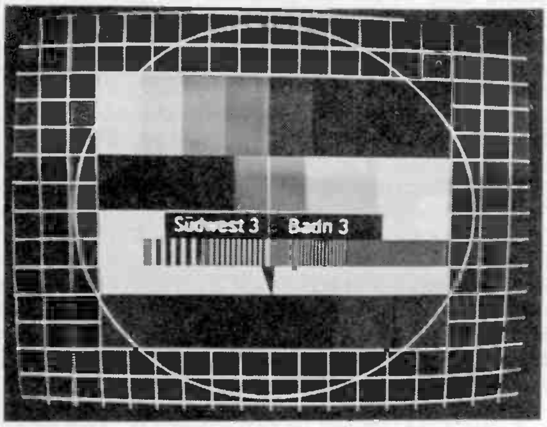
The 24th brought an unusual signal on ch. R2. The CST electronic pattern was noted at fair strength, actually somewhat on the l.f. side of this channel as it could be tuned separately from another signal on ch. R2. This was an extreme amount for an offset. Did anyone else see it? The time was 0740 and the pattern was preceeded by colour bars. The identification on the pattern consisted of two sets of letters.

Unusual sightings from other readers include the Swedish test card, resembling the old colour card but with the identification "TV1 Orego". Clive Athowe noted the T05



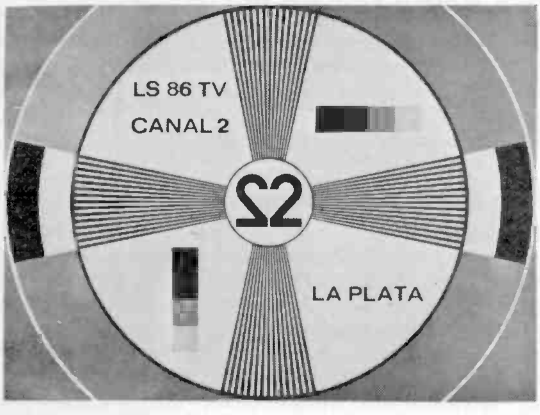
Indian head test card as used and photographed from station HZ22, Dhahran.

West German news caption. Photograph courtesy of Peter Vaarkamp



Fubk test card with SWF-3 identification. Photo courtesy Dieter Scheiba

BRT-2 (Belgium) identification slide. Photo courtesy Peter Vaarkamp



Television La Plata (Argentina) test card. Channel A2. Photo courtesy Garry Smith

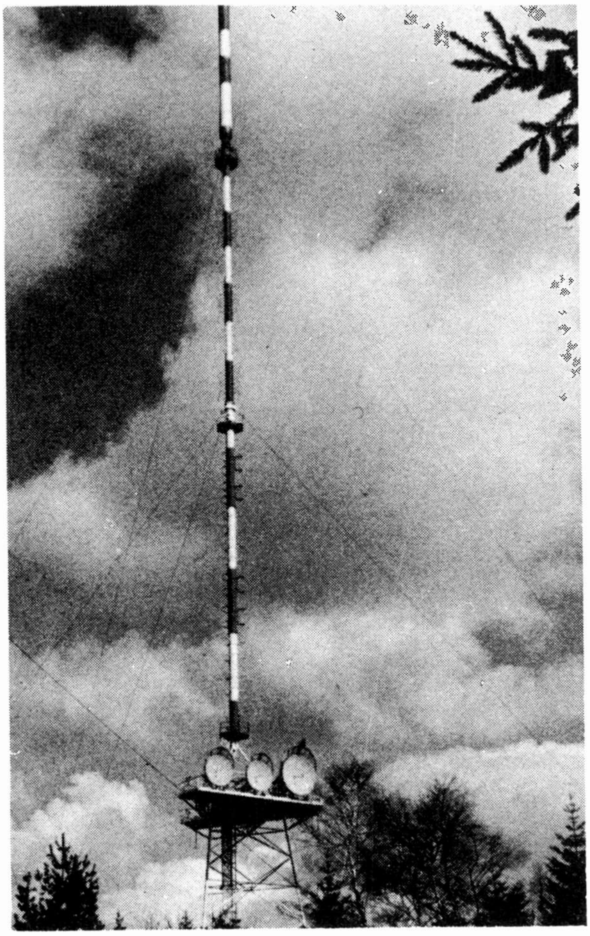
card from ORF (Austria) carrying a black bar just under the lower centre—within the bar were the letters "ORF FS1". TVR (Rumania) was noted with the usual EBU bar and a differing identification "140574 TVR Bucuresti". A new pattern too from TVE—a form of colour bars but with the first bars from the left being black, white, black. JRT was noted on ch. E3 with a pattern consisting of four vertical bars—black, white, black, white—in the upper two-thirds of the field and a conventional sawtooth beneath. The checkerboard was noted on TVE-2/RTP but with two central squares missing making a double cross. TVE has also been using a new clock—the clock being to the left with a "TVE" identification to the right. Ryn Muntjewerff noted the DFF (East Germany) test pattern carrying yet another identification "DFF F/NTD". This is an abbreviation for a text which when translated reads "technical test transmission, TV signal transmitted by DDR". The pattern has also appeared on ch. R1 with "DDR" on it.

News Items

Monaco: Tele Monte-Carlo changed on December 23rd last from system E with 819 lines to 625 lines on ch. F10. The other characteristics remain unaltered. Occasional colour transmissions are radiated for test purposes. The ch. F2 outlet is not in operation.

Middle East: Pye TVT have obtained a record contract—a complete TV system for Oman. A studio centre is to be constructed at Salalah—capital of Dhofar—with two colour studios. Four transmitters (all in Band III) will cover Salalah and the majority of the country—all are 10kW units. On air day is scheduled for Oman National Day, November 1975.

The TV Centre of the Dubai Radio and Television Service—commissioned in December last—will be operational this September. The service provides programmes in Arabic/English—and in colour.



The ORF (Austria) Jauerling TV mast—channels E2a and E21. Photograph courtesy Keith Hamer

An interesting footnote to the Oman operation is that a special studio is being established at the Sultan's palace at Salalah. This will be linked to the TV Centre "so that HM Sultan Qaboos Bin Saiid can be televised directly into the network".

Czechoslovakia: We now have details of the main CST u.h.f. transmitters, all second programme (courtesy Clive Athowe).

R22	Pardubice	600kW	R31	Ostrava	600kW
R22	Klatovy	100kW	R32	B. Bystrica	600kW
R24	Prague-City	100kW	R33	Usti n.l.	600kW
R25	Kosice	600kW	R34	N. Jicin	100kW
R26	Prague	1000kW	R35	Susice	100kW
R27	Bratislava	1000kW	R35	Zilinia	1000kW
R29	Namestovo	100kW	R35	Brno-Mesto	100kW
R29	Brno	600kW	R36	Jesenik	600kW
R30	Poprad	600kW	R36	Cheb	100kW
R31	Plzen	600kW	R37	Frydek	300kW
R31	Liberec	100kW	R38	Sokolov	300kW

All transmissions are horizontally polarised.

The following second chain test transmission times have been provided by Igor Hajek. Petřin ch. R24 Monday-Friday 0930-1300, 1300-1900 (colour bars), Saturday 0900-1300. Ostrava, Liberec (Jested) ch. R31, Brno ch. R35 Monday-Friday 0930-1300, 1300-1700 (colour bars), Saturday 0900-1300. These are official times given in the CST programme guide. Incidentally Petřin is a hill in central Prague with a miniature "Eiffel Tower" mast on top—the site of the Praha Mesto transmitter (Mesto means town). The main transmitter is to the South of Prague atop the Cukrak Hill. This serves central Bohemia. Jested is a mountain South of Liberec (1012m. a.s.l.).

North America: WTAF-TV Philadelphia has brought into operation on ch. A29 a 5MW u.h.f. transmitter. This is the first station to provide omnidirectional coverage with such a high power. The high-gain transmitting array is 108ft. tall and is mounted atop a 1,082ft. high tower. EMI Sound and Vision Equipment is to equip a new 1,805ft. high tower in Toronto, Canada. This will be 57ft. taller than the Ostankino TV Tower in Moscow. The transmitting arrays—over 300ft. high—will be carried on a 220 ton steel structure and will include arrays for chs. A29 and A19 at 1,695ft., ch. A9 at 1,635ft., ch. A5 at 1,572ft. and a master f.m. array with 11 channel capability at 1,513ft.

The European Broadcasting Union has published an excellent book on the test cards and test patterns used in Europe. The 40 page booklet ($8\frac{1}{2}$ x 12in.) contains very clear photographs (including colour) of the main broadcasters' test patterns together with information on the transmission standards used. Even the RAI test card numbers (transmitter identification) are given. Countries in North Africa and the Middle East are also included and there are short chapters on the production of and reasons for test patterns, methods of identification, transmission systems, lists of abbreviations of the broadcasters, etc. The one drawback is the exclusion of certain OIRT members, specifically TSS, TVP, TVR, CST and MT. Apart from the latter point I fully recommend this book to readers. It is priced at 80 Belgian Francs and is available from: European Broadcasting Union, 1180 Bruxelles, Avenue Albert Lancaster 32, Technical Centre, Belgium. The book is entitled "Identification of Television Transmissions in Europe", Tech. 3201-E.

"Beyond Shortwave" is the title of a booklet produced by the WTFDA (World Wide TV FM DX Association). It is basically a guide to the hobby of DXing in the TV, FM, and public-service bands. Included in the booklet are a number of charts which give very useful frequency allocation information. Chapters are included on propagation—particularly good—aerials, receivers etc. Although intended for North American enthusiasts it is of general interest and can justify a place on our bookshelves. Priced at $1.50, from WTFDA, PO Box 163, Deerfield, Illinois, 60015, USA. The price includes postage (surface).

From Our Correspondents . . .

I have been surprised (and inundated) by the number of letters this month describing reception. Unfortunately I can mention only a few. N. Hanwell (Sheffield) sent an urgent request for the address of Jordan TV—he received on ch. E3 a programme on elephants (being washed!) at 1650, June 3rd, complete with Arabic subtitles. He has been using a wide-band Band I array with a varicap tuner unit feeding into a Sobell receiver (two i.f. stages plus the v.h.f. tuner as another two-stage amplifier). Cliff Dykes (Sutton, Surrey) says he is having a bumper year for DX-TV—he has noted most countries, certainly for the longer skip distances. In common with others he has found the shorter skip signals absent. Cliff uses loft arrays (due to living in a flat) but has nevertheless received distant signals such as TVR. He has also noted WG at u.h.f. Phillip Norman (Withywood, Bristol) has received "all countries in Europe" excluding NOS ch. E4—Bristol is rather shielded in this respect. He hopes to install a 5.5/6/6.5MHz multi-standard sound i.f. strip

—continued on page 513

J.B.DANCE M Sc

AUDIO integrated circuits are being increasingly used in television chassis and certainly represent the simplest approach to improving the audio side of a TV set. A number of such i.c.s have appeared during the last couple of years: this article describes the use of two fairly recent ones, the SGS-ATES TBA800 and TBA810S. Both devices can provide reasonably high outputs into a suitable loudspeaker—the TBA800 will give up to 5W and the TBA810S up to 7W—the main difference between them being that the TBA800 is a somewhat higher voltage, lower current device. The TBA800 is used in the current Grundig and ASA 110° colour chassis while the Finlux 110° colour chassis uses a TBA810. In each of these chassis the audio i.c. is driven from a TBA120 intercarrier sound i.c. The TBA800 and TBA810S can also be used as the field output stage in 110° monochrome chassis with c.r.t.s of up to 17in. and as the field driver stage in larger screen monochrome sets.

Using the TBA800

The TBA800 is designed to provide up to 5W into a 16Ω load when operated from a 24V supply. It is encapsulated in the type of quad-in-line case shown in Fig. 1: the tabs at the centre are to assist in cooling the device and must be earthed.

The TBA800 can be operated from power supply voltages up to the absolute maximum permissible value of 30V. It is best to regard 24V as being the upper limit however in order to provide an adequate safety margin and prevent possible damage during voltage surges. The minimum power supply voltage recommended by the manufacturers is 5V, but the power output is then less than 0·5W.

The quiescent current taken by the TBA800 is typically 9mA from a 24V supply—no device of this type should draw more than 20mA. When an input signal is applied the current increases considerably—up to about 1·5A at full power.

Two circuits for use with the TBA800 are shown in Figs. 2 and 3 and give comparable performance. The circuit shown in Fig. 2 is somewhat simpler but that shown in Fig. 3 enables one side of the loudspeaker to be connected to chassis.

The input resistance of the TBA800 is quite high (typically 5MΩ) but a resistor must be connected between the input pin 8 and chassis otherwise the output stage will not operate with the correct bias. In the circuits shown the volume control VR1 provides this function: the bias current that flows through it is typically 1μA (maximum 5μA).

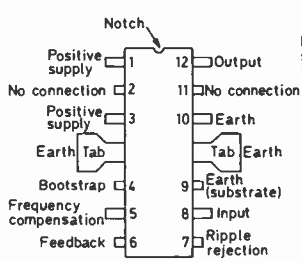
The average voltage at the output pin 12 is half the supply potential. The loudspeaker must be capacitively coupled therefore and the low-frequency response will be worse as this capacitor is decreased in value.

The output coupling capacitor C4 in Fig. 2 also provides the bootstrap connection to pin 4. In Fig. 3 an additional capacitor (C9) is required for this purpose.

In both circuits the value of R1 controls the amount of feedback and thus the gain. The output signal is fed back to pin 6 via an internal 7kΩ resistor. If R1 is reduced in value the gain will increase but the frequency response will be affected and the distortion will rise.

With the component values shown the voltage gain of both circuits is typically 140 (43dB) which is quite adequate for most audio applications.

R3 in Fig. 3 is necessary only if the power supply voltage is fairly low (less than about 14V).



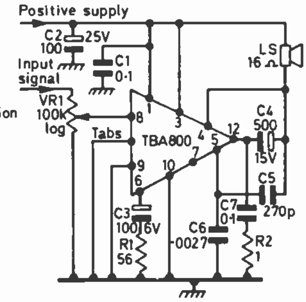
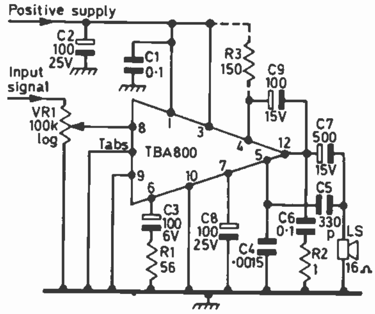


Fig. 1 (left): Pin connections to the TBA800. The TBA810S and TBA810AS are the same except that there is no connection to pin 3.

Fig. 2 (right): Circuit for using the TBA800 as an audio amplifier. The input signal should be coupled to this and the other circuits shown via a capacitor of say 0·047μF-0·1μF.



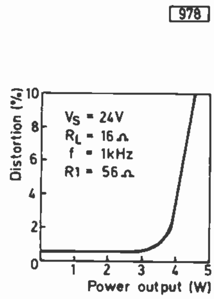


Fig. 3 (left): Alternative circuit with the loudspeaker returned to chassis—this reduces hum problems.

Fig. 4 (right): Plot of distortion against power output for the TBA800.

C2 smooths the power supply input and C1 is connected between pin 1 and chassis to provide r.f. decoupling and help prevent instability. If mains hum is present on the supply line with the circuit shown in Fig. 3 capacitor C8 should be included between pin 7 and chassis.

The circuits shown have a level frequency response (within $\pm$3dB) between about 40Hz and 20kHz. If you wish to reduce the upper 3dB level to about 8kHz C5 can be increased to about 560pF. The total harmonic distortion provided by these circuits remains fairly constant at about 0·5% until the power output reaches 3W: it then rises rapidly with power level as shown in Fig. 4.

Mounting the TBA800

The TBA800 can be operated from a 13V supply to feed up to 2·5W into an 8Ω load or from a 17V supply to feed the same power into a 16Ω load without an additional heatsink. If more output power is required the cooling tabs must be connected to a heatsink. Two methods of mounting the TBA800 are shown in Figs. 5 and 6. In Fig. 5 the device is inserted into a circuit board and a heatsink is soldered to the same points as the tabs: this has the disadvantage that the heatsink extends above the board though on the other hand the whole board can be used for the construction of the circuit. In Fig. 6 the tabs are soldered directly to a suitable area of copper on the board: this method has the disadvantage that about two square inches of the board are not available for component mounting.

It is generally best to make soldered connections to the pins of the device since this ensures good heat dissipation with minimum unwanted feedback. Observe the usual heat precautions when soldering. The pins can however be carefully bent so that they will fit into a 16-pin dual-in-line socket.

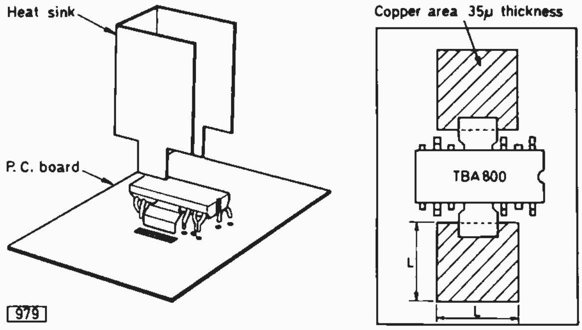
The TBA810S and TBA810AS

The TBA810S has the same type of encapsulation as the TBA800 and the connections are also as shown in Fig. 1 except that there is no internal connection to pin 3. An alternative version, the TBA810AS, has two horizontal tabs with a hole in each (see Fig. 7) so that a heatsink can be bolted on. Some readers may find it easier to bolt a heatsink to a TBA810AS than to solder the TBA810S tabs.

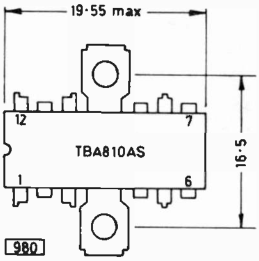
TBA810 devices can provide 7W of audio power to a 4Ω loudspeaker when operated from a 16V supply. Fig. 8 shows the change in maximum output power with different supply voltages. As a 4·5W output can be obtained with a 12V supply the TBA810 is much more suitable than the TBA800 for use with battery operated equipment. The TBA810 can provide output currents up to 2·5A.

Audio Circuits

Two circuits for use with TBA810 devices are shown in Figs. 9 and 10: they are very similar to the circuits shown in Figs. 2 and 3 though some of the capacitor values are larger because of the lower output impedance. The two circuits have comparable performance but that shown in Fig. 10 gives somewhat better results at low supply voltages (down to 4V). In either circuit R2 may be replaced with a 100kΩ volume control. The bias current flowing in the pin 8 circuit is typically 0·4μA and the input resistance 5MΩ (the value of R2 must be much less however to ensure correct bias...).



Figs. 5 and 6: Alternative heatsink arrangements for the TBA800 and TBA810S.



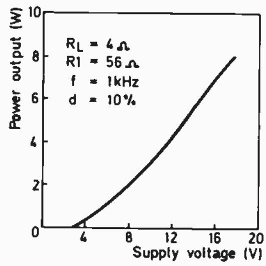
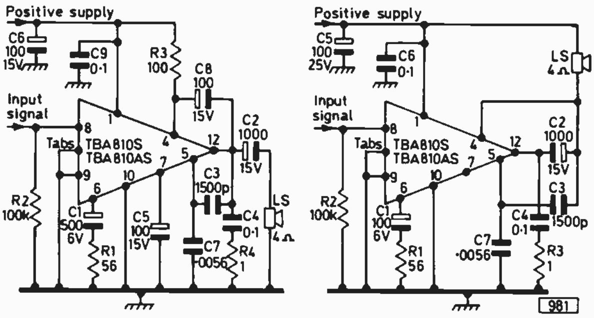


Fig. 7 (left): Outline drawing of the TBA810AS.

Fig. 8 (right): Maximum power output plotted against supply voltage for the TBA810S/AS when a total distortion of 10% at full power is acceptable.

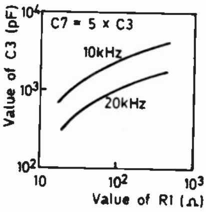


Figs. 9 and 10: Alternative audio circuits using the TBA810S or TBA810AS.

The gain decreases as the value of R1 is increased for the same reason as with the TBA800. The values of R1, C3 and C7 affect the high-frequency response. With the values shown the response is level within $\pm$3dB from about 40Hz to nearly 20kHz. Fig. 11 shows values of C3 plotted against R1 where the frequency is 3dB down at 10kHz and 20kHz and C7 is five times C3.

The output distortion with these circuits is about 0·3% for outputs up to 3W rising to about 1% at 4W, 3% at 5W and 9% at 6W with a 14·4V supply voltage.

The voltage gain is typically 70 times (37dB). Although this value is half that obtained with the TBA800 the input voltage required to produce a given output power is about the same for both types. This is because



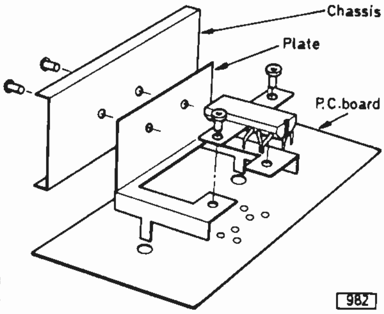


Fig. 11 (left): Value of C3 needed for use with various values of R1 when a response 3dB down at 10kHz and 20kHz is required. It is assumed that the value of C7 is five times that of C3.

Fig. 12 (right): One method of mounting the TBA810AS.

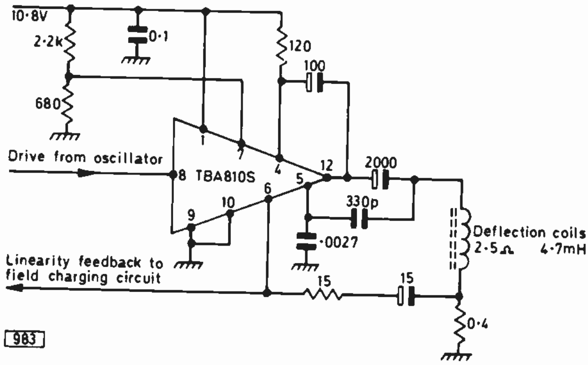


Fig. 13: Field output stage for 12-17in. monochrome receivers, using the TBA810S.

a smaller output voltage is required to drive a 4Ω load at a certain power level than is required to drive a 16Ω load.

Mounting Methods

The TBA810S may be mounted in the same way as the TBA800. One way of mounting the TBA810AS is shown in Fig. 12. It is simpler however to bolt flat heatsinks to the tabs.

Essential Precautions

Devices of this type will be destroyed within a fraction of a second if the power supply is accidentally connected with reversed polarity. When experimenting therefore it is wise to include a diode in the positive power supply line to prevent any appreciable reverse current flowing in the event of incorrect power supply connection. The diode can be removed once the circuit has been finalised.

The TBA800 is likely to be destroyed if the output is accidentally shorted to chassis. The TBA810S and TBA810AS however are protected from damage in the event of such a short-circuit even if this remains for a long time (but note that the earlier TBA810 and TBA810A versions did not contain internal circuitry to provide this protection).

The TBA800 is not protected against overheating but the TBA810S and TBA810AS incorporate a thermal shutdown circuit. For this reason the heat-sinks used with the TBA810S and TBA810AS can have a smaller safety factor than those used with the TBA800. If the silicon chip in a TBA810S or TBA810AS becomes too hot the output power is temporarily reduced by the internal thermal shutdown circuit.

As with all high-gain amplifiers great care should be taken to keep the input and output circuits well separated otherwise oscillation could occur. The decoupling capacitors should be soldered close to the i.c. —especially the 0·1μF decoupling capacitor in the supply line (this should be close to pin 1).

Field Output Circuit

Fig. 13 shows a suggested field output stage for monochrome receivers with 12-17in. 110° c.r.t.s using the TBA810S. For safe working up to 50°C ambient temperature each tab of the device must be soldered to a square inch of copper on the board. The peak-to-peak scanning current is 1·5A, the power delivered to the scan coils 0·47W, power disspipation in the TBA810S 1·8W, scan signal amplitude 4·1V, flyback amplitude 5V and the maximum peak-to-peak current available in the coils 1·75A. ■

DX–TV

—continued from page 510

for his DX work—in conjunction with a Thorn 850 chassis.

Finally an interesting letter from Anthony Mann in Australia. He too has experienced aircraft-flutter signals —usually ABSW5, BTW3 at 120 miles south and ABCW4 at 60 miles east of his home at Applecross, Western Australia. ABSW5 is received for approximately five seconds as a west-bound jet passes over his house. More often the reverse happens. As a large jet approaches the airport and crosses the line between the station and the house shallow, rapid fading occurs with a decreasing frequency of fading. Pointing the aerial at 90° to ABCW4 (minimum pickup) will give via a west-bound jet ABCW4 first on approaching the house and ABSW5 as it recedes. The Winter SpE season there was an eventful one, with the strongest openings in three years (another good sign for us in the UK?). Epic sightings were WNTV-1 Wellington NZ at 3,400 miles, Newcastle NBN-3 at 2,000 miles and Wollongong WIN-4 at 2,000 miles. WNTV were using the PM5544 card and the photograph shows an excellent, strong clear signal. During this opening AKTV-2 (Auckland NZ) was also momentarily seen. In February three Chinese ch. R1 stations were received via TE, also a Korean f.m. station on 44.9MHz. This would coincide with the reception in Cyprus of Gwelo ch. E2 mentioned in July—also via TE propagation. A new aerial has been installed—a Channel Master "Crossfire." It's a log-periodic with 11 active elements for Bands I and II, 9 Band III directors with appropriate spacing ahead of each of the first 9 dipoles, and 8 directors with folded "wiskers" covering Bands I, II and III in front of the log-periodic section itself. The device is mounted at 26ft. and connected by means of low-loss 300Ω ribbon feeder. The stations mentioned above are now regarded as local signals.

BRC 3000/3500 POWER SUPPLY common faults

PAUL E. SOANES

THE BRC (TCE) 3000/3500 single-standard colour chassis was introduced some five years ago. A number of modifications have been made since then. In this article we will deal with the power supply section. Since the circuitry is somewhat unusual we will start with a description of how the power supply system operates and then go on to report the more common faults we have encountered.

Circuit Operation

There are two stabilised lines, also an unregulated 240V h.t. line which is used for the RGB output stages. The 30V rail is stabilised by means of a simple emitter -follower series transistor while the 58-65V rail is regulated by means of a series chopper transistor. This latter is driven alternately on and off by a monostable circuit whose mark-space ratio is adjusted via a feedback amplifier as the rail voltage varies. Two electronic trips are used, one operating in the event of excessive current drain (dynamic trip) while the other (the "crowbar") operates in the event of the 58-65V rail rising to an excessive value—it triggers when the chopper output rises above 72V. A cut-out trip is connected in series with the mains supply in place of a fuse (in some very early chassis there is a fuse instead, in some chassis both).

Mains Transformer

Most of the supplies are derived from an autotransformer. This is not an isolating transformer of course and the normal live chassis precautions must be taken when servicing the chassis.

30V Supply

Taps on the autotransformer feed a full-wave rectifier (W603/W604) which supplies the 30V line. The output is smoothed by R606/C607 and then fed to the emitter-follower stabiliser transistor VT601. The operation of this is basically as follows (see Fig. 1). The smoothed d.c., approximately 40-50V, is applied to its collector while its base is held at 30V by zener diode W605. This is operated in the reverse-bias mode by the current through R608 which is fed from the 240V video h.t. rail. Since VT601 is a silicon transistor its base-emitter voltage will be approximately 0·6V when it is conducting. Thus the voltage across its emitter load will be held at around 29·4V (30—0·6).

Chopper Action

The collector of the chopper transistor VT604 is fed with approximately 300V obtained from the half-wave rectifier W602 and smoothed by R605/C606. The chopper transistor is switched on and off at line frequency by a squarewave signal from the driver transformer T602. The squarewave signal is obtained from the monostable multivibrator VT603/VT606 and its mark-space ratio varies as the 58-65V rail voltage varies. In this way the chopper transistor is switched on for longer or shorter periods. Current flows round the circuit when the chopper transistor is switched on (see Fig. 2): when it is off the voltage across its reservoir inductance L603 reverses and L603/W616 then act as an efficiency circuit, current flowing via L603, W616, chassis and the load.

The Crowbar

The "crowbar" trip consists of thyristor W621 which is connected across the input to the chopper transistor. It will conduct, thus shorting the input, only when its gate is positive with respect to chassis. Should the chopper regulated supply rise above 72V zener diode W617 will conduct and current will flow through R626. The voltage developed across R626 as a result is applied to the gate of W621 via R625. W621 conducts therefore and the cut-out trip operates. The time-constant of C618/R626 is arranged so that the crowbar does not operate as a result of flashovers.

Delay Switch

The 30V supply must be present before the 58-65V supply comes into operation. To ensure this condition the delay switch VT602 is included in series with one of the monostable multivibrator transistors. The base-emitter junction of VT602 is in series with the 30V stabiliser reference diode W605. When the 30V rail is present both W605 and the base-emitter junction of VT602 will be conducting. The purpose of this arrangement is to ensure that the monostable circuit does not operate if there is a fault condition on the 30V rail, for example W605 being open-circuit.

Monostable Circuit

The monostable circuit is driven by pulses from the line oscillator, which is powered from the 30V rail. These pulses are fed via C613 and W608 to VT603 base. W608 is included to ensure that only positive-going pulses reach VT603 base. The stable condition of the multivibrator is with VT606 conducting and VT603 cut off. The positive pulses drive VT603 on and this in turn results in VT606 being cut off through normal multivibrator action. After a period determined by the time-constant of the *CR* cross-coupling between VT603 and VT606 the latter once more conducts and the

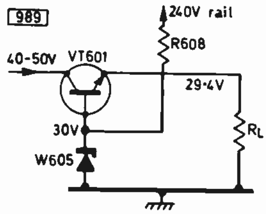
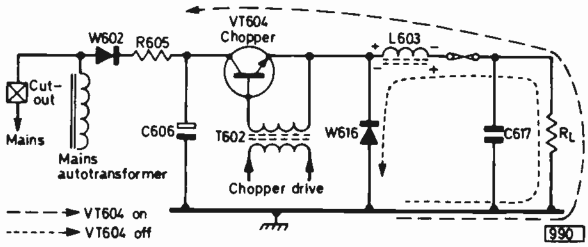


Fig. 1 (left): Operation of the series emitter-follower (VT601) which stabilises the 30V rail.

Fig. 2 (right): Operation of the chopper circuit which provides the stabilised 58-65V "h.t." rail.



former is cut off until the arrival of the next trigger pulse at its base. VT605 which drives transformer T602 conducts whenever VT606 is conducting.

Varying the Mark-Space Ratio

The time-constant of the *CR* cross-coupling network in the monostable circuit determines the mark-space ratio of the output waveform obtained from it and hence the length of time that the chopper conducts during each cycle of operation. The capacitors in the cross-coupling network are C614 and C615, the latter being returned via R621 to R637 which is the load of the feedback amplifier VT608. VT608 samples the 58–65V output rail voltage, the voltage across R637 varying in accordance with any changes in the 58-65V line. The voltage across R637 determines the charge on C615. When VT603 is driven on by the trigger pulse from the line oscillator the voltage at the cathode of W615 falls below that at its anode and it conducts, connecting C614 and C615 in parallel. Since the charge on C615 varies as the 58-65V rail fluctuates this means that the on/off time of VT606/VT603 varies and in consequence the mark-space ratio of the waveform used to drive the chopper changes.

Once the 58-65V line has been established C623 charges via R633. When it has charged to 30V W620 conducts, clamping the emitter of the feedback amplifier VT608 at this stabilised voltage. The base of VT608 is fed from a variable potential divider chain across the 58-65V rail. Hence any voltage fluctuation in this supply will appear at VT608 base and result in a proportional change in the voltage across its collector resistor R637. As we have seen the voltage across this resistor determines the charge on C615 and in consequence the mark-space ratio of the output waveform obtained at VT605 collector.

Protection Circuit

A protection circuit is included to ensure that the mark-space ratio of the chopper drive waveform is at minimum before the 58-65V supply is established—this is done to ensure that the chopper transistor is not overworked. The operation is basically as follows. The time-constant of R633 and C623 is such that following switch on VT608 is non-conducting, there is no voltage across R637 and thus no charge on C615. This means that the mark-to-space ratio of the chopper drive waveform is at minimum and the chopper is switched on for the minimum time during each switching cycle. W619 is included to rapidly discharge C623 on switch off or in the event of a sudden interruption to the supply. Since the 58-65V rail voltage drops rapidly when the supplies are removed this ensures that on restoration of the supplies the chopper drive mark-space ratio is at minimum.

Dynamic Trip

The dynamic trip consists of thyristor W622, the circuit operating as follows. The chopper current is

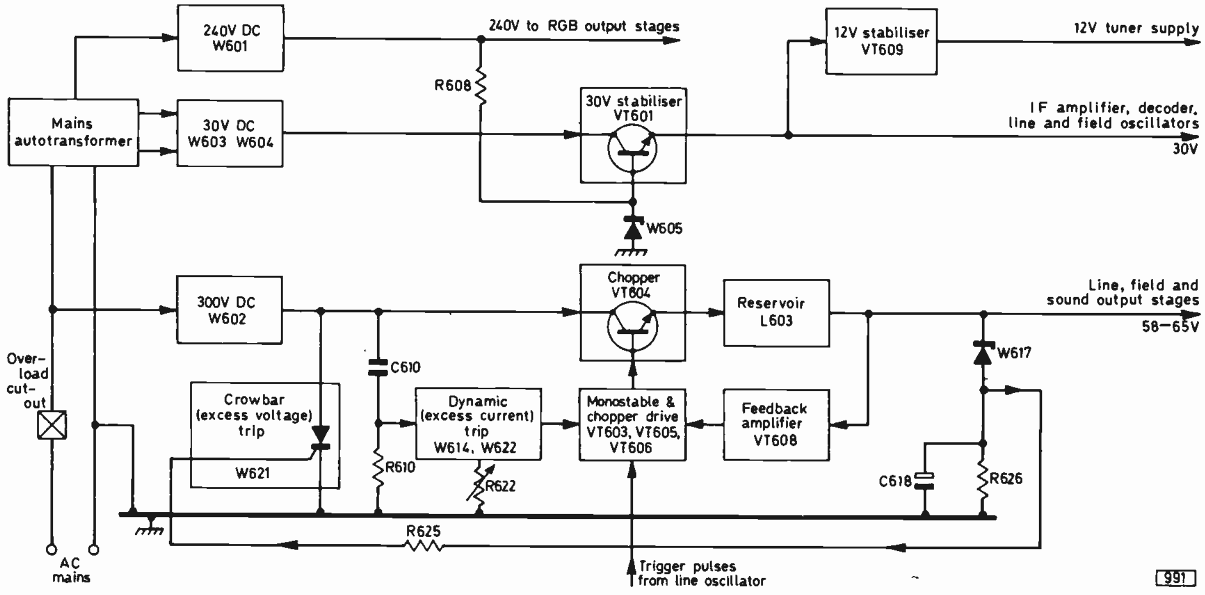


Fig. 3: Block diagram of the power supply arrangements used in the BRC/TCE 3000/3500 colour chassis.

bypassed by C610 and R610, resulting in an a.c. voltage being developed at the junction of these components. If the current drawn by the chopper transistor is excessive this voltage increases. The cathode of thyristor W622 is returned via W614 and R611 to the junction of C610 and R610. If the negative-going excursions of the voltage at the junction of C610 and R610 exceed the voltage at the gate of W622 the thyristor fires, coupling VT605 collector to chassis via R611 and R610 and thus removing the chopper drive. If the overload is moderate the dynamic trip will reduce the chopper drive and the set may continue to operate in this "tripped" state but the 58-65V rail will be very low

Miscellaneous Details

VT609 stabilises the 12V line that powers the tuner —this supply must be stable in order to prevent oscillator drift.

Protection is incorporated in the 240V line to the RGB output stages by means of the fusible resistor R602.

The block diagram (Fig. 3) is included to assist in identifying the various sections of the power supply circuit.

Cut-out Trip Operating

The cut-out will operate when a severe overload is placed upon it. In most cases the reason is one or more components going short-circuit. Shorted turns on the autotransformer will of course have this effect and this does occasionally occur. A far more common occurrence is that rectifier W602 or the chopper transistor VT604 (type R2010B) goes short-circuit. If the chopper transistor goes short-circuit it is worth checking W616 since if this is also short-circuit the replacement chopper transistor will be damaged. If the chopper choke L601 has shorted turns, the crowbar thyristor W621 is faulty, the 72V zener diode W617 goes short-circuit, C610 goes leaky or short-circuit or diode W615 in the mark-space ratio control circuit goes short-circuit the resultant overload will throw the cut-out trip.

A fault in the feedback circuit can also result in the cut-out operating if the feedback amplifier opens the monostable mark-space ratio beyond its normal operating point. A quick check that can be made to prove that the fault is in this part of the circuit is to disconnect one end of R621. On switch on the 58-65V rail will be low due to the monostable operating at minimum mark-space ratio (no charge on C615). The fault is then isolated to a few components in the feedback amplifier circuit—quite often the transistor VT608 is the culprit.

No Results, HT at VT604 Collector and F603 Intact

The symptoms of no results but h.t. at VT604 collector and fuse F603 intact can be due to a fault in the 30V rail. Faults that we have experienced here and are worth checking are C607 going open-circuit giving low voltage at VT601 collector, VT601 going open- or short-circuit and zener diode W605 going open- or short-circuit. If W605 goes short-circuit transistor VT602 will probably be damaged as approximately 35V will be applied to its base. Should VT602 go open-circuit its base voltage will rise to around 7V.

Faults other than those in the 30V supply can cause the same symptoms. In this case an oscilloscope to monitor the waveforms around the monostable circuit is an asset. We have experienced faults in all three transistors here, VT603, VT605 and VT606—possibly the most common occurrence is the driver transistor VT605 going open-circuit. VT604 can also go open-circuit of course. The chopper driver transformer T602 sometimes has dry-joints around its connections—frequently this causes intermittent troubles. Another common place to find a dry-joint or broken connection is on the driver transistor.

58-65V Rail Low

The symptoms when the 58-65V rail is low are lack of width and field foldover. The fault can be due to the feedback amplifier being inoperative or the dynamic trip over-riding it. To ascertain which circuit is faulty again disconnect R621 but this time connect an adjustable 9V d.c. supply to this resistor—negative to chassis. By increasing this supply (monitor the output at F603) the output from the chopper should be found to increase. If this is the case the fault is in the feedback amplifier therefore, the transistor itself (VT608) being the most likely culprit. If the 58-65V supply does not increase however the fault will probably be due to the dynamic trip thyristor W622 or to W615 or C615 being faulty.

Ringing

Ringing in the power supply is a fault that frequently occurs, often due to the electrolytic capacitor C619 going open-circuit. Similar symptoms can be traced to either C631 or C616 being open-circuit or, on the odd occasion, zener diode W618 being faulty.

Fuse Blowing

Under normal operating conditions the chopper supply current is approximately 2A. Should this figure be grossly exceeded F603 (2·5A) will blow. It is unusual for the fault to be in the power supply but it may be beneficial to check C617 and C619 in case they are short-circuit. The fault is usually on one of the other panels however. Common causes are a faulty line driver transistor (VT503) or the c.r.t. first anode supply reservoir capacitor (C523) being short-circuit. One quick check to see whether the fault is on the field timebase/sound panel is to operate the set-white switch on the video panel to the set-white position: if on switching on the fuse is intact the fault is on this panel. The voltage, which should be about 1·3V, across R907 on the beam limiter board gives a quick indication of the line output stage current consumption (this does not include the driver stage).

Under normal conditions the current drain from the 30V supply is 400mA: should F602 blow W620 and C624 are worth checking.

To Follow

We shall be following up with reports on the other sections of this chassis in due course.

Complete Circuit ➔

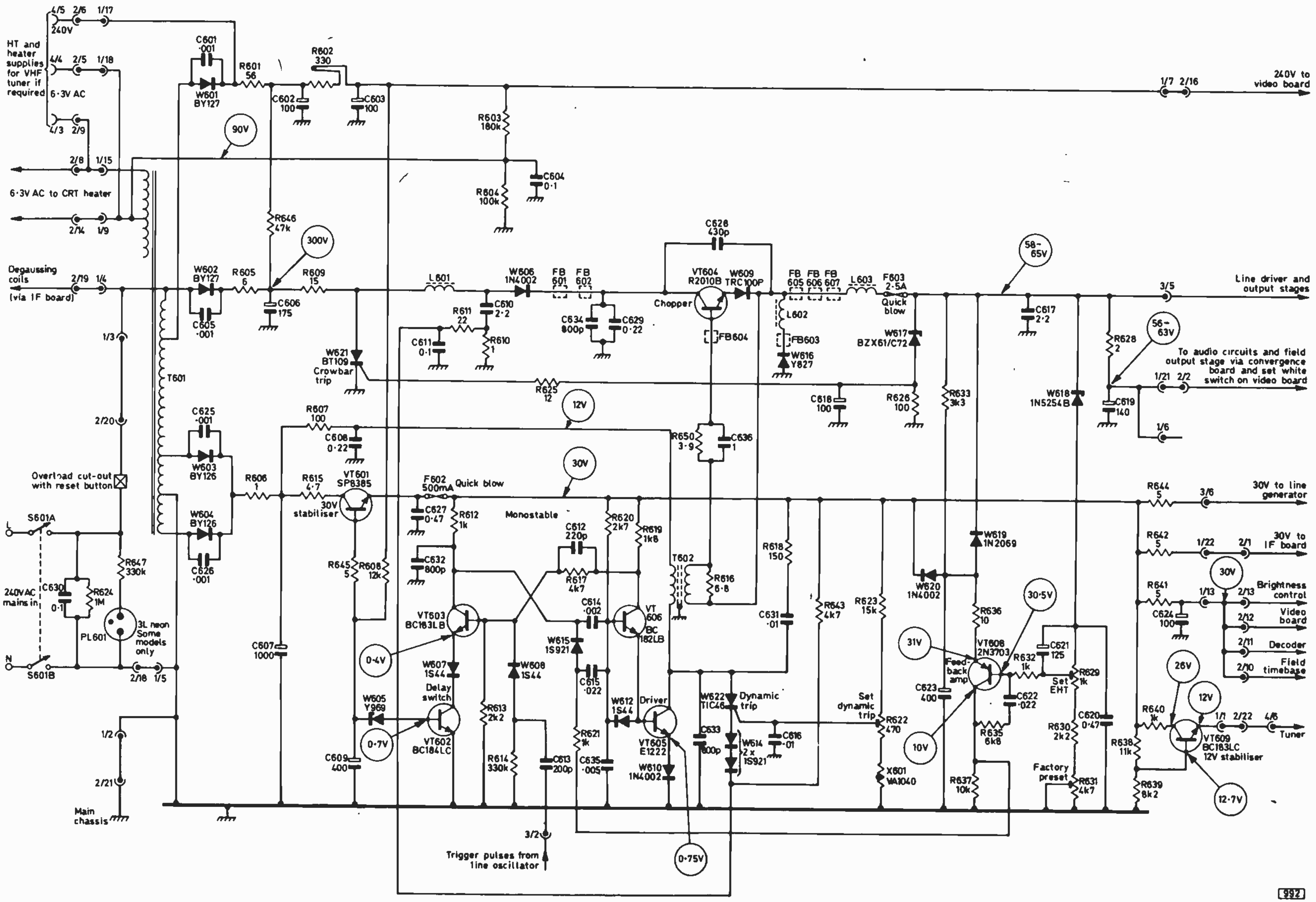
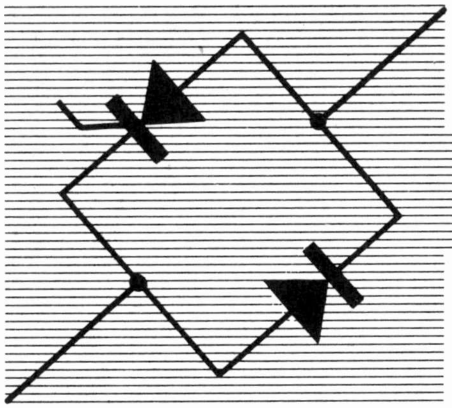


Fig. 4: Complete circuit of the power supply used in the BRC/TCE 3000/3500 chassis. Some of the component values found may vary slightly from those shown above. In earlier versions W602 is fed from the same tap on T601 as W601: the voltage at the junction R605/C606 is then about 235V.



thyristor LINE TIMEBASE operation

RICHARD COLLINS

THE massive demand for colour television receivers in the UK last year brought about an influx of sets from the continent. Many of these use the thin-neck (29mm) type of 110° shadowmask tube. Scanning of these tubes is accomplished by means of a toroidally wound deflection yoke (conventional 90° and thick-neck 110° tubes operate with saddle-wound deflection coils). The inductance of a toroidal yoke is very much less than that of a saddle-wound yoke, thus higher scan currents are required. The deflection current necessary for the line scan is about 12A peak-to-peak. This could be provided by a transistor line output stage but a current step-up transformer, which is bulky and both difficult and costly to manufacture, would be required. An entirely different approach, pioneered by RCA in America and developed by them and by ITT in Germany, is the thyristor line output stage. In this system the scanning current is provided via two thyristors and two switching diodes which due to their characteristics can supply the deflection yoke without a step-up transformer (a small transformer is still required to obtain the input voltage pulse for the e.h.t. tripler). The purpose of this article is to explain the basic operation of such circuits.

The thyristor line output circuit offers high reliability since all switching occurs at zero current level. C.R.T. flashovers, which can produce high current surges (up to 60A), have no detrimental effects on the switching diodes or thyristors since the forward voltage drop across these devices is small and the duration of the current pulses short. If a surge limiting resistor is provided in the tube's final anode circuit the peak voltages produced by flashovers seldom exceed the normal repetitive circuit voltages by more than 50-100V. This is well within the device ratings.

The basic thyristor line output circuit is shown in Fig. 1. The scan diode D2 and thyristor TH2 provide control over the current in the line coils (L3) during the forward scan period while the commutating diode D1 and thyristor TH1 start the flyback and control the deflection current during this period. Inductor L2 with capacitors C1, C2 and C3 provide timing and energy storage. The primary of the input transformer L1 provides a charging path for C2 from the h.t. line while the secondary supplies the gate pulse which, shaped by Cg, Lg and Rg, triggers the scan thyristor TH2. C2 also optimises the flyback time by resonant action with L2.

The deflection cycle is best described as a sequential process each stage of which involves a change in the conduction state of some of the switching devices. In the following description the functions of C1 and the e.h.t. transformer T1 with its associated capacitor C4 are ignored to start with in order to simplify matters.

Since scanning is a continuous process there is no actual "start". It is necessary to break into the cycle at some convenient point therefore, say time T0 in Fig. 2. At this time a magnetic field has been set up around the line scan coils (L3) as a result of the circuit action during the preceeding flyback. This magnetic field decays, generating a decreasing scan current which flows through D2 and charges C3. The current drops to zero when the stored energy has been expended, i.e. at time T2.

Whilst the current is decreasing, just before time T2 is reached, the scan thyristor TH2 is prepared for conduction by applying a positive pulse to its gate. TH2 does not conduct however until forward bias is applied between its anode and cathode, i.e. during the second half of the scan period. At time T2 capacitor C3 begins to discharge into the deflection coils (see Fig. 3). The circuit current reverses, D2 is reverse biased and cuts off while the scan thyristor TH2, already primed by the application of the gate pulse, is now forward biased and conducts providing a path for the discharge of C3 into L3. C3 must be of adequate value to provide a constant current so that the ramp current waveform produced during the scan period is linear.

Just before the end of the scan period, at time T3 —see Fig. 4(a)—the commutating thyristor TH1 is switched on by a gate pulse provided by the line oscillator. C2 which had previously charged from the h.t. supply then discharges through the commutating coil L2 and thyristor TH1. The discharge current builds up in the form of a half sinewave pulse because L2 and C2 form a resonant circuit. When this commutating current reaches a level in excess of the scan current D2 is once again forward biased, the forward voltage drop across it reverse biasing the scan thyristor TH2 which thus switches off. The situation is shown in Fig. 4(b). This process occurs during times T4-T5. At T5 the commutating current no longer exceeds the scan current and D2 switches off. Thus both elements of the scan switch—D2 and TH2—are switched off.

The large amount of energy stored in the deflection coils then forces a current through the commutating circuit—C2, L2 and TH1 (see Fig. 5). This energy is transferred to C2, reversing the polarity of the charge held by it. The energy transfer takes the form of a resonant oscillation: the current in the scan coils falls to zero and once C2 has charged to its maximum value (time T6) the current in the scan coils reverses, the

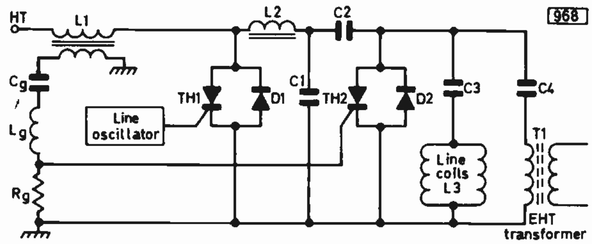


Fig. 1: Basic elements of the thyristor line timebase used with thin-neck 110° shadowmask tubes.

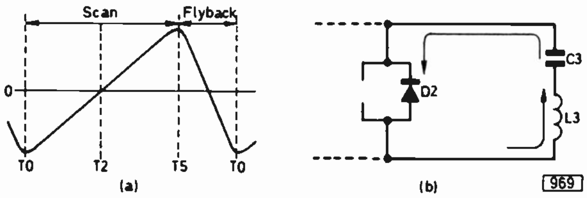


Fig. 2: (a) Output current waveform. (b) Current path during the period T0-T2.

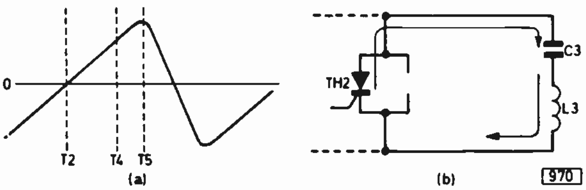


Fig. 3: Condition of the circuit between times T2 and T4, with TH2 conducting.

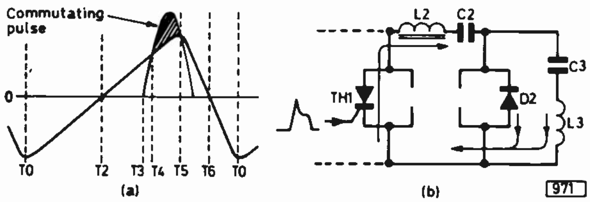


Fig. 4: Thyristor TH1 is triggered by a pulse from the line oscillator at time T3. When the amplitude of the commutating pulse exceeds that of the scan current (time T4) D2 switches on again and TH2 is switched off.

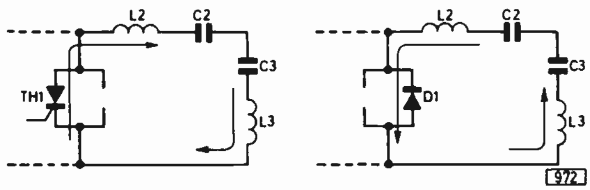
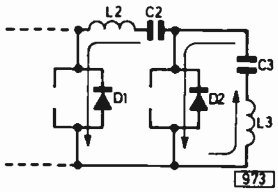


Fig. 5 left): Between times T5 and T6 TH1 conducts while D2 and TH2 are both cut off.

Fig. 6 (right): Between times T6 and T0 D1 provides the flyback current path.

charge stored by C2 flowing back again (see Fig. 6). Commutating diode D1 provides the return path for this reverse current flow, the voltage developed across D1 turning TH1 off. The voltage across C2 decreases

Fig. 7 (right): Condition of the circuit at the change-over from flyback to scan (time T0), with D2 taking over from D1.



as the current in the coils builds up and at time T0 the voltage is insufficient to drive current through L2, C2 and the coils. The current then finds an easier path (see Fig. 7) through scan diode D2 and we are back at the start of the next forward scan period.

Once the conduction of D2 divorces the scan coil current from the commutating circuit the commutating current rapidly decays, the energy stored in L2 re-charging C2 to its initial voltage—the transfer occurs quickly since the resonant frequency of L2 and C2 is high.

Summarising these actions then, D2 conducts during the first part of the scan period, from time T0 to T2, TH2 taking over at time T2; at time T3 TH1 is switched on and at time T4 D2 conducts again while TH2 cuts off. At the beginning of the flyback time, T5, D2 cuts off, TH1 conducting from T5 to T6 when D1 takes over until T0 when D2 switches on again to start the next forward scan period.

The input coil L1 plays a vital role in supplying energy to the commutating circuit and providing the turn-on action for TH2. During the flyback period the primary winding of L1 is connected between h.t. and chassis via either TH1 or D1. During the scan period however neither TH1 nor D1 is conducting (till T3) and this earth return path is open-circuit. This enables the commutating capacitor C2 to be charged by the energy stored during the flyback period in the input coil. This charging process continues during the scan period until just before the flyback. The charge stored in C2 then supplies energy to the scan circuit.

The waveform generated across L1 primary as C2 charges is applied via the secondary winding on L1 and the shaping network (Cg, Lg, Rg) to the gate of the scan thyristor TH2. The resulting pulse is timed to "prime" the thyristor so that it conducts as soon as it is forward biased—about half way through the scan period.

The purpose of C1 is to help turn off TH2, speed up the flyback time and provide an additional energy store. While TH2 or D2 conduct C1 is connected in parallel with C2. During the flyback time when TH2 and D2 are off C1 is effectively in series with C2 and L3: this decreases the capacitance in the circuit, increasing the resonant frequency and thus reducing the flyback time.

The e.h.t. transformer T1 is connected across the deflection yoke via the coupling capacitor C4. The pulse voltage produced by the fast collapse of the magnetic field around the yoke during the flyback is transformed to approximately 8·6kV peak. This is applied to an e.h.t. tripler which provides the usual 25kV.

Practical circuits are somewhat more complex than the basic circuit shown in Fig. 1, thought they are readily recognisable. The main addition required for practical use is circuitry to stabilise the e.h.t./width. This consists of a feedback amplifier which senses the h.t. and the amplitude of the flyback pulses developed by the e.h.t. transformer and applies correction by means of a transductor. This is generally used to adjust the input to the circuit via L1. Waveform shaping networks to provide linearity correction are also required. ■

YOUR PROBLEMS SOLVED

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EKCO T541

Although this is a new set there is considerable field hum on sound. The field output transformer was very noisy but I have managed to suppress this mechanical noise by packing etc. The field hum on sound appears even with the volume control at zero—I have established that it is field hum by putting the field timebase in and out of lock in order to distinguish between this and mains hum. Sound comes on first, free of hum, and the hum appears when the field oscillator starts.—K. Renfrew (Ryde).

It seems that the buzz is getting back through the h.t. smoothing, so the main smoothing block could be defective (make sure that the connections are good as well as the capacitance value). In recent production C49 (16μF) and C50 (32μF) have been transposed to improve the smoothing in the audio circuits. (Pye 769 chassis.)

FERGUSON 508T

The problem with this set is that resistors R31 and R32 overheat and give off smoke. I found that by disconnecting the tuner i.f. output lead from the i.f. board the overheating ceased.—J. Check (Bolsover).

These two resistors on the i.f. deck provide the h.t. for the pentode anode of the PCF80 frequency changer in the tuner unit. This valve could be faulty or the feedthrough capacitor C22 (10pF) defective.

DECCA CS2630

There is an intermittent fault on this set—a green cast appears on the screen. Sometimes it appears for only a few seconds, at others it remains until the set is switched off. The other colours are not affected. The fault does not occur every time the set is switched on—in fact the set has to be on for about an hour before it appears. The colour control has no effect on the cast which is also present on monochrome.—T. Stanson (Barking).

Since the inputs to the RGB output transistors are d.c. coupled from the MC1327P chrominance demodulator/RGB matrix and preamplifier i.c. there is not a great deal that could cause this problem. The G drive/bias controls VR317/VR321 could be faulty, as could the G output transistor TR216. Also check for dry-joints in this area. (Decca series 30 chassis.)

PHILIPS G20T322/01

A problem we have had with some of these sets is blown mains fuses for no apparent reason. In each case no short-circuits could be traced and the mains filter capacitor and bridge rectifier have been in order.—J. Yardley (Cheam).

You could have been involved with early versions of this chassis. Note that the bridge rectifier is followed by a thyristor—in the now conventional control loop—to rectify the 100Hz pulses from the bridge. Early thyristors were black bodied and none too reliable. The later, more reliable thyristor used has grey encapsulation and does not require a heat-sink. When this thyristor is used the mains fuse should be changed to an anti-surge 1·6A type. We suggest you make sure that the improved thyristor and up-rated fuse are fitted. For greater reliability the BY179 bridge rectifier could be replaced by four separate BY126 rectifiers connected as a bridge. (Philips 320 chassis.)

BUSH TV141

When the set is switched on there is a thin white line across the screen though the sound is normal. After about half an hour the picture opens out, giving normal height, but after another hour and a half the field again collapses and nothing will bring it back. The PCL85 field timebase valve, field charging capacitor 3C30 and field hold control have all been replaced but the fault is still present.—R. Golding (Birmingham).

You will almost certainly find that the trouble is due to a faulty track on the vertical timebase board from the PCL85 base upwards. We cannot say which particular track is at fault but it should not be too difficult to find it with a little probing and the application of pressure. The actual track itself may not be at fault: it is often the case that a blob of solder that appears to be making good contact with a track is not actually doing so.

ULTRA 6811

The brightness on this set is very unstable. It is difficult to obtain adequate brightness without a series of bright, diagonal parallel lines appearing on the screen and once the controls have been set to give this result the brightness shortly after drops suddenly to almost complete darkness. The display is more stable if left too bright but this occasionally results in rapid flickering.—G. Shaw (Otley).

The origin of the fault could be mechanical: the large, flat plate chassis is inclined to have hairline cracks in the print and also dry-joints. So check the connections carefully with a magnifying glass, also all interconnecting leads. The fault could on the other hand be due to a valve, valve base, poor decoupling or a faulty transistor. There is unfortunately no "instant diagnosis" for a fault like this. The diagonal lines could indicate that the field flyback blanking pulse coupling capacitor C86 is faulty—check this and also C87 in the blanking circuit. Check the voltages at the c.r.t. base in case any variations from the correct readings give a clue as to the area in which the fault lies. The e.h.t. tray or the c.r.t. itself could just possibly be faulty. (BRC 1500 chassis.)

KB CB701

This set gives perfect reception on BBC-2 and ITV but on BBC-1 it spasmodically drifts or "flicks" from colour to monochrome and back again. This happens throughout the viewing time, even over a period of several hours. In extreme cases there is loss of field hold and the sound volume is reduced. The colour can be restored by retuning, but the fault recurs. Often the fault starts with a slight fluttering of the picture. The colour picture is perfect between the unstable intervals. Thinking it might be press-button switch trouble I tuned a spare channel through all three station frequencies and found exactly the same conditions—perfect BBC-2 and ITV, instability on BBC-1.—E. Donaldson (Havant).

Problems do arise with this chassis due to the zener diode (D11) which stabilises the 33V tuning line. It may be one of two entirely different types, a large stud-mounted zener fixed to the metal frame below the sound output transformer or a small i.c. mounted on the printed circuit board beside the i.f. preamplifier can. Try a replacement, using the same type. If the fault persists an exchange tuner should be fitted—no attempt should be made to service the tuner. (ITT CVC5 chassis.)

RGD 619

Everything is normal for about ten minutes after the set is switched on, then the picture starts to roll upwards at about 100 to 120 flicks a minute. The field hold control is set at its extremity. The field timebase and sync separator valves have been replaced without making any difference.—T. Donovan (London SE12).

Note that the field hold control is connected between the grid of one section of the multivibrator circuit and a potential divider across the h.t. line. The most likely cause of the fault is that the upper resistor of this potential divider, R93 3·9MΩ, has changed value. We suggest you change it and if this is not effective replace the associated grid coupling capacitor C75 (0·04μF).

FERGUSON 3641

The faults on this set have been present for some months now without getting any worse. They are that on first switching on from cold the height is too great, though the height and linearity are correct after this, and there is lack of width—about half an inch at either side of the screen. The width control is set to maximum and I have fitted new valves in the field and line timebases. The h.t. voltage remains at the correct figure at all times.—P. Logan (Matlock).

It seems likely that the filter resistor R127 (220kΩ) in the boost feed to the height control is changing value. It would also be worth checking the associated decoupler C100 (1μF), R102 (330kΩ) in series on the other side of the height control and R133 (330kΩ) in series with the width control. (BRC 950 chassis.)

FERRANTI T1093

The problem with this set is field instability—the picture rolls and can be locked with the field hold control but soon starts to roll again. The setting of the field hold control is quite critical—a mere touch either way is enough to disturb it. There are sometimes white flyback lines over all or part of the picture width when the picture rolls. If left alone the picture will stabilise—at present it rolls two or three times slowly, then remains stable for a minute or so.—R. Skinner (Chesterfield).

The difficulty should be solved by replacing the interlace diode (V16) which is near the preset vertical amplitude control on the lower part of the panel. Almost any small-signal silicon diode will do. (Pye 11U series.)

PHILIPS 19TG171A

The trouble with this receiver is lack of brightness, more so on 625 lines. On a blank raster a dark patch is visible in the centre of the screen—about 4in. in diameter. Thinking that the tube was faulty I fitted a new one. The voltage at pin 3 of the c.r.t. is low but all else seems to be in order.—T. Milne (Aylesbury).

The problem seems to be due to inadequate line timebase output, especially as it is worse on 625 lines. It is always worthwhile in these receivers checking the two 8·2MΩ resistors R427 and R457 (grey-red-green) in the width circuit. They are situated above the width controls and tend to increase in value. After replacing these, check the line output stage generally (valves etc.). The low c.r.t. pin 3 voltage is likely to be the result of its 0·05μF decoupling capacitor C108 being leaky. (Philips Style 70 chassis.)

PYE 95

When the set is switched on the picture and sound are normal but after two or three minutes the picture begins to fade until there is no raster at all. At the same time that the picture is fading a "short" starts to build up in the DY802 e.h.t. rectifier—when the raster has completely gone the "short" is more or less all over the DY802. A new DY802 was fitted but made no difference.—C. Young (Salford).

It seems that the heater supply to the DY802 is dying. You will find a small 1·2Ω resistor inside the DY802 base connector: this could be faulty or dry-jointed. (Pye 169 chassis.)

BUSH TV125

I am having difficulty obtaining flywheel line sync discriminator diodes for this set. Are there any equivalents, and what is the correct procedure for adjusting the discriminator phase control 3RV1?—K. Hadley (Lowestoft).

We suggest you use two BA144 diodes to replace the flywheel sync discriminator block, ideally with a 15kΩ resistor in series with each though this is not completely necessary. To adjust 3RV1 disconnect 3C9 so that the sync pulses do not reach the flywheel sync circuit then set 3RV1 for a hovering picture. Reconnect 3C9 and reset 3RV1 for adequate line hold control pull-in range.

SOBELL ST196DS

The initial problem with this set was sound but no picture. A replacement PY800 boost diode restored the e.h.t. but the picture, though filling the screen, is very weak. The e.h.t. rectifier has been replaced and the voltages around the timebase panel all seem to be correct. The sound is good.—H. Richards (Enfield).

We suggest you check the following voltages: video amplifier anode (PCL84 pin 6) 140V; c.r.t. grid (pin 2) 0-100V (varies with brightness control); c.r.t. cathode (pin 7) 90V; c.r.t. first anode (pin 3) 470V. The boost voltage measured at the junction R127/C139 should be 770V with the set boost control P11 set near midway—if this is very low suspect R125 (470kΩ) in series with this control and R126 (1MΩ) connected to its slider. Check R136 (470kΩ) in series with the brightness control and C145 (0·022μF) which decouples its slider.

BUSH TV145

The trouble with this set is dark vertical bands down the left-hand side of the picture.—J. Smithers (Timperley).

The most likely cause of the striations on the left of the raster is that the line linearity coil is ringing due to its parallel damping resistor 3R28 (4·7kΩ) being open-circuit or of changed value. The trouble could also be due to a faulty valve or even an aerial problem however.

PUBLISHER'S ANNOUNCEMENT

Readers may have learnt by now of the difficulties recently experienced in the printing industry. We are aware of the inconvenience that delayed publication causes our many thousands of loyal readers and our advertisers and sincerely regret this.

VAT

This issue was prepared before the revised VAT rate was announced. Inclusive prices shown in advertisements in this and previous issues are based on the old rate therefore. With effect from July 29th VAT was changed to 8% on all taxable goods and services. Allowance should be made as appropriate by deducting an amount equal to 1/55 of the 10% rated inclusive price. Zero rated goods are not affected.

FERGUSON 3622

This set gives excellent reception on BBC-1 but on BBC-2 the picture is very grainy and lacks definition despite a good aerial being used. The sound is all right. —T. Grainger (London W4.)

When the picture is grainy suspect inadequate aerial input or a faulty r.f. amplifier in the tuner. First check whether the coaxial downlead has come adrift anywhere as often happens and that the lead end is making good contact with the aerial plug. Try connecting the 405-line aerial to the 625 socket to see what results—if any—are obtained. If BBC-2 then comes in fair or even tolerable this suggests a defect in the 625-line aerial installation since the u.h.f. aerial should give far better results on BBC-2 than the v.h.f. one. If you are receiving both BBC-1 and BBC-2 on u.h.f. however the aerial might need adjustment for optimum position or could be a type with inadequate bandwidth. If aerial problems are ruled out change the PC88 in the u.h.f. tuner—also the PC86 if necessary—and make sure that the h.t. supply to it is correct (approximately 165V at pin 5 of plug/socket 304). R168 (1·4kΩ, 1W) in the h.t. feed to this socket can increase in value. If the trouble is still present the u.h.f. tuner is probably defective. (BRC 850 chassis.)

PYE 86

We were experiencing sound distortion on this set so a new PCL86 sound output valve was fitted. This improved the sound but there is still some distortion after the set has been on for a while.—T. Dance (Grimsby).

The tuning of the 6MHz quadrature coil L11 near the intercarrier sound i.c. is quite critical—try tuning it for maximum undistorted sound (only slight adjustment should be necessary). If the i.c. fitted is a TAA570 try fitting a 4·7kΩ resistor between pins 5 and 6 (assuming that one is not already fitted). Since you have found it necessary to replace the PCL86 it would be advisable to check its 150Ω cathode resistor (R54). (Pye 169 chassis.)

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TELEVISION SEPTEMBER 1974

TEST CASE

141

Each month we provide an interesting case of television servicing to exercise your ingenuity. These are not trick questions but are based on actual practical faults.

? *The symptom reported on a Bush Model CTV184S was picture fade-out after a few minutes of normal operation. Preliminary tests in the customer's home proved this to be the case, the receiver operating normally on both vision and sound for about three minutes after switch-on from cold. The raster then suddenly evaporated, leaving normal sound however.*

The effect was that of line timebase failure and subsequent tests proved that the line oscillator ceased to operate when the symptom occurred. The chassis employs three transistors in the line oscillator circuit (see Fig. 4, page 422, July). One of these transistors (5VT3) is connected via a 100Ω resistor (5R20) between the base circuit of the line oscillator transistor and chassis.

The three transistors were partially disconnected from circuit and checked; all were normal, in terms of forward and reverse conduction of their emitter and collector junctions at any rate. It was then accidentally discovered that by disconnecting 5R20 the line oscillator stage came to life and the receiver then performed normally.

Further investigation revealed a miniature neon connected on one side to 5VT3 base through a 5·6kΩ resistor (5R15) and on the other to a potential divider across the h.t. line. Reconnecting 5R20 and then disconnecting 5VT3 base circuit also restored line drive.

● *What is the purpose of the neon in this circuit and what was the most likely cause of the fault, bearing in mind the conditions given above? See next month's* TELEVISION *for the answer and for a further item in the Test Case series.*

SOLUTION TO TEST CASE 140

Page 475 (last month)

When the field synchronisation is affected by changes in the overall brightness of the transmitted picture the likelihood—in spite of reasonable line lock—is that the sync separator is not working correctly. The tendency however is to assume that the sync separator is normal and to concentrate attention on the field sync integrating, coupling and if used amplifying circuits.

In the case of the Ekco Model T530 attention was ultimately directed back to the sync separator stage, where careful tests with a high-impedance voltmeter set to a low-voltage range showed that while the collector voltage was normal the base voltage was slightly low—just under 200mV instead of the correct 250mV. positive with respect to chassis.

The circuit showed a 4·7MΩ base bias resistor which when measured out of circuit was found to have a value more like 20MΩ! Replacement brought the base voltage back to normal and produced very solid field lock. The lesson then is not to overlook the sync separator stage when a field sync fault is accompanied by good line lock.

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