Practical TELEVISION

JANUARY 1968

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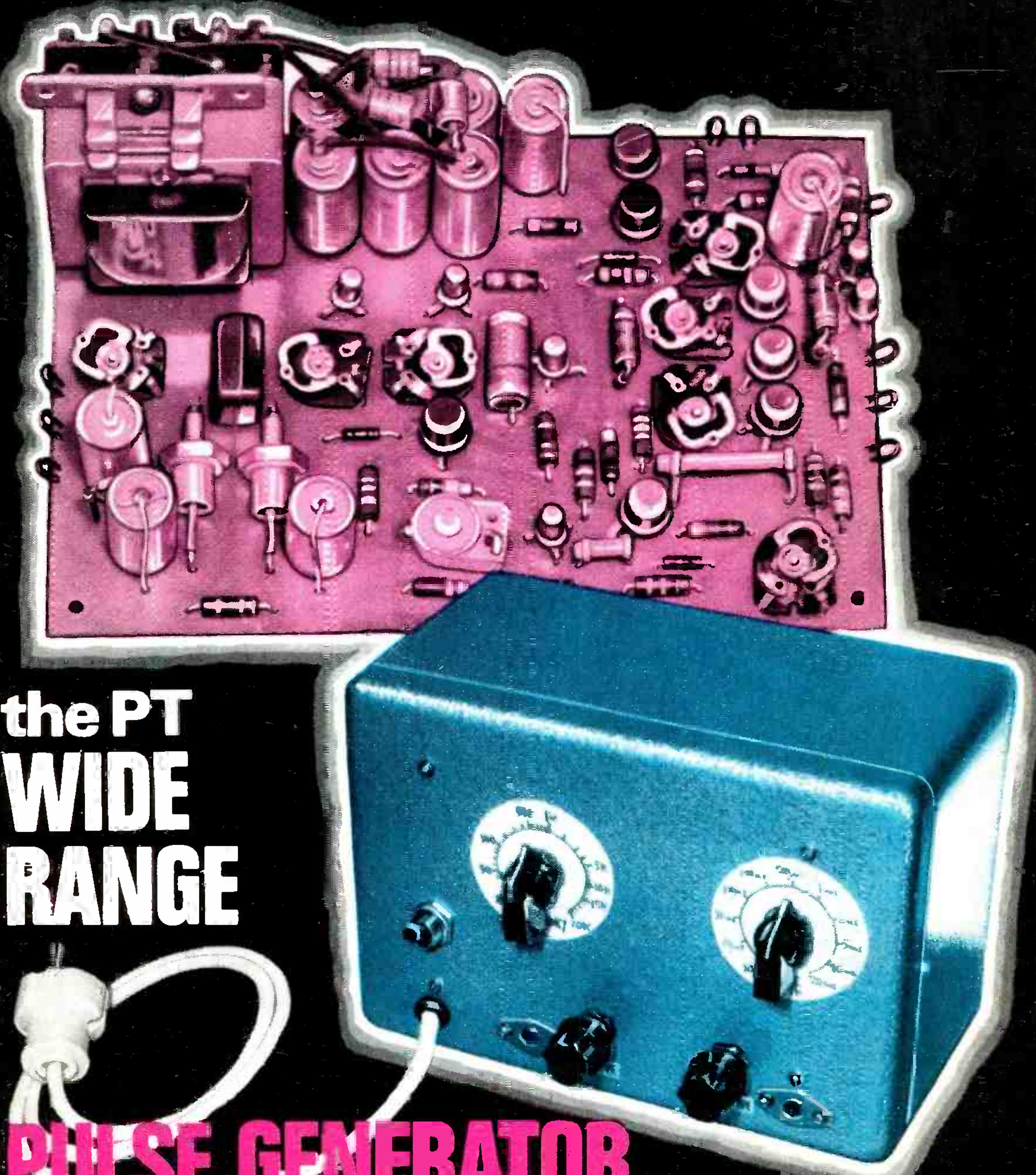

the PT WIDE RANGE PULSE GENERATOR

Practical Television

Ideas for 1968

IN one sense we are now back where we were a generation ago. Then, the TV service had just started up again after the war and the man who owned a television set basked in the glory of his status. Today, the few who own colour receivers find themselves in the same exalted position. Then, as now, the proud possessor of the latest receiver is discovering many long-lost friends!

For the home constructor, however, the situation is different. In those early post-war years a veritable mountain of surplus equipment was modified, adapted and transformed into workable TV receivers and in a multitude of homes six-inch green-trace VCR97s, with magnifying lenses, flickered nightly.

Today, alas, there are no convenient pieces of cheap equipment to convert into colour sets, nor is the construction from standard components an economically favourable proposition to the average enthusiast, even assuming he has the knowledge and facilities to build such a complex piece of electronics.

Nevertheless there is still much that can afford relaxation to the constructor. Among the projects published in PT over the last year were a bar and pattern generator, an aerial intercom unit, various aerials, a multiplexer, a wide range wobbulator, a pre-amp baby alarm, a transistorised e.h.t. meter, a u.h.f. aerial pre-amplifier, integrated circuit test oscillator, a wide range pulse generator. Other interesting projects are already in the pipeline for future publication.

Many of our supporting articles have provided ideas and circuitry for the experimentally minded. And, of course, PT has always been strong on articles with a servicing flavour. So, if you cannot yet build a colour receiver, there is plenty of opportunity to take an active and practical interest in television in 1968!

A Happy Christmas and a Successful New Year

from the Editor and Staff of
Practical Television

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JANUARY 1968
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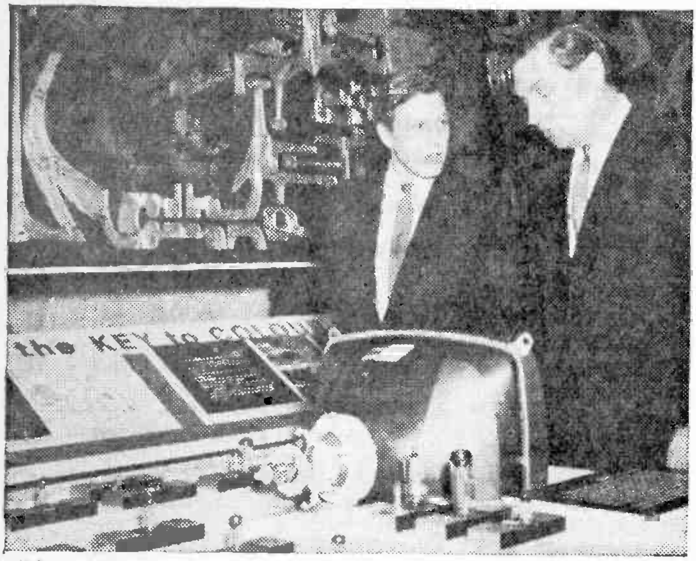
THIS MONTH

THE NEXT ISSUE DATED FEBRUARY WILL BE PUBLISHED ON JANUARY 19

TELETOPICS

THE COLOUR TV FAIR



THE Colour TV Fair, sponsored by Mullard Ltd., which was held at Mullard House, Torrington Place, London, W.C.1, from November 17 to December 2 was opened by David Attenborough, Controller of BBC-2. Mr. Attenborough was introduced by Dr. F. E. Jones, M.B.E., F.R.S., managing director of Mullard Ltd.

Colour receivers by Alba, Baird, Bush, Decca, Derwent, Dynatron, Ekco, Ferranti, G.E.C., Murphy, Philips, Pye, Rediffusion and Stella could be seen working in separate room settings and throughout the run of the Fair, these sets displayed normal BBC colour launching programmes, or special material brought by GPO landline from the Lime Grove Studios, or programme material supplied through the ITA by the Independent television companies, or the output of the Fair's studio.

One of the highlights of the Fair was an interview studio, where visitors were able to appear on closed-circuit colour TV and, from time to time, see visiting celebrities.

In the Mullard House Theatre, the company's 16-minute film, *Colour Television* was screened every half-hour daily from 10.30 a.m. This film described in general terms how colour television works.

Picture shows David Attenborough (left) with Dr. F. E. Jones.

BRITISH COLOUR TV GROUP AT MILAN FAIR

TWO senior engineers of the Plessey Components Group's Wound Components Division at Titchfield, Hampshire, have been in Milan attending the Fifth Technical Convention on Electronic Components recently (September 12 to 14, 1967)—the most important gathering of colour television experts yet arranged.

Mr. Arthur W. Lee, presented a paper on "Advances in line output stage techniques", and Mr. Peter H. Phillips, gave a paper on "Considerations in the development of a deflection coil for 90° shadow mask colour cathode ray tubes". The convention was attended by leading figures in colour television from all the major industrial countries of the world.

SWEDEN'S SECOND TV PROGRAMME

THE Marconi Company has received an order worth nearly £½ million from the Swedish Telecommunications Administration (S.T.A.) for the supply and installation of 13 u.h.f. transmitters, which will play a major role in the launching of Sweden's second television programme service. Although the transmitters are to be operated singly at present, they are suitable for parallel operation and may be operated as such without modification.

The equipment for the Swedish order comprises two 10kW and eleven 40kW u.h.f. transmitters, the latter being one of Europe's most powerful single broadcasting transmitters in the u.h.f. band. Both units are equally suitable for both colour and black-and-white transmissions and are designed for fully remote operation.

The 40kW transmitters are to be installed in stations at Emmaboda, Vastervik, Uddevalla, Vasteras, Backefors, Halmstad, Sundsvall, Borlange, Visby, Nassjo, and Sunne; the 10kW transmitters at Varberg and Karlstad.

LIGHTING CONTROL FOR BBC COLOUR TV

THORN Electronics Limited announce that one of their computer-type lighting control systems has been installed in Studio 8 at the BBC television Centre, Shepherds Bush.

In this installation, the Thorn "Q-File" system, controls over 290 lighting circuits using thyristor type dimmers, and feeds over 500 studio lamp outlets. Control is by a special purpose computer which processes and automatically files dimmer settings in any one of 100 memories during rehearsal. A simple push-button operation recalls the settings for programme production. Many of the complex processes of lighting control may be pre-programmed, greatly easing the task of the lighting operator and permitting even more imaginative lighting in both television and theatre productions.

UPLIFT IN RADIO AND TELEVISION DISPOSALS

THE relaxation of Government restrictions at the end of August coupled with the normal seasonal increase in disposals of radio and television receivers to the trade resulted in a substantial uplift in September, according to the Economic and Statistical Division of the British Radio Equipment Manufacturers' Association.

Television receiver disposals at 170,000 for September show an increase of 81,000 over August and are 58,000 more than September 1966, although still 13,000 below the deliveries for the same month of 1965.

Radios accounted for 147,000 giving a lift above September 1966 and 1965 of 22,000 and 15,000 respectively.

Radiograms at 21,000, although showing an increase over August of 8,000, were lower than the September figures for 1966 and 1965 by 3,000 and 11,000 respectively.

The trade has been running at a low ebb for the past few months but these latest figures indicate renewed interest in radio and television.

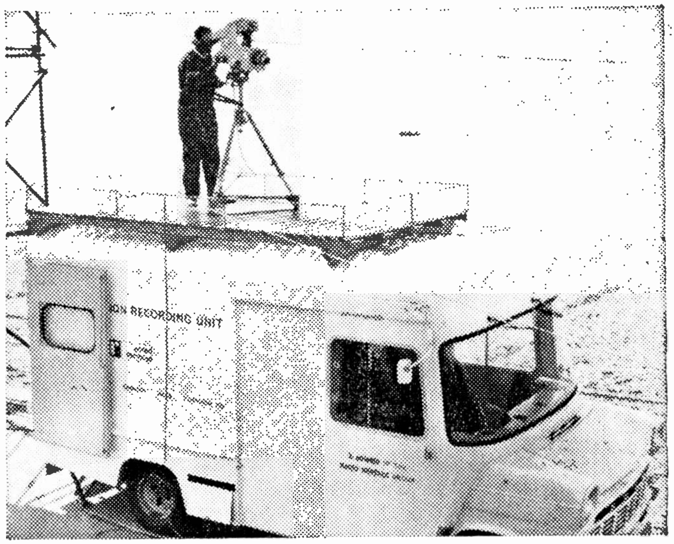
In the nine months' period from January to September comparisons with this year and the two previous years show that overall television deliveries are 7 per cent less than for the same period of 1966 and 20 per cent less than 1965. The radio total, however, shows a slight 3 per cent increase over 1966 but a 20 per cent drop compared with 1965. Radiograms show a decrease of 2 per cent over last year and are less by 19 per cent against the year before.

These estimates are net figures of deliveries by manufacturers to the home market on firm and other accounts including those to specialist rental and relay companies.

Colour TV Pioneer is Technical Manager

ONE of the men who pioneered the development of colour television equipment in Britain, Mr. Norman Parker-Smith, has been appointed Technical Manager of Marconi's Broadcasting Division. This is a new post involving the control of two development laboratories in the Chelmsford area.

MOBILE TV RECORDING UNIT AT SCOTTISH MOTOR SHOW



THE Radio Rentals Wired Services Mobile Television Recording Unit was one of the attractions among Ford commercial vehicle exhibits at the Scottish Motor Exhibition at Kelvin Hall, Glasgow (10 to 18 November, 1967). The mobile recording unit was fully operational throughout the exhibition, transmitting a closed-circuit television service to each of the six Ford commercial vehicle dealer stands.

Each stand had two Baird 19in. television sets showing a three-minute programme of Ford films.

Picture shows the Radio Rentals Wired Services Mobile Television Recording Unit, specially designed to provide closed-circuit television systems for education, industry, exhibitions, conferences and similar events.

BEDFORD RELAY STATION

THE BBC-1 television relay station to serve Bedford was brought into service on November 20. It transmits on Channel 10 with horizontal polarisation.

The BBC-1 relay station is situated at Sheerhatch Wood, some five miles east of Bedford. It will serve Bedford and Kempston, and a surrounding area including Willington, Cardington, Houghton Conquest, Stewartby, Wootton, Bromham, Biddenham and Renhold. For most viewers in this area, the most suitable aerial to use will be one of the special wide-band types designed to receive the BBC-1 channel (10) as well as the ITA channel for the area (6). Existing aerials in use for Channel 6 may not be satisfactory for use in the new BBC-1 service.

UNIVERSITY TV ORDER FOR EMI

EMI Electronics have received an order from Glasgow University for the largest first fully professional university television installation in the UK.

The university has made available and is converting Southpark House into a programme origination studio which will employ four EMI Type 201 cameras, capable of producing broadcast-quality signals on either 405 or 625 line standards. Two cameras will be equipped with zoom lens systems, one with a turret lens. The fourth camera will be used in a telecine channel based on the professional EMI Type 404 telecine.

A scheme for relaying programmes to local schools has also been proposed.

TUNING-IN WITH A diode

by K. ROYAL

A JUNCTION diode in reverse conduction acts as a capacitor and the trend now is to employ such a device in television tuners—especially u.h.f. ones—for keeping a selected transmission spot-on tune. This is really automatic frequency correction (a.f.c.), but semiconductor diodes are being used, too, for tuning over the v.h.f. and u.h.f. channels by means of a potentiometer arranged to adjust the reverse bias and hence the capacitance. This in effect gives remote tuning and eliminates the mechanical tuning capacitor.

Why does a junction diode act as a capacitor? This question is best answered by looking at the elementary principles of the semiconductor diode effect. Junction diodes are made of either germanium or silicon. These substances have a crystalline make up, which simply means that the atoms are arranged in the formation of a crystal lattice—germanium, for instance, has the diamond lattice.

Gemanium and silicon are not initially "pure" and before they can be used for semiconductor applications have to be highly purified or refined.

All the atoms of the pure crystal are bonded lattice-wise owing to the outer-orbit (valence) electrons of the atoms "interleaving" with the orbits of adjacent atoms. All the valence electrons are thus accounted for in this way and none is available for current conduction. Pure crystal is, therefore, an almost perfect insulator—that is, as perfect as the crystal can be made pure.

While this sets the stage, so to speak, for semiconduction, current carriers have to be introduced into the pure crystal for controlled conduction. By the addition of a small amount of antimony or arsenic, for instance, electrons—negative current carriers—are made available for conduction. The crystal will then conduct to a degree determined by the quantity of the impurity introduced. This happens because each impurity atom has one electron more than is required for bonding to the crystal lattice. Thus each atom gives one electron for conduction. Semiconductors of this kind are called n-type—*n* standing for *n*egative carriers (electrons).

If the impurity is aluminium or indium each atom of this material again "fits into" the crystal lattice, but because each atom has one electron less than is required for bonding there is an electron vacancy per impurity atom introduced. This, for obvious reasons, is called a *hole*. Now, if electrons are introduced into this type of semiconductor they will be attracted by the holes and eventually caught by them. As unlike charges attract, holes are considered as positive charges and semiconductor material to which this type of impurity has been added is called p-type—*p* standing for *p*ositive.

N-type semiconductor thus has negative carriers and p-type positive carriers—electrons and holes respectively.

A junction diode is created by the uniting of p- and n-type semiconductors. In practice, one piece of germanium or silicon is used and processing gives rise to p and n regions at either end (or side). A p-n junction is in this manner created, and at the moment of forming holes start to flow from the p-type to neutralise the electrons of the n-type and electrons from the n-type to neutralise the holes of the p-type region.

One might expect this interchange of carriers across the junction to continue until all the p-type holes are filled by the n-type electrons. This does not happen, however, because as soon as the p-type starts to lose some holes and the n-type some electrons, the former in effect charges negatively and the latter positively, giving a potential across the junction which immediately blocks further interchange of carriers.

The idea is shown in Fig. 1, and the potential region is called the *depletion layer*. Now if an external supply is connected positive to the n-type and negative to the p-type, to aid the junction potential, as shown in Fig. 2, the depletion layer effectively widens. The device is then said to be in reverse conduction, and only a very small amount of loss current flows.

When the external supply polarity is reversed as shown in Fig. 3, the depletion layer potential is countered and overcome. The depletion layer then collapses and carriers continue to interchange across the junction as long as the external supply remains. This is the forward conduction state, giving relatively high current flow.

We have seen then how the p-n junction diode rectifies, but this still fails to explain how it acts as a variable capacitor. Well, when the diode is in

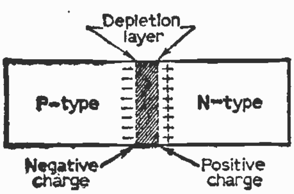
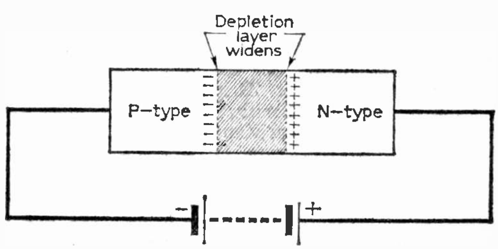


Fig. 1 (left): How the depletion layer in a p-n junction is formed.

Fig. 2 (right): The depletion layer widens when the reverse bias is increased.



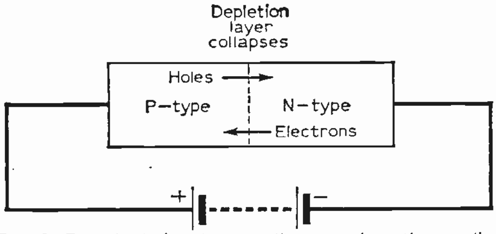


Fig. 3: The depletion layer collapses when the applied potential is reversed, the diode then going into forward conduction.

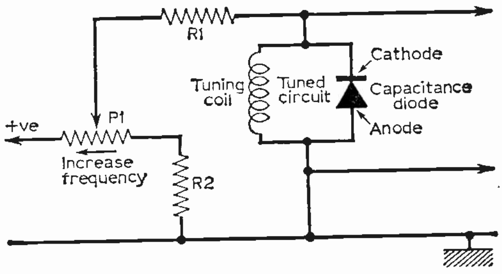


Fig. 4: Basic set-up for controlling a tuned-circuit remotely by means of a capacitance diode.

reverse conduction, the depletion layer zone acts rather like the dielectric of a capacitor and the positive and negative charges as the two plates. Capacitance thus exists across the diode in reverse conduction, the value of which is governed by the width of the depletion layer. As the reverse bias is increased, the capacitor "plates" move farther away from each other and the capacitance decreases, and conversely as the reverse bias is decreased. In forward conduction, of course, there is no capacitance effect, just a low resistance.

Figure 4 shows a diode connected across a v.h.f. or u.h.f. tuning coil—the circuit could be part of the oscillator tuning, for instance—in place of the usual tuning capacitor. The diode is reverse-biased by the positive control potential applied to P1 and thence to the diode "cathode". R1 holds off the low-impedance control potential source from the tuned circuit, while R2 ensures that the diode remains a little in reverse bias even when P1 slider is farthest away from the positive input. P1 thus controls the reverse bias on the diode and in this way changes the frequency of the tuned circuit.

Some idea of how the capacitance of a diode might change over a reverse bias range of 3V to 25V is shown in Fig. 5. There is, of course, a reverse bias limit which, if exceeded, causes a sudden rush of current through the diode. This is sometimes called the zener effect. Very low capacitance values can thus not be attained simply by increasing the reverse bias. In any event, the capacitance curve tends towards non-linearity at extremes of reverse bias, as Fig. 5 shows.

It has already been intimated that a very small current flows in a diode under conditions of reverse bias. This is called leakage current, and it can be looked upon as being caused by a loss resistance in the diode. This reduces the Q value or "goodness" of the diode. Germanium diodes, while acting as capacitors, tend to have relatively high losses in this respect, especially at higher than normal ambient temperatures. Silicon diodes are less affected by temperature in this way and they can be designed with an extremely low reverse loss, making them ideal as capacitors.

Indeed, a new crop of silicon diodes—epitaxial planar versions—has recently been introduced by Standard Telephones and Cables Limited designed specifically as a variable capacitance. Q values as high as 300 are attained, and the capacitance swing is sufficient to give continuous tuning over each of the Bands I, II, III, IV and V. These figures are for type BA141. For the v.h.f. bands only there is a type BA142.

U.H.F. tuners are already being made incorporating similar capacitance diodes, and one by Telefunken tunes from 470 to at least 790Mc/s with a control potential of 2V to 30V. There is also a v.h.f. model tuned electronically over Bands I and III separately. This uses a selector switch for the particular band, and a third position on the selector arranges for an input from a u.h.f. tuner in the usual way. Integrated v.h.f./u.h.f. and all-band diode tuners are available too, and all models have provision for a.f.c.

Once a diode is incorporated in the oscillator tuning it is of course a relatively simple matter to add a.f.c. The scheme is to derive a control potential from a phase detector or discriminator energised by a signal from the vision i.f. channel. When the oscillator is tuned for the correct i.f. response the control potential is nominal or zero, but when the oscillator tends to wander from the correct tuning point a positive or negative control potential is produced and this is fed to the capacitance diode which alters in value in a manner to restore automatically the oscillator tuning.

Early a.f.c. systems had to rely on valves arranged in the form of electronic reactances—capacitive or inductive as required—but the development of the capacitance diode has considerably simplified matters.

The latest colour television sets are employing a.f.c to keep the u.h.f. tuner accurately on frequency so that the vision carrier, colour subcarrier and sound carrier always remain at their correct positions along the i.f. response curve. Deviation of the colour subcarrier, for instance, can cause pattern interference due to increase in amplitude of the sound carrier/colour subcarrier beat. Conversely, the colours can be desaturated or lost completely. Accurate tuning is thus extremely important in colour sets.

The block diagram in Fig. 6 shows the basic scheme. Some of the signal in the vision i.f. channel is taken out and applied to the a.f.c. amplifier, which lifts the signal sufficiently for application to

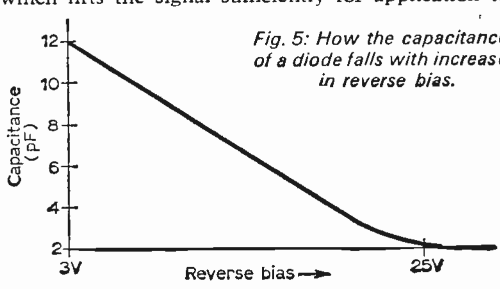
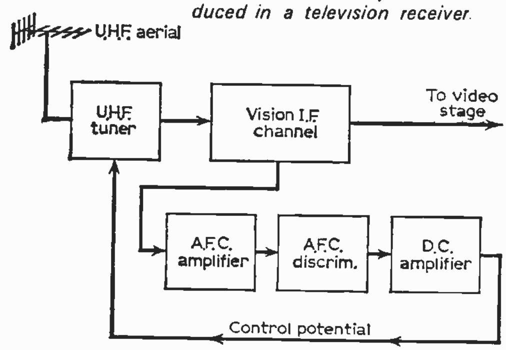


Fig. 5: How the capacitance of a diode falls with increase in reverse bias.

Fig. 6: How a.f.c. may be introduced in a television receiver.



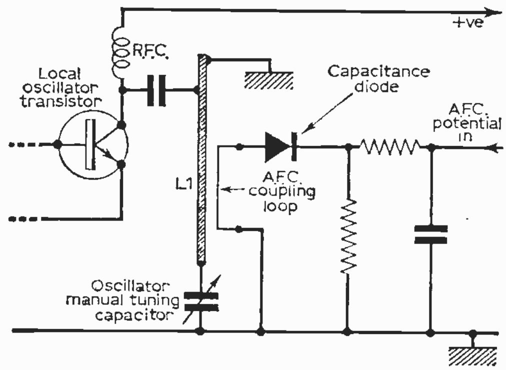


Fig. 8: One way of connecting the capacitance diode for oscillator tuning.

the a.f.c. discriminator—which acts rather like an f.m. detector. The control potential from the discriminator is increased in d.c. value by the d.c. amplifier stage and then fed to the capacitance diode in the oscillator circuit of the u.h.f. tuner.

Figure 7 shows the circuit of the i.f. amplifier, the discriminator and the d.c. amplifier. The second transistor in the i.f. amplifier section acts as an amplitude-limiter and ensures that the signal level applied to the discriminator remains constant irrespective of the input signal amplitude.

D1 and D2 are the discriminator diodes fed from the discriminator transformer T1, and provided the i.f. input signal is accurately tuned to the resonant frequency of T1 no output appears across C1. Should, however, the i.f. signal applied tend to wander from T1 resonant frequency the balance of D1 and D2 conduction is destroyed and a potential occurs across C1 of polarity governed by whether the detuning is above or below the carrier frequency and of magnitude corresponding to the degree of mistuning. This d.c. output is applied to the base of the third transistor (the d.c. amplifier) through R1, and appears considerably amplified at the collector from whence it is fed to the capacitance diode in the tuner unit.

The thermistor in the d.c. amplifier emitter provides thermal stabilisation, while the "set a.f.c." preset allows the capacitance diode value to be adjusted initially in relation to the manual tuning capacitor for the correct oscillator frequency. This preset simply adjusts the standing d.c. voltage on the discriminator diodes.

The other end of the arrangement—in the tuner—is shown in Fig. 8. The transistor here is the local oscillator (in the u.h.f. section), and the tuning is achieved by the usual quarter-wave line, represented by L1 in the circuit. Manual tuning is by the small variable capacitor at one end of the line, while a.f.c. is given by the capacitance diode. This is connected in an artful manner to avoid the d.c. control potential appearing in the transistor circuits proper. A coupling loop is placed close to the oscillator line L1, and as the capacitance on this changes so, too, does the oscillator frequency. The loop, of course, is electrically isolated from the tuned line, and since one end is connected direct to chassis it is a simple matter to pass d.c. through it and the series diode to secure the required capacitance change.

It will be seen that the a.f.c. potential is applied via an *RC* filter to the "cathode" of the diode. Thus an increase in positive control potential here gives reduced capacitance and an increase in oscillator frequency. ■

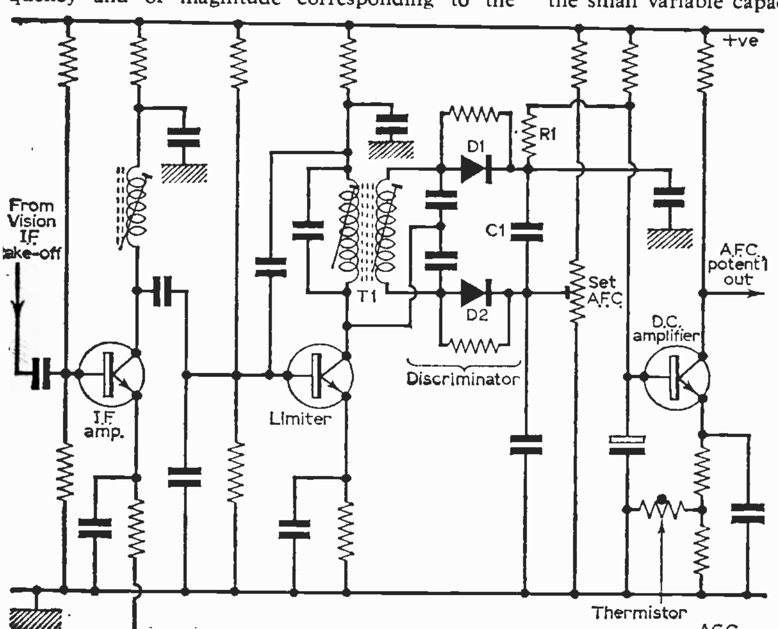


Fig. 7: The a.f.c. circuits of the B.R.C./Thorn all-transistor colour receiver

EXPERIMENTAL TV AERIAL FOR BANDS III, IV, V

By Ivor N. Nathan

THE author has often found the need for a simple but robust television aerial for either experimental or test purposes in addition to the main domestic array on the roof of the house. It may, for example, be required for testing a second receiver without disturbing the rest of the family's viewing habits or for initial experiments in deciding the best position for a more elaborate aerial array for contemplated DX-work.

CONSTRUCTION

The basic aerial is a folded dipole constructed from tinned-copper wire of a gauge large enough to make it self-supporting on its mount. As shown in Fig. 1, the aerial is conveniently mounted on a three-pin mains plug from which the earth pin has been removed. The wire must first be cut to the required length for a folded dipole to resonate in the channel required, plus two inches to allow for wrapping each end around the plug pins prior to soldering. Remember to insulate the wire and the pins with suitable lengths of sleeving before soldering the two ends. The outer covering cut from a length of coaxial cable is ideal sleeving for this purpose. For safety reasons (live-chassis receivers) the aerial should be either isolated by capacitors or the exposed tips of the plug pins fully covered by plastic insulating tape after soldering.

Connection to the dipole is made by feeding the coaxial lead-in through the normal cable-entry at the end of the plug and securing the tinned wire ends by tightening the pin screws as for a mains lead. If the cable-grip screws are then tightened the complete assembly is most sturdy and will withstand constant handling. For Band III the average length of the dipole (after folding) is 30in., and for BBC-2 (Crystal Palace) 10in. which makes physical handling simple.

As a simple folded dipole the aerial is now complete and in some areas will suffice as a permanent indoor aerial. An aerial of this type cut for BBC-2 and positioned horizontally in an optimum room position has been functioning very well in this locality (Southgate, N.14) for some considerable time. If the aerial is to be kept in a permanent position the retaining screw can be removed from the plug cover and a hole drilled completely through so that a woodscrew can be used to fix the aerial in position and retain the plug cover.

MULTI-ELEMENT ARRAY

When previously living in Luton, Bedfordshire, the author constructed a folded dipole of this type cut to resonate in Channel 11 and mounted it horizontally outside the back of the house to receive ITV Anglia from Mendlesham. The optimum position, found by trial and error, was found to be surprisingly low and was just under the glass roof of a lean-to which conveniently provided shelter from bad weather. A reflector and directors were progressively added, the extra elements being cut from the same gauge wire as the dipole and

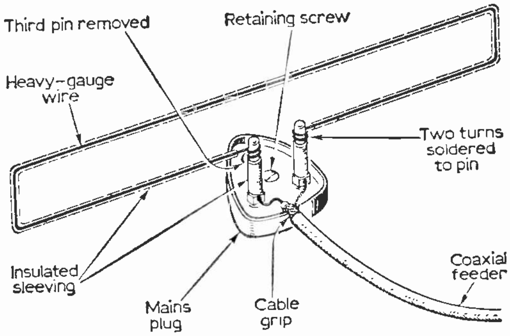


Fig. 1: Basic folded dipole.

mounted in plastic terminal blocks, as shown in Fig. 2.

The dipole and its associated elements were secured with woodscrews driven into the wooden members of the lean-to. This arrangement provided an alternative ITV programme to Channel 9 which was received on the main domestic array. Reception of Mendlesham was snowy during bad conditions but good under normal conditions.

As a second aerial for alternative channels the need for changing-over input leads can be obviated by using a suitable splitter circuit, of which many examples have been described in previous issues of this journal. The use of a pre-amplifier may also be of assistance in weak signal areas.

Quite an elaborate array can be installed in a loft using this method of construction and, for Band III, a 12-element (or more) aerial is feasible in fringe areas, giving results which compare most favourably with an unsightly roof-top aerial. An added advantage is that it is relatively unaffected by the atmosphere and retains its "as new" performance. Again, it is advisable to find initially the optimum position for the basic folded dipole and then progressively to add the extra elements. This tailor-made approach ensures optimum matching between the aerial, feeder and receiver, the extra elements being positioned in turn while the receiver is switched on so that results can be constantly compared for picture improvement. ■

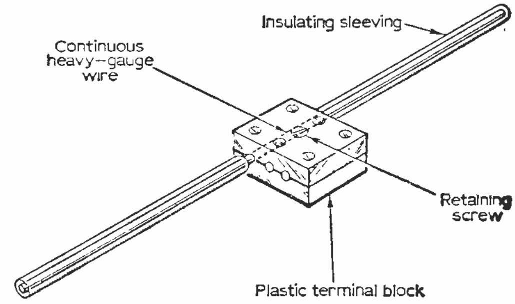


Fig. 2: Reflector or director element.

PHOTOMULTIPLIERS

PART 2

K. T. WILSON

THE current from the photocathode, termed the photocurrent, is very small; and as we have seen it is even smaller when a tube is in use in a flying-spot scanner. To be usable, such a very small signal must be amplified, but this cannot be done in a straightforward manner in the normal type of amplifier. Every amplifier gives an output signal even when no input signal is present. This output signal is termed "noise" and is due to the random movement of electrons, whether in a beam or in a solid material. The noise output signal of an amplifier of several stages is due mainly to the noise in the first stage, since this is amplified in all subsequent stages. Because of this it is convenient to think of amplifier noise as if it were all appearing at the first stage from a signal generator. We can calculate the strength of the noise signal which would cause the noise output we see: it is the noise output divided by the total gain of the amplifier. Looking at it in this way it is easy to see that the noise signal is competing with the input signal at the first stage of the amplifier, and if the input signal is many times greater than the noise signal then the input signal retains this advantage all the way through the amplifier; but if the input signal is less than the noise signal, it remains indistinguishable amongst the noise no matter how great the amplification.

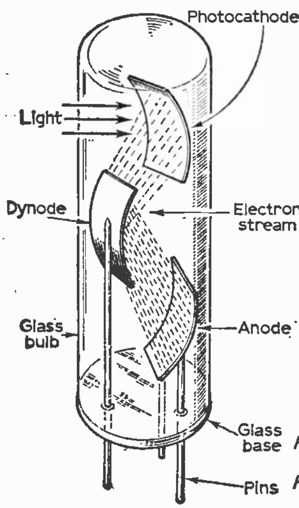
The output of most photocells used in flying-spot scanners is well below the noise level of the best video amplifiers unless a very high light level can be obtained from the c.r.t. scanner, and it is therefore necessary to find some method of amplifying the signals from the photocathode, without introducing noise, until they are considerably greater than the noise of the video amplifier. This is accomplished in the photomultiplier by a process termed secondary emission multiplication.

Secondary emission

We have seen that the alkali metal caesium is extensively used in the formation photocathodes. Caesium has another property besides photoemission which is very useful: if a film of caesium on nickel is struck by electrons from a cathode 50—500 volts negative, more electrons leave the caesium surface than strike it. One may imagine a blindfold man at a snooker table, who has struck a ball and finds that two or three return to him. Many materials behave in this way, and if an anode at a more positive voltage is present the extra electrons flow to it. This process of trading one electron for two or more is called secondary emission and has been known for a considerable time. The ratio of the number of electrons leaving a surface to the number of electrons striking it is known as the secondary emission ratio. For most substances it is between 1 and 2, but for caesium on nickel it may be as high as 6.

Secondary emission is a form of amplification, therefore, and has the remarkable advantage of being practically noiseless. The disadvantage of requiring the presence of caesium to ensure large gain is unimportant in a photomultiplier, since the caesium has to be present anyway. There is no advantage to be gained by the use of secondary multipliers in valves in respect of noise since most of the noise is due to the high temperature of the cathode; but in the photomultiplier this disadvantage is absent.

A secondary emitting electrode is known as a *dynode*, and the simplest form of photomultiplier (Fig. 5) would consist of a photocathode, a dynode and an anode. Some care must be taken to ensure that all the electrons from the photocathode land on the dynode and do not bypass it to land on the anode, but otherwise the structure is simple and straightforward. This process may be extended, and we can imagine the dynode of Fig. 5 as the source of electrons for a second dynode. This process may be continued to a large



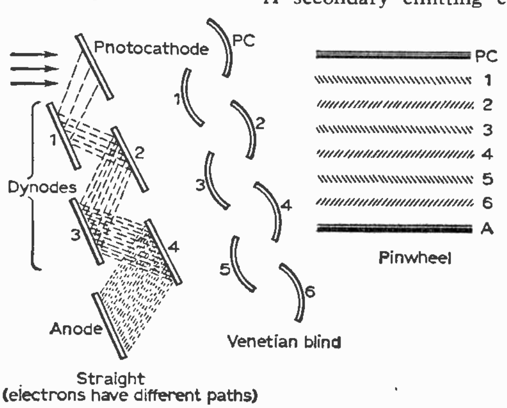
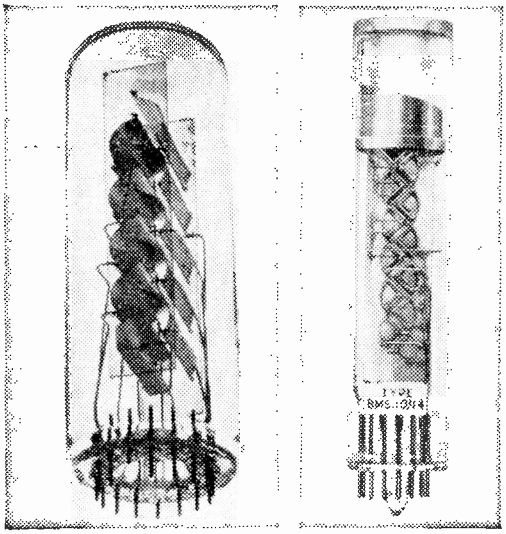


Fig. 6 (above): Alternative designs for dynode structures.

Fig. 5 (left): Simple photomultiplier with single dynode.



Typical small photomultiplier tubes.

number of stages (fourteen in some cases) and the electron current is multiplied by the secondary emission factor at each stage, hence the name of the photomultiplier.

The gain of a secondary multiplier assembly may be very large indeed, even if the gain of each stage within it is small. As an example, if the gain of one dynode is 2, that of two is 4, three 8, four 16, five 32, six 64, seven 128, eight 256 and so on.

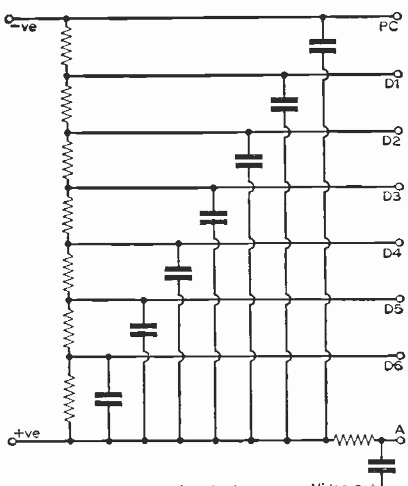


Fig. 7: Dynode supply chain.

The overall gain is given by the formula $G = S^n$ where G is the overall gain, S the gain per stage and n the number of stages. Although in theory the gain could be made as high as desired by increasing the number of stages, in practice the gain is limited because high gains cause instability due to feedback (the signal at each dynode is in phase

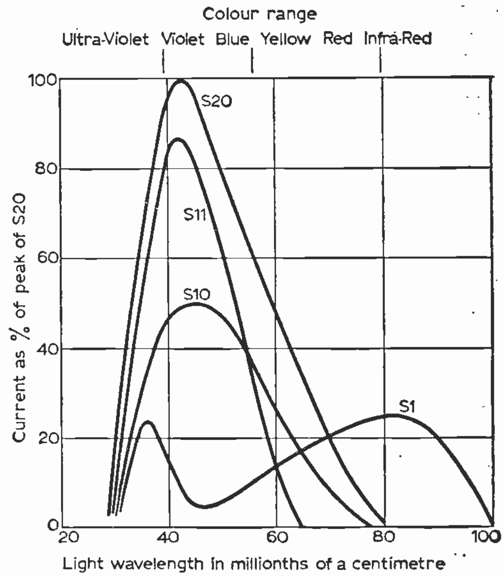


Fig. 8: Photocathode colour response characteristics. The response of the S20 photocathode is very similar to that of the human eye.

with that of the other dynodes), because it is difficult to arrange the dynodes geometrically so that all the electrons from one dynode hit the next dynode, and also because of the difficulty of depositing an even layer of caesium on each dynode. An arrangement which is ideal in one respect may be useless in another and hence unusable.

Another point which restricts the geometrical arrangement is that the total path of an electron from any point on the surface of the photocathode to the output must be the same regardless of its route through the multiplier. This is particularly important for photomultipliers used to record the pulses of light from nuclear reactions. When a pulse whose width is measured in nanoseconds (1,000nanosec. = 1μsec.) is applied to a photomultiplier any path difference causes the output electrical pulse to be considerably longer, i.e. integration takes place.

Some of the arrangements which have been used for photomultipliers are shown in Fig. 6.

Circuitry

For photomultiplication each dynode must be more positive than the preceding one and, preferably, the voltage between adjacent dynodes should be constant. This is usually achieved by setting up a voltage divider chain (Fig. 7) where each dynode is fed from a tapping on a set of series resistors. It is important that each tapping point should be decoupled as shown to prevent feedback from one dynode to another lower in the chain.

The video signal, in the case of a flying-spot scanner, is taken from the anode by a load resistor

—continued on page 159

INSIDE tv TODAY

PART 4 M. D. BENEDICT

TOO often sound tends to be forgotten when compared with the vision side of television; but it must be realised that without sound most programmes would be meaningless and unintelligible. Television sound springs largely from sound-radio practice, but now techniques developed for television are finding their way into sound radio. Film practice has also much to offer television, so the result is largely an amalgamation of the two techniques.

Microphones

Sound always starts with the microphone. In television, microphones divide into three categories: those for use "in shot", those out of shot, and personal microphones. In shot microphones have to be neat and simple in appearance; this factor must not clash with requirements for high quality. Most of these are small moving-coil microphones with a baffle arrangement at the back. Such microphones, as used by pop groups, are often found in an improved version in television work particularly in light entertainment, used by singers, either hand held or clipped on to a microphone stand.

For static shots of newsreaders, announcers and actors at desks, electrostatic or condenser microphones on a table stand are usually used. These are less robust, as the microphones contain a pre-amplifier within the case, but clean, high-quality results are obtained with them. Along with moving-coil microphones, these electrostatic microphones are used on stands to cover orchestras and pop groups, or where a singer works to the microphone.

Obviously the presence of such microphones will distract the viewer and for applications such as drama microphones must not appear in shot. In these cases a microphone mounted on a boom is used. The operator, standing on the platform, can rotate the microphone from side to side, tilt it up or down, or extend the boom to reach any position. As the microphone at the end is directional, the operator can rotate and tilt the microphone to pick up a particular person who may be speaking. By this means the boom can be held just out of shot of the camera, but near enough to the performers for most applications. As the action moves from set to set and area to area within the studio, the microphone boom, mounted on its stand, can be moved to a different set. On large sets, two or more booms may be used.

It will be appreciated that the boom operator needs great skill to avoid the microphone appearing in shot at the top of a picture, especially as performers stand up or where a wider shot is taken. As zoom lenses come into common use, so the boom operator's problems increase as he cannot gauge the shot by the lens selected by the cameraman. The positioning of the microphone boom is very important in determining sound quality, and to assist in positioning the sound supervisor in his control room can communicate with the boom operator in order to guide him.

Microphones used on booms are usually high-quality moving-coil units with cardioid, i.e. unidirectional pick-up. Cardioid microphones are considerably more sensitive in one particular direction, the response curve of sensitivity and direction being cardioid, i.e. heart shaped. Many microphones have this characteristic as it tends to prevent acoustic feedback howl in Public Address systems. In television, the boom operator positions the microphone between the speaker and the source of any unwanted sounds so that the microphone is "pointed" at the speaker and the unwanted noise is in the direction of minimum sensitivity, thus reducing its effect. Electrostatic microphones are sometimes used for music but care has to be exercised to avoid wind noise where fast movement is called for.

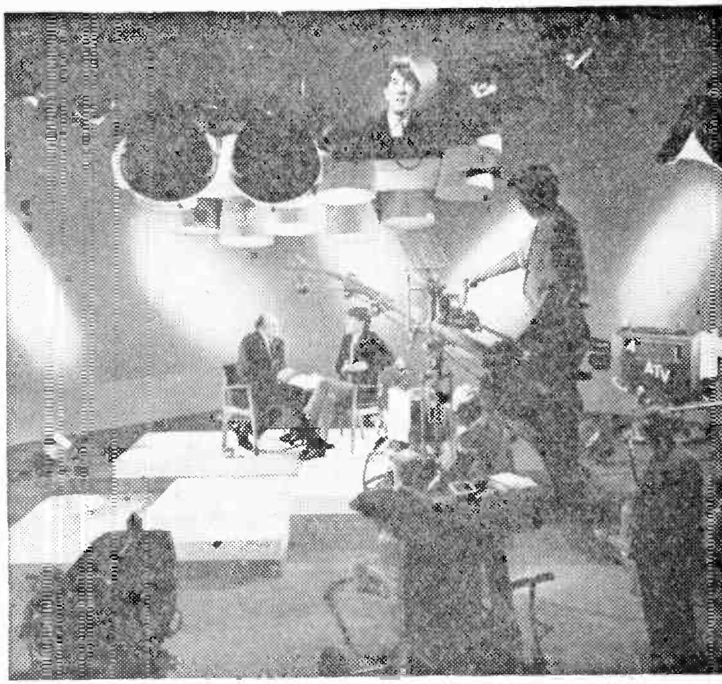
For very wide shots or fast-moving sequences such as a song-and-dance routine a boom cannot follow or get close enough to cover an artist, so personal microphones are used. Lanyard or neck microphones, as these are also called, can be suspended around the artist's neck or fixed to the clothing in such a manner that it is out of sight of the camera. Personal microphones are usually very small moving-coil microphones and are white or dark green to merge with the tones of the clothing worn by the artists.

Compensation is applied for the sound picked up, as speech will be addressed away from the microphone and the sound picked up is mostly from the artist's chest, resulting in a loss of some of the higher frequencies. Artists' clothing and the position of the microphone will vary, as does the build of the artist, so that this compensation is variable and it is necessary to match the sound received by the microphone to compare with other microphones in use by using an adjustable tone control unit.

Microphone cables would be a problem in some cases so that a miniature f.m. radio transmitter is sometimes used. To reduce the variation in the level of the transmitter a compression amplifier is used to even out the artist's speaking level; otherwise overloading might occur. The transmitter, compressor, microphone amplifier and batteries are packed in a case about the size of a packet of cigars. In some cases an aerial is provided by the short microphone lead to the transmitter.

Other microphones used are the very directional rifle and parabolic microphones employed for picking up a source some distance away.

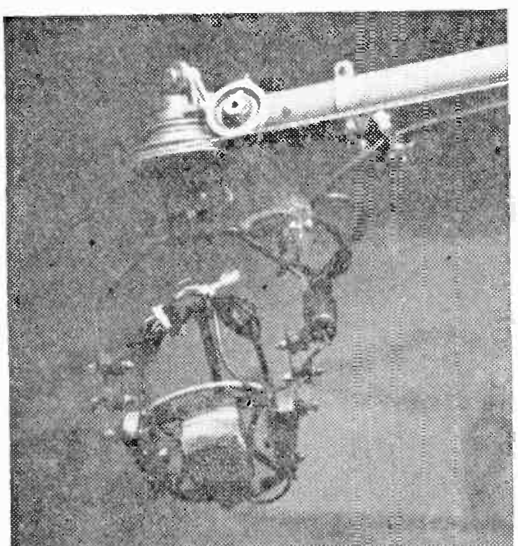
Parabolic microphones are bulky, being three or four feet in diameter; rifle microphones are mounted in a tube about a foot long. Both suffer from lack of direction at the bass so it is usual to tailor the bass response off. However, they are used in conjunction with other microphones and on outside broadcasts for effects when they are fixed to the side of a camera. For O.B. use the lack of bass is an advantage. Out-of-vision commentaries use a special noise-cancelling lip microphone held against the commentator's mouth. A ribbon-microphone unit suffers from bass sensitivity when used in this way so that special compensation is used. Extraneous noise is cancelled by the shape of the housing and the falling bass response due to the compensation.



The microphone boom. On the platform stands the operator who with the handle in his right hand can extend the boom, and twist or tilt the microphone with the controls on his left. The boom can be swung from side to side and moved from set to set as required. *ATV photo*

Jackfields

Around the studio are placed several wall boxes; a box with camera cable sockets and microphone sockets and outlets for various talkback distribution as well as other lines to the sound control room. Into these boxes are plugged the microphones and other apparatus, allowing the microphone cables to be kept to a minimum. From these microphone points permanent cables feed the signals to a special panel on or near the sound mixing desk. Called a jackfield, it allows up to 400 inputs and outputs such as microphone points, gramophones and various points on the sound mixing desk to be interconnected using short leads terminating in plugs. Any jack connected to a particular source is plugged via the panel to any source, in the manner of a telephone switchboard, so the jackfield is a very flexible method of connecting sources as required.



The microphone in its cradle at the end of the boom. The cradle is twisted and tilted by the cables and pulleys. *ATV photo*

Sound Mixing

Sound mixing units are usually built into a desk, with the controls easily to hand. As studio mixers vary from a simple six channel mixer to those with over sixty channels it is impossible to describe all the variations. However, Fig. 5, showing the simplified diagram of a 16-channel mixer, demonstrates some of the facilities often found on a sound mixing desk.

Most desks accept a microphone level input to each channel and reduce the level of all other sources, tape, grams, telecine and video tape, to this level. All channels are, therefore, identical, giving operational flexibility. Each channel starts with a microphone amplifier followed by a balance control, the latter being a switched attenuator used

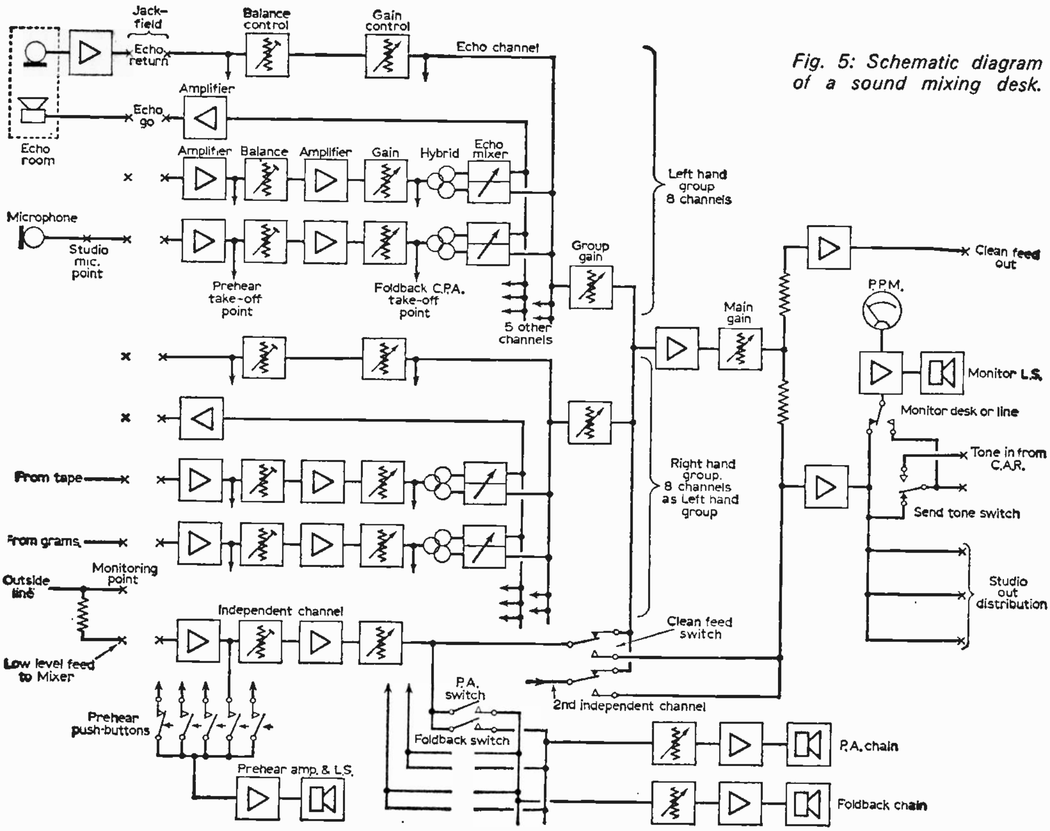


Fig. 5: Schematic diagram of a sound mixing desk.

to set the coarse gain of the channel. Then follows another amplifier, and the channel gain control. Nowadays most of these are quadrant faders which are more convenient to operate than the rotary types previously used; each fader being a high quality stud attenuator whose input and output impedance remains constant, unlike the case with a potentiometer.

From the fader a special hybrid transformer splits the channel into two feeds. Hybrid transformers have the property of almost complete isolation between their two outputs so that anything mixed with one output does not appear on the other.

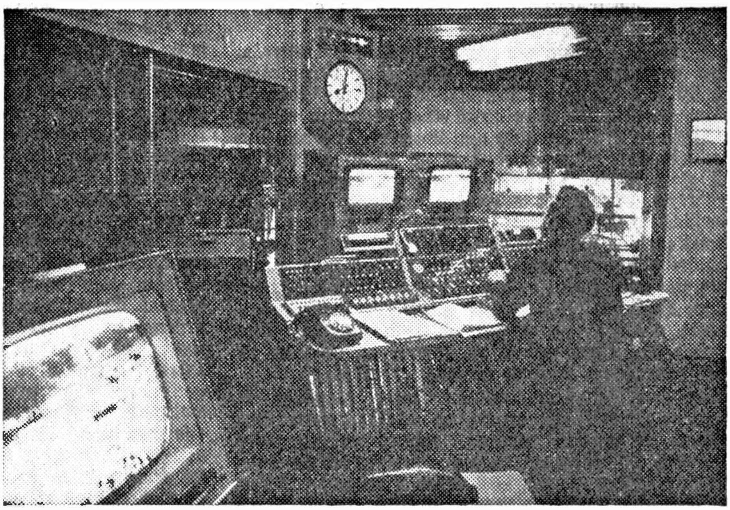
Both outputs are fed to an echo mix switch which varies the levels fed to the echo and the direct chain by increasing the amount fed to the echo chain and decreasing that fed to the direct chain. This affects the amount of echo output for each channel and balances the feed to the echo chamber (or echo plate). All the echo feeds are combined and fed (via an amplifier) to the echo chamber, a reverberant room with a microphone picking up the output of a loudspeaker. Alternatively, a loudspeaker mounted on one corner of a flimsy metal plate about 6 x 4 ft. with a microphone at the corner opposite the loudspeaker gives a very good approximation of an echo, with the advantage of smaller size and a variable reverberation time. The output of the plate is fed back via a balance control and fader and mixed with the combined direct outputs of the left hand group.

For convenience when dealing with several pop groups or an orchestra it is useful to combine the outputs of several channels and feed them through a group fader to allow a balance of the orchestra or pop group to be made and left, yet allowing the whole orchestra to be faded out together with this group control. Without this, every time the orchestra was faded, up to ten channels or more would require operation at once!

Up to five groups are used and often each channel can be selected on to any group. For announcers, soloists, compères, etc. it is often more convenient to have some independent channels. These have no group fader but are mixed after the two group faders are combined. After this mixing another stage of amplification precedes the main gain control and the output amplifier.

Studio output is distributed to several sources: production control room, cameras, the studio wall boxes, etc., as well as being fed to the central apparatus room where it is networked or fed to a video tape recorder. To identify the output line and for adjustment of levels, etc., a tone is fed out via a send tone switch. So that rehearsal may continue during line-up, it is customary to feed all the distribution from a point before the tone is switched in but for safety's sake the sound mixer's monitoring loudspeaker and his programme meter can be switched to the output line.

The sound mixer has a very high quality monitoring loudspeaker and a special programme meter to guide him. Peak programme meters, as they are called, indicate the level of the loudest passages, and feature a very fast rise time and slow fall time, to give an easy-to-read yet very accurate movement. Logarithmic amplification is used to give an approximation to the aural response.



Sound control room with sound mixer at the sound mixing desk. Preview and transmission monitors in front of desk. Sound mixer's hands are on the channel faders with other controls and switches above *Rediffusion photo*

Independent channels can be used in another mode. If a programme requires a contributor who cannot be present at the studio it is possible to conduct an interview or a discussion with the contributor in a different studio anywhere in the country or even abroad. To do this a music circuit of the master studio output is sent to the remote studio and fed to a loudspeaker placed before the contributor to allow him to hear the interviewer's question. When the master studio fades up the remote studio, howl-round will occur as the contributor's microphone is feeding, via the master studio, his own loudspeaker. To avoid this, a "clean feed" is sent. Clean feed is studio output without the remote source's contribution, so the contributor hears everything except his own output. With the independent channel in the clean feed condition, mixing of the independent channels takes place after the main gain control and after the point in the chain where the clean feed output has been taken off. Padding resistors (or a hybrid transformer) ensure that little or none of the independent channel's output appears on the clean feed output. A special sub-mixer may be incorporated, which allows five remote contributors to hear each other and talk to each other. To do this each must have its own clean feed. Current affairs programmes often require these facilities.

Other facilities provided are prehear, where outputs are taken from each channel and fed via a push button to a small loudspeaker, allowing any source to be checked simply by pushing a button. Foldback and public address systems are provided. Foldback is the technique of feeding sound from telecine, grams and tape into the studio so that performers can hear contributions from outside the studio on the studio floor. Public address is similar in circuitry to foldback but is used for audience shows where microphones are also combined to allow the audience to hear all that occurs. Trouble may occur with howl-round if care is not exercised. Both feeds are routed via switches from each channel, after the channel fader.

Other items found on the sound desk are effects units with tone controls, which can be connected to any group or even any channel on modern sound desks. Switching, controlled from the vision mixer, is provided for these units, so that a telephone conversation can be simulated. To do this the voice of the person out of shot must be distorted by the tone controls as though speaking through a telephone yet, as the shot changes to bring him into the picture, the distortion must stop.

Effects units arranged for each channel are switched in or out when a particular shot is selected by the vision mixer. Pop groups often require an effects unit for each microphone to obtain the sound of the group's latest record. Special telephone ringing machines have been built to simulate the ringing of an automatic or a manual exchange (which must cease as the receiver is lifted); to provide ringing, dialling or engaged tones; and to provide an actual telephone link between performers on different sets when a telephone conversation is called for.

It is interesting to note that four separate amplifiers are used in the complete chain. Normal microphones produce an output signal of around $100\mu V$ for the moving-coil type of microphone and 5mV for the condenser type. However, it is necessary to provide enough gain to work with inputs as low as $30\mu V$. If a condenser microphone is used with very loud sounds, e.g. a trumpet or a pop singer who has almost swallowed the microphone, the output from the microphone might be nearly 50mV. If one amplifier was used to provide all of the gain for the desk, the output from this would be nearly 1000V, and obviously distortion would have set in long before this level was reached. Instead, a gain control in the form of a balanced potentiometer is incorporated after the first amplifier, which has a fairly low gain, and this is set to absorb excessively high signals so that signal levels through the rest of the chain remain more or less constant. Identical amplifiers are used at each point in the chain to avoid several different types of amplifiers, and to make the provision of spares easier. In the modern sound desk, using transistors, considerable distortion may occur if any stage is overloaded, without an excessive output level occurring.

Effects and music are often supplied by records. Most sound control rooms have four turntables, usually providing instant starting of the records by supporting an aluminium disc with the record on it above the turntable and lowering it when the music is cued. The record is up to speed within half a second or so. High-quality pickups are fed direct to an amplifier and a prehear facility is provided so that the gram operator can cue up each record whilst another one is playing. Special pickups allow the record to be turned backwards from the start point to a point about half a second before the starting point, to allow for the run-up. Faders control the output of each pickup. The outputs are then mixed to appear as one, or in some cases two, sources on the sound deck.

Similarly, a high quality tape recorder is frequently used for music or effects, sometimes dubbed from the records, sometimes specially recorded. Dubbing on to tape has the advantages of being easier to cue, and when a second track is available this becomes very useful for sound effects of an exterior of a car or train and its interior. Once synchronisation of the two effects has been achieved, the sound mixer merely fades from track to track as the shot changes from interior to exterior of the vehicle.

Often it is impossible for a performer to sing and dance at the same time without a boom coming into shot or a personal microphone picking up rustles from the performer's clothing as he moves. In such cases pre-recording is resorted to, with the performer miming to his own recording. At other times partial pre-recording is used with a live orchestra following the pre-recorded opera singer's voice. In these cases the piano accompaniment for the artist's pre-recording may be recorded on the second track of the tape recorder and fed to the conductor as a guide. Pop stars often have to pre-record the instrumental part of the arrangement and sing to the backing on transmission. This overcomes the problem of artists who cannot mime accurately.

Studio acoustics are very important. Drama studios are usually comparatively dead to dampen the noise of cameras and staff movement and to simulate outdoor scenes where there is no reverberation. Light entertainment and music require a longer reverberation time to reinforce the musician's efforts. Ambiophony is an artificial method of increasing the reveberation of a studio which is sometimes used, particularly for music. Applying echo to the studio output is fine for dramas where the scene is set in a church or a cave but it is useless for music as the musician cannot hear the echo and tends to force the music to compensate. Ambiophony uses the studio itself as its own echo room by feeding at low level many loudspeakers placed around the studio walls at irregular intervals. A delay unit feeds different delays to each group of loudspeakers to give the required reverberation.

The communication facilities in television studios are, of necessity, very complex. As mentioned, the director has a microphone with which he can talk to the cameramen, the sound crew and anyone else who requires instructions or cues, in particular the floor manager who is the director's representative on the studio floor. He receives the talkback, as it is called, on a special radio receiver so that he can move quietly to any part of the studio without an encumbering lead. Headphones or earpieces are used to receive these instructions, and are plugged into the talkback receiver or special points on the cameras, booms and other apparatus.

Special talkback from the various sound and vision supervisors is fed to the sound and camera crew, and reverse talkback facilities from the booms and cameras allow the cameramen and boom operators to talk to their respective control rooms should they wish to do so. Talkback from a special microphone direct to the gallery can be arranged. Naturally, the use of these facilities would have to be curtailed on transmission to avoid the studio microphones picking up unwanted comments. By pressing a loudspeaker talkback switch the director can speak direct to the artist via the foldback loudspeaker, enabling him to instruct artists directly. When the studio is switched to its transmission condition this facility, along with certain others, is removed as a precaution against misuse. Red warning lights indicate that the studio is on transmission to people entering the studio, meaning that great care is needed to avoid all unwanted noise.

Other communication is provided by a flexible telephone system which allows any area outside the studio, telecine, video tape, outside broadcasts, central apparatus room and master control to speak to any of the checking points within the studio, such as sound and vision control, the apparatus room, the gallery engineer and the director and producer. Also provided are telephone outlets for the newsreader, interviewer or compère on the studio floor. Usually these are provided by a telephone switchboard operated by the studio engineer in the control gallery, allowing anyone to speak to any other source. Certain push-to-speak intercoms are used to connect the various engineering control positions with base maintenance, the video tape area, telecine, central apparatus room and other technical areas.

Naturally, the sound supervisor's job depends largely on the type of programme on which he is working. Planning meetings where the production staff discuss with the senior cameraman, lighting and sound supervisors, the basic requirements for the programme give him a basic idea of what is required. He will then decide the number of booms needed, the number and type of stand microphones, the sort of sound effects, arrangements for outside sources, and many other points. Any special tape recordings will be done before starting rehearsals if possible.

Mixing Techniques

Sound mixing falls into two categories: those operations requiring the balancing of the outputs from several microphones, such as for a musical item, or when many people speak on a large set; and those types of operation where only one or two microphones are faded up together but the action moves from source to source and constant changes of source are involved. Current affairs, sports and news programmes tend to fall into the latter category but these are complicated by minimal rehearsal (if any) so that the sound mixer has to be on his toes. Balancing, however, requires great skill to ensure that each instrument and singer can be heard at the correct level related to the rest of the orchestra, and a lot of experience and artistry is needed to get good results. Drama programmes usually rely on boom microphones, with up to two or even three booms used to cover the larger sets. Small areas may be covered by a fixed microphone, held or hung just out of shot. Sound effects, usually transferred from records to tape, or specially recorded for the programme, are mixed in as required, and the foldback loudspeaker allows the actors and performers to hear these effects. Similarly, some sequences may be on film or video tape which are mixed to when started. Foldback is used for these as well.

Light entertainment shows with audiences usually have special line-source loudspeakers suspended above the audience. Line-source loudspeakers have directional characteristics which gives greater protection against howl-round. Balancing for the musical items varies from one microphone placed above the conductor in the case of some orchestral music to close microphone techniques to separate the various groups of instruments in the orchestra. This allows the sound mixer to balance the orchestra to give the required emphasis to the instrument being featured. As is to be expected, pop groups are balanced by applying the technique to the ultimate, where each guitarist will have an instrument microphone in front of his guitar loudspeaker and a vocal microphone, usually on a stand. So a group of four might require eight microphones to be balanced satisfactorily!

Discussion and current affairs programmes usually involve microphones placed on tables or desks just out of shot. Booms are used when movement is expected. Considerable skill and concentration are required of the boom operator to lead the conversation and have the microphone pointed at the next speaker or for the sound mixer to have the correct microphone faded up before a new speaker starts to speak.

Unfortunately, sound in television still tends to be a secondary consideration. Television sound comes under criticism from many people who, listening to the small loudspeakers on their domestic receivers, complain of the quality. Problems for the sound crews are aggravated by many things. Lighting supervisors do not like boom shadows on the background so that the position of the boom and the key lights are critical, hence co-operation is required over these points; and directors often insist on microphones being out of shot. As mentioned, musical balance of pop singers has to compare with records made under ideal conditions using multitrack records which are re-balanced many times before the disc is finally cut.

The sound mixer has to work with unobtrusive microphones, a visual layout of orchestra and artists, little rehearsal and only one final balance. It is quite remarkable that the results obtained are any good at all, yet when the sound is received in the viewer's home it is often heard on tinny, sideways-facing overloaded loudspeakers, the resulting quality being similar to that found on many of the intercom systems!

To be continued

PHOTOMULTIPLIERS

—continued from page 153

just as if a valve were being used, and the same considerations of choice of value of load resistor apply. Too small a load wastes gain, too large causes loss of high frequencies; a common value is 22kΩ. Photomultipliers cannot be used in conjunction with d.c. amplifiers as any fluctuation of the steady current (dark current) of the photocathode is so enormously magnified by the multiplier portion. If a non-modulated light source has to be examined, it is better to "chop" the light optically by means of a shutter so that the photomultiplier is amplifying square waves rather than a d.c. value.

Photomultiplier characteristics

The quoted test figures for photomultipliers require some explanation. The sensitivity is quoted in amperes per lumen, but this does not imply that the anode current is measured in amperes since the optimum load resistance seldom permits more than a few milliamps to be drawn. The sensitivity quoted is usually maximum sensitivity, which occurs with one specific colour. To determine the sensitivity for other colours, the spectral response curve for the photocathode must also be consulted; the sensitivity at another colour is given by:

$$\text{Maximum sensitivity} \times \frac{\text{Height of graph at other colour}}{\text{Height of graph at colour of maximum sensitivity.}}$$

For flying-spot scanner use, the S—20 photocathode gives the best response, but the S—11 and S—10 give good results also.

The dark current is the current flowing with no light input and is sometimes quoted as the equivalent light input to emphasise the fact that light levels causing an output about the size of the dark current are undetectable. Other relevant figures are the number of stages and the optimum volts per stage (to aid design of the divider chain) and the temperature of operation (which affects dark current).

Table 1 gives abbreviated data for some of the range of photomultipliers made by 20th Century Electronics Ltd.

TABLE 1: PHOTOMULTIPLIER SPECIFICATIONS

Type	*Cathode*	*Overall Sensitivity (A/lumen)*	*Maximum Voltage Overall (V)*
BMS10/14/B	S11	150	1400
VMP11/111/B	S11	200	1900
CV2316	S11	200	1920
CV2317	S11	10	1920

The author wishes to record his thanks to 20th Century Electronics Ltd. for information quoted in this article. ■

PART 1

ON TURNING PRO

BY VIVIAN CAPEL

THE servicing and repair of television receivers is undoubtedly a fascinating hobby. Technical knowledge, the ability to think logically and manual skills are all brought into play. As a result many amateurs often express the feeling that they would like to earn their living by this means. Frequently reports are heard of high wages being offered to skilled engineers by the trade, and often too are heard accounts of high labour charges that are made. The impression can easily be gained that a small fortune can be made by becoming a service engineer.

Before giving up one's job and plunging headlong into the servicing trade, however, careful thought should be given. Things are not quite as rosy as they may seem and there are many pitfalls and other factors to be given consideration.

Prospects

First of all what are the prospects and opportunities of obtaining a job as a service engineer with a television repair firm in the retail trade? Judging by the advertisements the prospects would appear to be good. There seems to be a perpetual shortage and adverts for engineers are always appearing in the technical magazines and local papers. In most cases, though, it will be found that these are for fully experienced engineers only. Reputable firms will generally only accept men who have served an apprenticeship, who hold the R.T.E.B. servicing certificate or who have had many years of experience with other reputable firms in the trade. Unfortunately, many years of study and practice as a keen amateur will cut little ice with a prospective employer. He is only interested in someone who can quickly and effectively repair any fault that is likely to occur in a wide range of receivers varying from current models to the vintage ones of all makes. However good and knowledgeable they may be, there are few amateurs who can claim such a wide range of experience.

One may find an opening if one is prepared to accept a lower grade job. If one can drive for example there may be an opportunity as a delivery and installation engineer. By applying oneself to the job and becoming familiar with the receivers being handled and installed, there may well be a future opportunity as an outside engineer with possible promotion.

Many of the large multiple television stores (although, we must add, not all of them) employ only semi-skilled or non-qualified engineers. They do this by offering low wages and poor working conditions. Wages are often only three-quarters or even less of what can be earned elsewhere and the workshop often takes the form of a small room behind or over one of the multiple stores. This is equipped with a table, a multirange meter and a soldering iron with perhaps a few odd valves and spares in a box in a cupboard. Needless to say no first-class engineer would work under such conditions and so such posts are usually filled by others. Such firms are thus prepared to accept a non-qualified engineer and so this might appear to be a good opportunity for the amateur to get into the trade. While it may be tempting to accept a job as an engineer with such a firm instead of a lower grade job with a more reputable concern, the matter should be given cautious thought. Remember that if such a job is accepted further progress in the trade is unlikely. There will be no opportunity to learn from a good experienced professional engineer because there will be none. Often these firms keep an engineer and a "workshop" at each branch rather than a central service department, in which case the engineer will be working on his own. Should any unusual or difficult fault arise there will be no one to turn to for assistance.

The reputation of these firms is usually well known locally in the trade so if one were subsequently to consider leaving and going to another job the experience gained there would be no recommendation. In fact, to say that one worked with such a firm for a period of time would be a disadvantage in seeking a new position.

Evening classes are run in most areas and at the conclusion of the set course it is generally possible to sit for the R.T.E.B. trade servicing certificate. This along with a semi-technical job is probably the best way for an amateur to turn professional.

Opening a business

Many amateurs may have aspirations for opening their own business and becoming self-employed. Here there are many dangers to beset the unwary. Many not in the trade will find it difficult to believe, yet it is true, that many businesses run their service departments at a loss and consider them a necessary adjunct to their sales activities. Actually service need not be run at a loss if it is organised effectively, but if losses are accepted by established businesses it just shows that the beginner needs to watch out if he is not to find himself in financial difficulty. Many are the small businesses that have opened full of promise, operated for a while and then been forced to close.

One common trouble from which many such businesses suffer is under-capitalisation. The overhead costs involved in keeping a business running seems unexpectedly large to those who have had little experience in such matters. Business premises must be rented, heating, lighting and water rates must be paid for as well as insurance on stock and against third-party liability. Then comes the cost of keeping a van on the road, which is essential, as well as of course personal living expenses. All this together with other smaller items forms quite a sizeable weekly outgoing before any profit can be made for the business whatsoever. It is true that all these can be more than met from an established and flourishing business, but many underestimate the length of time required for the business to reach this stage. The time will vary with individual circumstances and locations, but about two years is usually considered the minimum. Capital then, should be sufficient to cover these various outgoings for a minimum period of two years with little return.

One essential provision that will have to be met from capital is the acquisition of suitable stock. Large sums can be tied up in stock so the extent and variety will have to be limited initially. Many small businesses start originally with almost their entire stock made up of second-hand receivers. As the business grows, these are then augmented with new ones and eventually manufacturers' agencies may be obtained. Although the main interest of the business may be in television yet other related lines should be stocked as well, such as radios, fires, electrical appliances, plugs, batteries, etc. These smaller items will bring customers into the shop who may later become interested in a television receiver. Also, of course, the profit on such small items although not large is always helpful.

Buying stock especially for a new business is a difficult job and one which is beset with many pitfalls. The beginner should guard against over buying. Travellers may paint rosy pictures of the large volume of sales of their products being made elsewhere, but remember that his job is to sell you his product and in as large a quantity as possible. Extra discount for quantity buying is not worth it if the product lies on the shelves for long periods. Quantity buying is all right for the established business with large capital, but even then it has its dangers. The new business would be well advised to stick to small quantities.

Another factor that has brought downfall to many a small business is bad debts, so care must be exercised in the matter of giving credit.

Making a profit

Sooner or later, if care has been exercised and the major pitfalls avoided, the tide will begin to turn and the business will begin to show a profit. This often presents yet another snare to the unwary. After, of necessity, living economically for so long, there is then a tendency to feel that the need for thrift is over, the fruit of one's labours can be enjoyed and one's living standards can be appreciably increased. This is a dangerous attitude and many businesses that have been successfully nursed through the critical early stages have foundered at this point. While some relaxation of the strict economies that may have been imposed earlier may be permissible, yet the bulk of these profits should be ploughed back into the business. A wider variety of stock can be invested in and quantity buying of lines that have proved themselves to be fast moving can now be embarked upon for the additional discount. The business can be built up into a really strong position and a good capital reserve should also be developed.

Any established dealer will tell you that the trade usually proceeds in a series of booms and recessions. Recessions can come quickly and unexpectedly, often as a result of the political or economic situation. A good capital reserve therefore will help to tide over any such difficult times which may lie ahead.

All this may seem rather discouraging and the hopeful reader may point to the cases of individuals who are now highly successful but who started with little or no capital or business experience. It is true of course that many have indeed done so, but remember that many more have also fallen by the wayside. Conditions in the trade are much more competitive now than they were when many of these well-known names made their start.

There is one way that many have chosen to start a business with the minimum of capital and difficulty and that is by concentrating on service until the business is well known and the sales side can be developed. This has several advantages from the point of view of the beginner. Perhaps the greatest one is that a large amount of capital does not have to be found and then tied up with stock. Another one is that shop premises are not necessary and in fact the business can be run from one's home, although there can be disadvantages in doing this.

If one is carrying on a business at home the conditions of tenancy and certainly the rating position will be affected. The premises will be now used partly as a business house and therefore will be liable for an increase in rates. If the house is owned by the council then rent increases may be made or they may prohibit you from conducting a business there altogether.

To many people a private address does not possess the same aura of technical efficiency as does a shop in the High Street. The man in the white coat behind the counter is looked on as more of an expert than the ordinary individual who answers the door of a private dwelling even though he may be the same person. This is understandable as the first is obviously a professional (i.e. he earns his living from it) whereas the second is taken to be a part-time amateur. The building up of a core of satisfied customers, then, is likely to take much longer when operating from home than when using accepted business premises.

Obtaining supplies from wholesalers is also difficult when operating from a private address as they consider that such is not a bona fide trade business even though it may be operating full time.

A still further effect that may be found is that many clients seem to expect to pay next to nothing for repairs done at a private address and yet would cheerfully pay an inflated charge to a shop. Of course, a good business can, as many have, been built up from a humble start at a private address, but it is as well to know the difficulties involved. A compromise may be effected by taking small shop premises in what may be considered a poor business area for an ordinary shop, painting over the shop window and using the shop itself as a workshop. This would cost much less to start and to run than a well-stocked shop in a good area and yet would have the advantage of endowing the business with premises accepted by both trade and public.

Whatever is decided in this respect, the business will be built initially upon good service. The proper and effective running of a service department will therefore be essential. How this may be done with the needs of a new business particularly in mind will be discussed in Part 2 of this article.

Part 2 next month

VIDEO TAPE RECORDING

PART 4

H.W. HELLYER

WE have in previous parts of this series looked briefly at the general principles of tape recording, going just deeply enough into the theory behind the lens to show that storing and reproducing pictures is not quite such a straightforward business as recording sound—although the principle is basically the same. Later on, we shall consider a quite different principle for picture storage and replay, but for now let us keep to magnetic recording. The Sony system was described as a dramatic breakthrough in home television taping when it first appeared on our market. It is still at the time of writing the least expensive system on the market by a handsome margin. But not by any means the cheapest in design, construction or concept. As with their domestic audio tape recorders, the Sony company have put into their video machine a very high standard of workmanship. But before looking at what it is and what it does, let us consider a few of the hurdles the designer has to surmount.

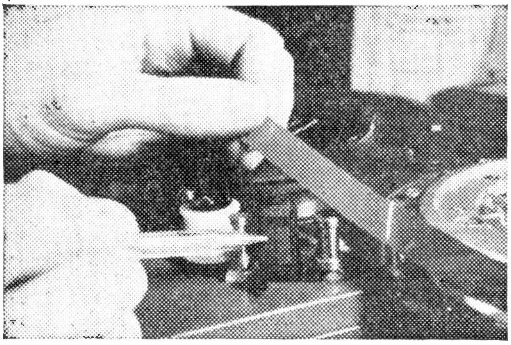
Problems in the design of a tape recorder to store and reproduce television signals are imposed by the need for a greatly extended bandwidth. For an audio tape recorder the frequencies to be handled cover only a range of some 20,000 cycles, which is a little more than the limits of human hearing. The upper limit is determined by the dimensions of the gap in the recording and replay heads and by the speed at which the tape passes the gap. With good quality audio heads the frequency is roughly 2,000 cycles for each inch per second of tape velocity. Thus a good tape recorder at 7½in./sec. should give a reasonably flat response from the lower useful frequencies (say 40 c/s) up to 15,000c/s. By comparison, the video tape recorder has to handle frequencies extending from zero c/s (d.c.) up to 3Mc/s for 405-line signals and up to 4·7Mc/s for a 625-line television signal.

Increasing the linear speed of the tape transport is not an acceptable answer. To record even up to 1Mc/s it would be necessary to increase the tape speed to 500in./sec. A reasonable video picture can be resolved with a bandwidth of 2·7Mc/s (405-line signal) but the high speed of tape transport raises formidable problems of stability, head and tape wear and, perhaps most important, limitation of programme time. For example, an early version of a linear machine, using triple play tape and with a bandwidth much less than is currently acceptable, ran at 90in./sec. to give a half-hour programme—and this needed 11½ in. spools.

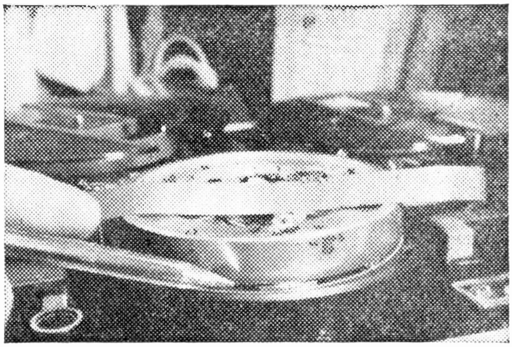
The solution is to increase the relative head-to-tape velocity while keeping the linear tape speed as low as possible i.e., to move the recording and replay heads.

Professional machines, which cost many thousands of pounds, overcome the problem by a system of transverse scanning. Heads are mounted on a disc which revolves at right angles to a wide tape. For a tape speed of 15in./sec. a relative head-to-tape velocity of 1,500in./sec. can be obtained with a bandwidth up to 10Mc/s. (The usable bandwidth is limited by the need to record the signals within the protection of a frequency-modulated carrier, making the practical bandwidth more like 6Mc/s for this system.) But the intricate mechanical systems and complicated circuitry needed for these systems make them impractical for a domestic video tape recorder.

A compromise system which retains sufficient bandwidth to resolve a good picture and limits the speed sufficiently to allow a reasonable programme time is the helical scanning technique. In this system, the tape passes around a drum in the form of a helix, while within the drum recording and replay heads revolve in a contrary direction. The result is that the recorded tracks lie side by



View of the full-track erase head. Also shown are the size and disposition of the tape and, on the left, the guide roller.



View of the fore part of the rotating head drum, showing one of the heads protruding through the slot.

side at an angle across the tape width. The Sony VC2000 employs this system. The tape transport arrangement is illustrated in Fig. 12.

Tape speed is 7½in./sec., using ½in. wide tape. Spool size is 7in. giving a playing time of 60 minutes. Audio signals are recorded linearly along a narrow track at the bottom of the tape and servo signals to maintain synchronising of the recording with the television signal (and locking of the signal for replay) are recorded along the top of the tape. Erasure prior to recording covers the full tape width.

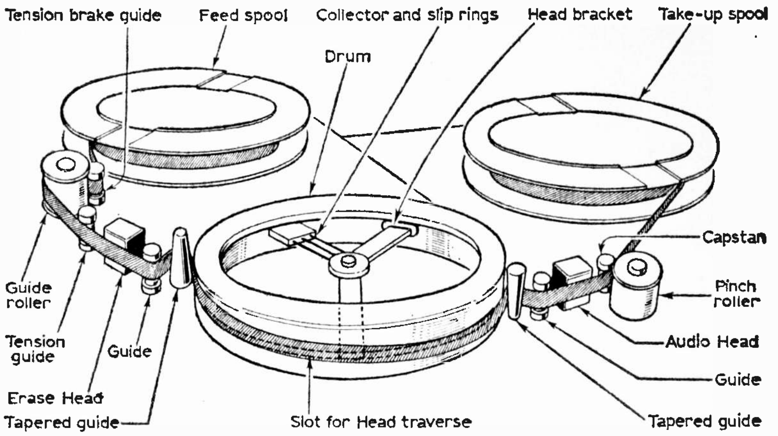


Fig 12: Tape path, Sony CV2000B video tape recorder, showing disposition of guides. Note tapered guides at entry and exit of head drum. These provide the helical path for the tape.

The Sony VC2000 is designed to record and reproduce the British 405-line TV system. This system employs an interlaced scan consisting of two 202½-line fields for each complete picture, repeated every fiftieth of a second. The lines of the interlaced fields lie between each other to give the 405-line picture. Thus each complete picture occupies one twenty-fifth of a second. The heads of the tape recorder rotate at 25 r.p.s. and the servo motor system locks and synchronises this rotation to the field pulses of the television signal.

The video bandwidth needed for a television picture is related to the number of lines, giving a balance between vertical and horizontal definition. In practice, only about 400 of the 405 lines are seen the others being blacked out during the field synchronising period of the television signal. Vertical definition is fixed by the line structure; a 405-line signal needs a video bandwidth of nearly 3Mc/s to achieve the correct balance. By comparison, the 625-line signal needs more than 5Mc/s for the same resolution of picture.

To limit the bandwidth, the Sony VC2000 has a vertical definition of approximately 200 lines and the overall record/playback response need only extend to 1·8Mc/s. This is only a little below the off-air definition and certainly as good as the resolution achieved by many domestic television receivers.

The restriction in bandwidth is achieved by recording alternate fields and playing back these alternate fields twice, to give a simulated interlaced scan. The two-head system is arranged so that the recording mode employs only one head, rotating at 25 times a second, giving a track corresponding to one field. But when switched to replay the second head becomes active and scans the same track, reproducing each recorded track twice. Thus information is fed from the head system each fiftieth of a second.

Synchronisation

Three different sets of timing pulses are obtained from the rotating assembly within the drum, which is driven by a crossed belt from a single hysterisis synchronous motor. These pulses are at 25, 50 and 10,125 intervals per second. The 25c/s pulses are obtained (see Fig. 13) by a coil mounted in the drum wall acted upon by a single pole piece mounted on the rotating assembly. The positive pulses are amplified, gated and integrated and fed to a d.c. amplifier from which a control current is fed to the stator coil of the braking mechanism.

This braking mechanism is employed to stabilise the speed of the rotating assembly, which, uncontrolled, tends to run at 25·3 or 25·4c/s. The exact speed of rotation is thus related to the common assembly on which the heads are mounted. Speed stability is within ±0·2%.

The pulses are recorded on the control track of the tape from the speed reference pulse amplifier, and are picked up during playback, processed in the same way as the reference pulse and employed to control the servo mechanism.

The 50c/s pulse generator consists of two pole pieces passing through the field of a single coil each rotation. The resulting pulses are amplified and applied to the mixer circuits for monitor synchronisation and to the camera as a trigger pulse for the vertical oscillator.

The 10,125c/s pulses are obtained from two coils mounted axially to give 180 deg. out-of-phase

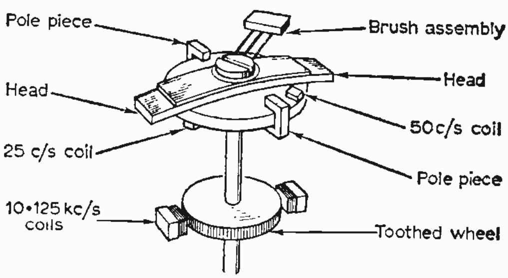
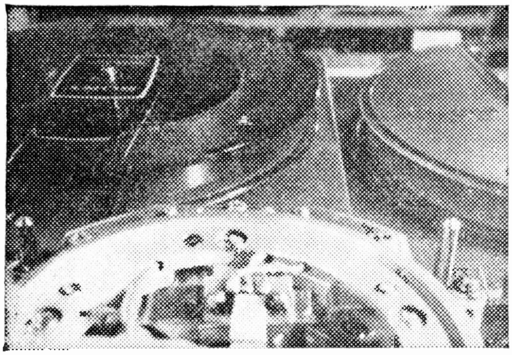


Fig. 13: The head and servo assembly is concentric with the main spindle. The pole pieces and servo coils are mounted on the main disc, but are separately adjustable for exact timing. Line frequency pulses are obtained by the varying flux from a toothed wheel in the field of twin pick-up coils.



Top of drum and head assembly, showing brush take-off wiring. Note also different feed and take-up spool levels to provide level tape feed after helical movement.

signals from a toothed drum mounted on the rotating assembly. The drum has 405 grooves and rotates at 25c/s so that a 10,125c/s signal is produced. Output from the coils is fed to a balancing circuit, amplified, coupled to a variable tuned circuit and fed to the camera as a trigger pulse for the horizontal oscillator.

The vertical sync pulse during TV recording is obtained from the incoming sync pulse which is applied to a monostable multivibrator with its stable output time set for approximately 40μS. Recording from a camera employs a similar operation, except that the 25c/s reference pulse is used as a trigger, the output being recorded in each case on the tape and acting as a trigger to the vertical sync circuits in the same way during playback. In this way, the Sony system is largely independent of variations in television sync pulses or power supply frequency.

Synchronisation and locking of the head rotation phase to the recorded tracks on the tape is achieved by the pulse sensing circuitry coupled with the foregoing triggering. Thus the playback automatically locks into exact synchronisation within a starting period of six seconds (maximum).

Video signals to the monitor are at 1·4V peak-to-peak; with negative-going sync. Input video signal level is approximately 1V, negative sync, from TV or camera, and is used to modulate a double-sideband f.m. generator. Frequency modulation is employed to preserve the recording characteristic and maintain playback equalisation without the need for high frequency bias, and also to prevent amplitude variations due to uneven contact of tape and heads from affecting the signal. An additional advantage is that f.m. allows the recording and transmission of the d.c. component.

During playback and for monitoring the f.m. signal passes through several stages of limiting, is demodulated and then applied to a multistage video amplifier. Pulse mixing takes place in this section and a unique noise cancellation circuit amplifies the high frequency component of the signal (where the noise peaks occur) and feeds it back to the main signal channel in opposite phase. Signal-to-noise ratio is better than 40dB.

Audio signals are recorded and played back in the normal way. A push-pull oscillator provides bias and erase current at a frequency of approximately 90kc/s.

A vidicon tube camera employing silicon planar transistors operates over a light range of 6000 to 1. An f/1·9 lens with 25mm. "C" mount gives a sensitivity from 100 lux to near infinity. A camera selector switch is a standard accessory, allowing two cameras to be connected and switched instantaneously. In practice, by some adroit interconnection, one can use as many as six cameras with one machine; can adapt the camera triggering system to make it link directly with the monitor as a closed-circuit television rig and, by interchange of lenses, vary from telephoto and zoom right down to a close-up focus on a single tooth! The last was done by way of demonstration at a West-country dental teaching hospital quite recently by the author and his colleagues. Other demonstrations have included the operation of a giant aircraft undercarriage mock-up, inspection of a fierce flame at a steelworks, some candid-camera work to aid the police in their war on housebreakers and—perhaps the most enjoyable job of the lot!—an audition for would-be television advertising girls at a well-known Bristol model agency.

There are, of course, some limitations with a machine of this nature. To begin with, the basic model with which we are dealing at present is suitable only for the 405-line system. A 625-line model is due to be marketed at the time of writing, costing only a little more than the price of the Sony VC2000B, which costs 351 guineas for the recorder and its monitor and 125 guineas for the camera. Another of the drawbacks that should be beaten in the new model is a picture break of up to six seconds when switching from record, rewind or off to play. The third feature that limits the original model is the composite picture and sound tape that must result from the full-track erase system, so that dubbing and post-recording sound synchronisation becomes very difficult. It has been proved possible, in practice, by some switch and connection juggling to dub from one machine to another while re-recording the sound, but a good deal of care is needed to guard against losses in picture quality.

Editing, in the sense of "patching scenes", is surprisingly effective. A straight splice with no special care to locate individual tracks gives a picture "flick" of much less duration than the normal switching break. But if exact editing is needed, as for example to retain lip synchronisation, then it would be necessary to cut along a field track length and this means a very long diagonal splice, practically impossible to make with any degree of accuracy. In this area, at least, the film-makers have the advantage with their successive frames of still pictures.

So much, then, for the surface details of the Sony system. Digging a little deeper we shall in the next part go on to the actual circuits that provide the pulses for the servo operation, the video and limiter circuitry and some of the refinements needed to make video recording possible. Space precludes the possibility of giving a complete circuit, for this uses 50 transistors, 28 diodes and some fairly complex switching. But next month we shall simplify matters by reducing the sections to their fundamentals and discussing each in turn.

TO BE CONTINUED

DX-TV

A MONTHLY FEATURE FOR DX ENTHUSIASTS

by Charles Rafarel

CONDITIONS during the past four weeks have been no worse than the previous period; in fact they have been rather better. Sporadic E reception is still with us, however.

Therefore try to dispel any despondency about DX by remembering that we shall soon be "turning the corner" for the next Sp.E. season beginning around March or April, with a few Sp.E. openings to sustain our interest in the interim period, and perhaps, even some extreme F2 DX in January and February.

Back to the current period, we are still waiting for the usual late autumn tropospheric opening, but on 18/11/67 there was an excellent opening, and this should be maintained for a very long time. Until now, high winds and rain have played havoc with tropospheric reception.

Sp.E. reception from 16/10/67 to 18/11/67:

23/10/67: Czech. R1.

24/10/67: USSR R1, Yugoslavia E3, Italy IA, and IB.

26/10/67: USSR R1, Czech. R1.

28/10/67: Czech. R1, Austria E2a.

29/10/67: Yugoslavia E3.

30/10/67: W. Germany E2.

1/11/67: Sweden E2, USSR R1.

6/11/67: USSR R1, and R2, Czech. R1.

7/11/67: Czech. R1.

10/11/67: USSR R1, Poland R1, W. Germany E2.

16/11/67: Hungary R1, Austria E2a.

17/11/67: USSR R1.

Apart from the above, there have been many very short "bursts" on most days, and some of these at least are due to meteor showers.

We have the following news items to report:

(1) The mystery test pattern on R1 mentioned in our September issue (the one with the black-and-white rectangles at the bottom) has now been identified, as anticipated, as of Czech. origin.

(2) A new "exotic" country is coming soon. For political reasons, Israel is now committed to open a TV service in 1968, provisional opening date 1st April. No news yet about transmission in Band I, but if so we have a reasonable chance.

(3) French manufacturers are now offering sets that will receive both 625 lines and 819 lines in the u.h.f. bands. This can only mean that the French first programme is, or will be, relayed on Bands III and IV, and if these include some relays in the northern coastal areas of France, they may be receivable here.

(4) Another mystery received by R. Bunney on E2 on 2/10/67: yet another test pattern, a shaded rectangle with the black section on the right, resting on three squares, the L/H one black, the centre one white, and the R/H one grey. Probably W. German we think.

(5) R. Bunney again, this time with a "smeared" sawtooth pattern on E2, of uncertain line frequency, appeared to be over 625, Ch. E2. Where did this one come from? Dare we whisper the magic words F2?

There are encouraging signs here. As you know, Mr. Papaeftychiou of Cyprus has been getting results for some time now and his latest batch of F2 DX includes Nigeria Kano E4. Even more spectacular is his mention of E3 reception of an announcement almost certainly "Ceylon TV Service". No lists show Ceylon on E3, but his aerial direction was right, and he knows what he is doing!

At this end I have heard considerable sound activity in Russian about 40Mc/s. The band 39·98 to 40·002Mc/s is allocated for space research and as this activity was on the 2nd to 4th November, about the time of the last Russian space shots, the transmitters may well have been at or near the launching pads in the Ural Mountains in Asia.

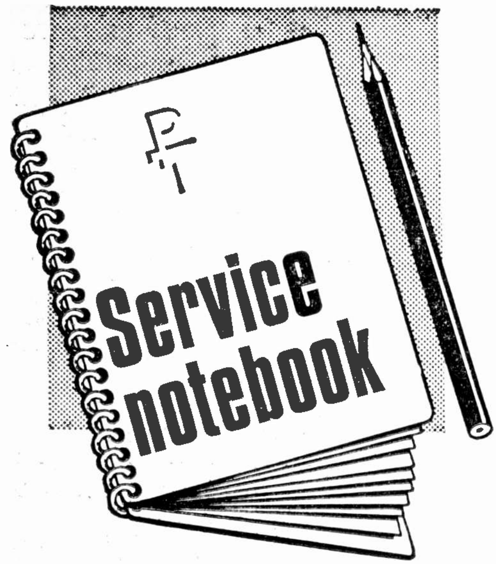
C. R. Dykes of Bexleyheath has now also had the paging station QRY508 at New Orlando USA about 35Mc/s, so that is another instance of F2 reflection.

Although the above two items come more within the province of our S.W.L. friends, I feel that all reception reports above 30Mc/s are worth noting in view of their DX/TV implications. Many TV sets can tune down to 40Mc/s, although there may be instability problems as we approach the standard i.f. frequencies of the set.

R. Roberts of Bracknell reports on Ch. R1 a small check-board pattern of black, white, and grey squares. (This is of Czech. origin, but I cannot recall seeing this one since I first saw it some five years ago.) He has also had good results from most countries of Europe including Finland and Denmark which seem to have been difficult this year.

M. R. Hall of Guisborough has made his mark as a DXer, his more recent reception shows Norway, Sweden, W. Germany, Poland/Hungary, USSR, and Switzerland. He notes the latter as "fantastic" and has sent us a photo to prove it. We agree! He has a "Starpbridis" caption on E2, does anyone know what this is?

C. R. Dykes of Bexleyheath has also been noting short bursts of Band I reception and rightly suggests meteor reflection. His most recent log includes Spain, Portugal, Italy, USSR, Poland/Hungary, amongst others. He has kindly sent a list of South American exotics which we will publish soon.



by G. R. WILDING

Aerials

YOU never can be certain about aerials. This fact was vividly brought home to us the other week when making a service call to a 19in. R.G.D. receiver which was giving first-class Band I results but poor Band III reception. This fault is generally caused by a low emission r.f. amplifier valve, but this time replacement effected no worthwhile improvement. Changing the frequency changer valve also produced no improvement and after cleaning the tuner contacts and ensuring that they all firmly made, it began to look as if the tuner itself was faulty.

The aerial was a chimney mounted Band I/III combined type with single downlead and, as BBC reception was really good, beyond checking that the co-ax input plug was correctly fitted there seemed little point in making further checks on the aerial installation. The receiver was therefore taken to the workshop with a suspect tuner fault. On test, however, reception on both bands was normal.

Subsequent inspection by riggers of the customer's aerial then revealed a complete disconnection of the outer braid from the lower section of the Band I dipole, inside the junction box. This disconnection had produced no noticeable effect on Band I yet had almost completely killed Band III reception. You never can tell.

Normally the best drill for testing a suspect aerial is to remove the aerial input co-ax plug completely, check results with the inner conductor of the feeder only connected to the central part of the aerial socket, and then note whether signal strength increases or decreases when the outer co-ax braiding is contacted to the aerial socket outer ring.

A reduction in signal strength on making contact in this way with the outer braiding is usually a sign of a short-circuit somewhere in the aerial installation. This may be inside the actual aerial connection box, at some point where a staple may have pierced the outer plastic covering, or at a taped co-ax extension.

When we need a temporary aerial for installation or as a check and do not have a commercial indoor one with us in the van, we often make one from a length of co-ax wire, and quite effective this proves in most areas. The outer plastic covering is stripped from the cable for about 4ft.; then, after making a hole in the metal braiding beneath, we pull the inner conductor through. The braiding and inner conductor then form the two halves of a dipole and, after connecting a plug to the other end of the cable, leaving several yards as the downlead, it only remains to move the dipole about until best results are obtained and secure it to the picture rail or window frame. Ideally of course the length of the dipole so formed should be the appropriate length for the local Band I channel.

Finally, if as often occurs we are asked the best way of extending a co-axial lead inside a house, we emphasise that if the two leads to be joined are first separated as mentioned above, that is by pulling the inner conductor through a hole in the outer braid, there will be no danger of the latter subsequently working up the lead and shorting the "inner".

Quick voltage checks

A number of voltage checks can help speed up fault diagnosis. For instance, to check if a frequency changer is oscillating there is no better way than to note if there is a negative voltage at the grid of the oscillator section. This negative voltage should disappear when the tuned circuit is shorted.

In the case of a receiver giving normal sound but a blank raster, the fault can be in the vision only i.f. stage, the video detector or video output stage. By applying a voltmeter on a low voltage range to the detector output, the presence or not of a video signal can be checked, thus localising the faulty stage or stages. If in any doubt as to whether the voltage measured is the actual video signal, simply remove the aerial plug or switch to a dead channel position. Of course in 405-only receivers and in dual-standard types with direct coupling between the video detector and the video output stage—the commonest practice — it is easiest to detect this voltage at the grid of the video pentode, sometimes from the video test point provided.

When in doubt about the functioning of the a.g.c. system, or to check if the contrast control circuit is operating normally, a meter connected from the a.g.c. line to chassis will show up but not measure the negative potential which should be present. With a normally working a.g.c. rail, the mere application of a meter should increase gain on strong signals by reducing the a.g.c. voltage.

Fuses

When we find that receiver failure is due to a blown h.t. or heater circuit fuse and the set works well when this is replaced, the view is usually taken that the fuse was blown because of a switch-on surge, or, if it appears to be old, by vibration, and not by any actual fault in the circuit. If PY33 or dual PY82 rectifiers are fitted, the latter being in many Philips receivers, we would probably give them a tap to see if there was any sign of internal sparking or fragments of cathode coating bridging the anode/cathode spacing.

When the h.t. fuse blows immediately on replacement, first suspect must be a valve with an internal anode or screen short-circuit to grid or cathode, and which is fed via a low resistance from the h.t. rail. Should, on the other hand, the heater chain fuse blow immediately on replacement, the first suspect must be a heater/cathode short-circuit in the boost rectifier, line output pentode or h.t. rectifier valve where fitted.

Although they might appear such obvious suspects, the paper capacitors connected directly across the mains input by many manufacturers to filter out mains-borne interference seldom if ever break down.

Where the plug fuse in a 13A circuit is open-circuit but the set's fuses are intact, the almost certain cause is a shortening tape join in a mains lead extension to the receiver.

Incidentally, the rating of a fuse is not the value at which it blows, but represents the current it can carry indefinitely till exceeded by a close pre-determined rise. I must admit, however, that I have never been able to find out exactly what this permissible increase is.

Surge limiters

Although they are generously rated by most receiver manufacturers, the replacement of surge limiters is a regular feature of everyday servicing. Of course the stringent working conditions of these wire-wound components is the principal cause of their failure, for whereas the h.t. drain from the reservoir capacitor is about 300mA, the replenishing feed to the rectifier anode takes the form of short duration, high value pulses. Not only is rectifier conduction confined to the positive half-cycles of the input a.c. waveform, but to that section of the half-wave which is at a higher potential than the rectifier cathode. As the cathode voltage is usually about 200V, the average charging period is only a fraction of the full one-fiftieth of a second cycle. On this basis, the average charging current pulse can be many times the constant d.c. drain from the reservoir capacitor, and rise to a maximum value measurable in amperes. Thus these small value resistors have to pass this comparatively heavy on/off current, which imposes a thermal strain on the winding.

However, when a surge limiter goes open-circuit in a little used receiver, the probability is that there is an underlying cause. For instance, we came across a nearly new K-B 19in. receiver which had an open-circuit 9Ω surge limiter section on the multiple mains dropper resistor. On replacing this section and switching on, sound returned, the new resistor started getting very hot but there was no line whistle. The PL302 line output valve then commenced running red hot due to lack of grid drive, and we were about to switch off and make further tests when line oscillation suddenly commenced. The PL302 then operated normally, the replacement 9Ω resistor reduced to normal temperature and the set worked perfectly. We subsequently found that the PCF 802 line oscillator valve was defective and only commenced to oscillate about 7-8 minutes after the set was switched on. We replaced this valve and experienced no further trouble.

On another occasion, with an older Regentone set, we found that the cause of the surge limiter going open-circuit was a defective PY81 efficiency diode. This resulted in the PL81 line output valve receiving zero anode voltage but normal screen voltage, so that the screen passed a current far in excess of the normal total anode and screen currents. The strain on the PL81 had been intensified by the owners using the set for sound only after vision had failed, so that we had to replace both the PL81 and PY81 valves as well as the surge limiter.

A further regular source of service work is a break in the mains dropper resistor, and the usual practice is to shunt the open-circuit section with a high wattage resistor of equivalent value. However, although service manuals invariably quote the resistance values of each section, they rarely state the individual wattages. It then becomes necessary to resort to Ohm's Law. As a typical example, if a 50Ω section is to be replaced, heater current being 0·3A, the wattage will be I^2R or $0{\cdot}3 \times 0{\cdot}3 \times 50$, equalling 4·5W. On the face of it, therefore, a 5W resistor will do, but in practice as this replacement will have to be mounted close to the very hot main component it is best to be generous with the rating and double that found by calculation.

So as a general rule for every 50Ω of dropper resistor, use 10W rating. When mounting these replacement sections keep them as far as possible from the main dropper resistor and follow rigorously the first law of good soldering, which is that a good soldered joint is first of all a good mechanical connection. Butt joints just will not do in this position. If the soldered connection deteriorates because of heat, sparking will occur and burn away the tag as well as imposing a strain on all the valve heaters.

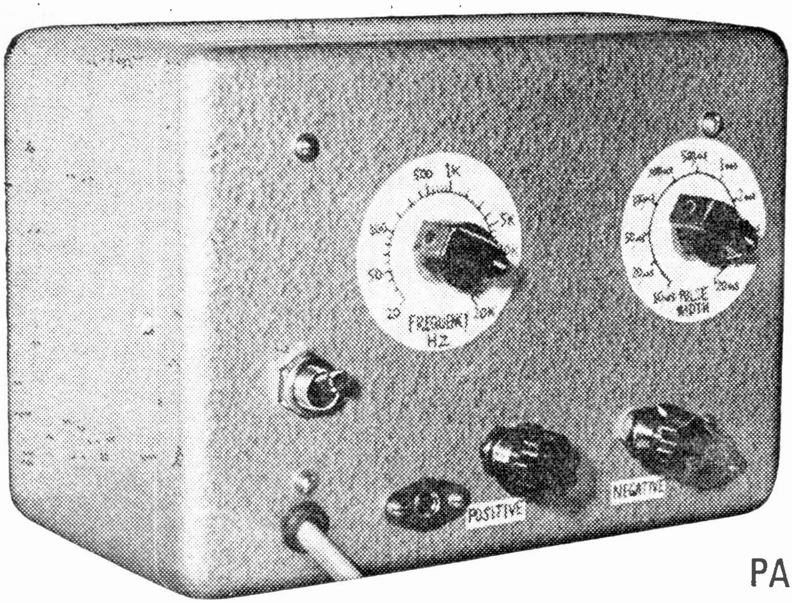
An unusual heater circuit fault

A very unusual and for a time perplexing fault showed up on an older 17in. Bush in our workshop recently and, as the circuitry involved is used on many more recent models, is certainly worth describing. The symptoms were that the set took an extremely long time to warm up and when it did at last begin to operate, gave just about observable results with a reduced size raster complete with extensive bottom fold-over.

As the valve heaters were obviously not at normal temperature we first suspected that the thermistor was failing to reduce in value or that there was an intermittent heater chain connection, probably on the mains dropper resistor.

We then placed an a.c. voltmeter across the c.r.t. heater to see what it was getting, and found to our surprise—no reading. Thinking the a.c. ranges of the meter were o/c, we checked on other circuit points and found that the meter was quite in order but failing to read because the heater supply was pure d.c. After quite a bit of circuit exploration we found that in these models, as in many other Bush

—continued on page 181



pulse generator

PART 1

BY MARTIN L. MICHAELIS, M.A.

THE ideal pulse is a rectangular waveform. In other words, a certain voltage or current change takes place suddenly, the new value then persists for a certain time, whereafter an equal magnitude change suddenly takes place in the opposite sense, returning the voltage or current to its original value. The initial and final voltage changes are known respectively as the leading and lagging flanks of the pulse and their durations are ideally zero, i.e. the flanks should be of infinite slope and thus take place instantaneously.

Actual pulses will fall short of these ideal characteristics; the flanks will be of finite slope and thus take a certain time, and the voltage between the two flanks (known as the roof of a positive pulse or the trough of a negative pulse) may not be flat, but manifest a slope or other irregularities. Furthermore, subsidiary pulses or other irregularities may be present immediately before or after a flank, or even on the flank itself. The extent to which these pulse distortions are tolerable will depend upon the functional purpose of the pulse in a given circuit.

TIME EXPRESSION

In television waveforms any narrow vertical objects in the picture will correspond to pulses in the video sections of the lines concerned, but these are incidental features. On the other hand, the sync and blanking pulses are prominent features of the complete waveform. Their flanks define the instants at which successive picture lines and fields must commence. The time interval between the leading and lagging of flanks of a blanking pulse define the period for which the c.r.t. must be cut off to render flyback traces invisible, and the time interval between successive pulses defines the duration of a line or field of the picture.

The electronic expression of instants and intervals of time is thus one important group of functional purposes for pulses. For all such applications, the steeper and thus briefer the pulse flanks are, the better. But the residual uncertainty in the definition of an instant in time is not necessarily as great as the pulse flank duration, as one might at first suppose, because the actual criterion used in many circuits is the instant at which the flank crosses some voltage threshold at which a subsequent circuit responds. The steeper the pulse flank, the smaller will be the resulting timing errors due to inevitable drift or fluctuation of the threshold level. But the timing error will nevertheless be smaller than the pulse flank duration, since the maximum drift of the threshold level will normally be only a small fraction of the total amplitude of the pulse flank.

CIRCUIT TESTING

The second important group of functional applications for pulses concerns circuit response testing, particularly when designing precision equipment in modern fields such as CCTV or colour television. The respective amplifiers must be able to handle the incidental pulses in the picture video waveforms without undue distortion, since the picture contours will otherwise be diffuse instead of sharp. The sync pulses must also be passed on without undue distortion if picture lock is to be secure.

Applications of a pulse generator as a signal source for circuit testing clearly impose more exacting demands on pulse waveform accuracy than is the case for timing applications. We require very accurate input pulse waveforms when using them to determine the extent of distortion of an ideal pulse in a particular experimental circuit. Whilst

ide range

the output pulses of the unit described in this article are sufficiently accurate for much work of this kind, a more comprehensive precision pulse generator will be required for critical instances.

The prototype of the wide range pulse generator described in this article was actually built as an accessory unit for use with a commercial precision pulse generator, to permit advance triggering of an oscilloscope and thus allow full display of the leading flanks of pulses from the precision pulse generator after passing through the circuits on test. This facility is of vital importance for systematic design work in modern fields of television and all other branches of pulse electronics. It is known as the *strobe-trigger* mode of operating an oscilloscope.

TRIGGERING AN OSCILLOSCOPE

The problem may be explained as follows. The time interval between the leading and lagging flanks of a pulse, known as the *pulse width*, is often only a small fraction of the time interval between the leading flanks of two successive pulses, known as the *pulse interval*. For example, the line and field blanking pulses in the television waveform possess respective widths which are only a small fraction of the line and field durations. If we synchronise the free-running timebase of an oscilloscope for a stationary display of such a pulse waveform, we must accommodate at least one pulse interval across the c.r.t. screen. The actual pulses will then appear very narrow and it is difficult or impossible to assess the extent of any departure from the ideal waveform. For this purpose, it is desirable to *expand* the pulse display over nearly the whole screen area, irrespective of the pulse width to pulse interval ratio.

One requirement for achieving this aim is to trigger the oscilloscope timebase instead of synchronising it. The triggered timebase does not run of its own accord, but is made to run once only across the c.r.t. screen, at any desired speed setting, for each pulse fed to the trigger input of the oscilloscope. The spot waits (blanked out at the c.r.t. grid) at the left of the screen after completing each stroke until the next trigger pulse arrives. In this arrangement, the timebase sweep speed (time/centimetre) can be chosen independently and thus can be made fast enough to magnify the pulse display to the desired extent, irrespective of the duration of the pulse intervals.

An oscilloscope which can be triggered as well as synchronised is thus essential for systematic television design work. The oscilloscope timebase mode switch usually possesses three settings, for sync, positive trigger, and negative trigger respectively. When set to positive trigger the timebase fires on that flank of each trigger input pulse which is rising to a more positive (or less negative) voltage, i.e. on the leading flank of a positive pulse or the lagging flank of a negative pulse. The converse applies for the setting negative trigger.

STROBE-TRIGGER OPERATION

Due to circuit inertia in the oscilloscope there is an inevitable small delay after the triggering flank before the timebase stroke commences. If we were to use the same input pulse for triggering the oscilloscope and for feeding the experimental circuit whose pulse response is to be tested, most of the leading flank will have passed before the timebase of the oscilloscope commences its run. By selecting a sufficiently fast oscilloscope timebase sweep speed setting, we can certainly display the pulse roof or trough and the lagging flank over the entire screen area, but we are unable to obtain a complete display of the leading flank, which is the most important criterion for the pulse performance assessment of many circuits.

To display the entire leading flank of a pulse from a circuit under test, we must devise some method for triggering the oscilloscope timebase with trigger flanks which appear at a time t earlier than the leading flanks of the pulses fed to the circuit on test. If t is made about $\frac{1}{4}$ of the pulse width and the timebase sweep speed is set such that the screen width is about 1·5 times the pulse width, then the complete leading flank will be displayed in the left-hand part of the screen, and the complete lagging flank will be displayed in the right-hand part of the screen, irrespective of the pulse width to pulse interval ratio. This is just what we set out to obtain.

Good commercial precision pulse generators are also able to operate in a free-running mode (with or without sync) or in a triggered mode. When triggered, they produce accurate output pulses which start coincidently with each input pulse flank of correct polarity. The waveform of the input pulses may thereby be inferior to those produced by the precision pulse generator without impairing the performance of the system.

If the positive output pulses of the wide range pulse generator described in this article are fed to the trigger output of the oscilloscope set to positive trigger, and the negative output pulses are simultaneously fed to the trigger input of a precision pulse generator set to positive trigger, then the precision pulses from the latter will have their leading flanks coincident with the lagging flanks of the pulses from the wide range pulse generator. In other words, the precision pulses commence at time t after the start of each oscilloscope timebase run, where t is the pulse width setting on the wide range pulse generator.

CONTROL SETTINGS

In this arrangement, the frequency control on the wide range pulse generator determines the repetition frequency of all pulses. The pulse width control on the wide range pulse generator positions the pulse display on the screen of the cathode ray tube. The width of the precision pulses actually applied to the circuit on test and checked with the

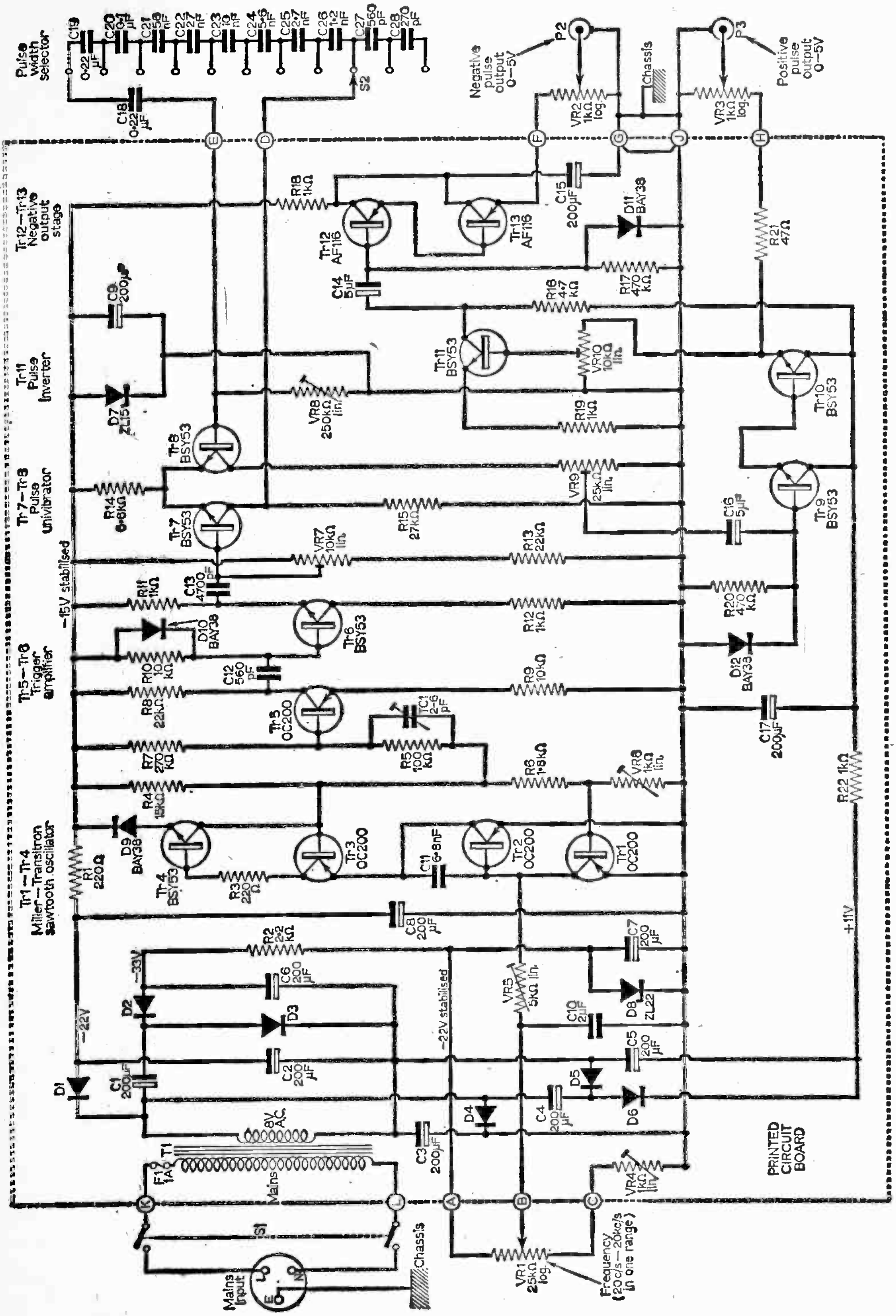


Fig. 1: Circuit diagram of the wide range pulse generator.

oscilloscope is of course set with the controls of the precision pulse generator.

Optimum positioning and size of the pulse display on the oscilloscope is obtained when the pulse width setting on the wide range pulse generator is about a quarter of the pulse width setting on the precision pulse generator, and the oscilloscope timebase sweep speed is set so that the screen diameter corresponds to about 1·5 times the width of the output pulses of the precision pulse generator. These settings are of general validity and they are not critical. They are independent of the pulse repetition frequency, which merely affects the brightness of the display and thus can be chosen as required, setting the brightness control of the oscilloscope accordingly, in order to simulate the actual operating conditions for which the circuit on test is ultimately intended.

An apparently simpler method of displaying complete pulses would be to decrease the pulse interval, i.e. to increase the repetition frequency, so that the pulse intervals become comparable to the pulse width. Reasonably large pulse displays are then possible on an oscilloscope even with an ordinary synchronised free-running timebase. However, this arrangement is often ruled out because the performance of the circuit being tested may alter substantially when the ratio of pulse width to pulse interval is changed. Many pulse circuits in television equipment are designed for the particular time ratio prevailing in the actual television waveform. They will not operate correctly with greatly different time ratios. This is the case, for example, in circuits employing rectification and integration of the pulses to derive bias voltages and establish the operating points of individual stages.

INTERVAL TRANSIENTS

Another general consideration demanding long pulse intervals for the early steps in designing and testing new circuits is the fact that unwanted disturbances following each pulse may persist for a multiple of the input pulse width before terminating. Thus long quiescent intervals must then be checked between successive pulses, for assessing the necessary improvements which must be made to the circuit design.

Without changing any other manual control settings, it is merely necessary to reduce the timebase sweep speed setting of the triggered oscilloscope so as to compress the pulse to the left and thus bring any desired portion of the pulse interval on to the trace. If sharp transients appear at some point along the pulse interval and it is necessary to magnify these over the entire screen area of the oscilloscope for proper examination, merely switch back to a fast timebase sweep speed and increase the pulse width setting on the wide range pulse generator (i.e. increase the trigger delay time for the precision pulse generator) so that it corresponds to the time interval between the transient and the leading flank of the next precision pulse. In practice, the procedure is to gradually magnify the transient display by increasing the timebase sweep speed setting on the triggered oscilloscope, while empirically following-up with the pulse width setting on the wide range pulse generator to keep the display on the screen.

OTHER APPLICATIONS

The described strobe-trigger function for use with a precision pulse generator used in conjunction with a triggered oscilloscope is the chief application for which the author designed and built his prototype wide range pulse generator as presented in this article. The delightful ease of operation and great versatility of this method of oscilloscopy, leading to rapid progress in the practical development of even ambitious television or other pulse circuit designs, is already adequate justification for publication of this simple pulse generator. However, this by no means exhausts all its possible applications.

The pulse waveform is sufficiently accurate to serve as a precision pulse signal source for determining the frequency and phase response of all types of *audio* equipment. The unit also serves as a useful audio signal source. Furthermore, it may be employed as a master drive oscillator (clock pulse generator) for many experimental television circuits, CCTV networks, etc.

The foregoing discussion of the applications of the wide range pulse generator has served to pinpoint the performance demands and was thus a necessary preliminary for proper understanding of the detailed circuit description. If desired, the accuracy of the output pulse waveforms can be improved still further by measures which will be described subsequently. Readers who do not possess a triggered precision pulse generator for the strobe-trigger oscilloscopy application can duplicate certain stages in a modified form to serve this purpose. The refinements for obtaining improved pulse waveform accuracy need be applied only to these duplicate stages, which may be constructed as a separate unit, or they may be included as an extra module in the case of the basic unit.

PERFORMANCE

From the foregoing description of the functions and purposes of the basic unit, it is evident that a wide range of variation for pulse width and pulse repetition frequency is more important than extreme accuracy of the pulse waveform. The latter must merely be reasonable, which means that the flank durations (rise time from 10% to 90% of the pulse amplitude, or vice versa for fall time) should not exceed about 20% of the shortest pulse width setting, and the pulse roof or trough as well as any pre- or post-flank overshoots and transients should not deviate by more than ±5% of the pulse height with respect to the horizontal.

The published design satisfies these tolerance limits, indeed at most settings it gives considerably superior, almost ideal, waveforms. The leading flank has a duration of about 2 microseconds for *all* pulse width settings, so that it just reaches the tolerance limit at the narrowest pulse width setting of 10 microseconds, but has reduced to a negligible 0·01% of the pulse width at the widest setting of 20 milliseconds. Performance is even better for the lagging flank, which has a duration of less than 1 microsecond.

RANGES PROVIDED

Since wide control ranges are more important

COMPONENTS LIST

Resistors:

R1	220Ω	R12	1kΩ
R2	2·2kΩ	R13	22kΩ
R3	220Ω	R14	6·8kΩ
R4	15kΩ	R15	27kΩ
R5	100kΩ	R16	4·7kΩ
R6	1·8kΩ	R17	470kΩ
R7	270kΩ	R18	1kΩ
R8	22kΩ	R19	1kΩ
R9	10kΩ	R20	470kΩ
R10	10kΩ	R21	47Ω
R11	1kΩ	R22	1kΩ

All ½w ± 10% carbon

VR1	25kΩ log	potentiometers, with control knob
VR2	1kΩ log	potentiometers, with control knob
VR3	1kΩ log	potentiometers, with control knob
VR4	1kΩ lin	miniature skeleton
VR5	5kΩ lin	miniature skeleton
VR6	1kΩ lin	miniature skeleton
VR7	10kΩ lin	miniature skeleton
VR8	250kΩ lin	miniature skeleton
VR9	25kΩ lin	miniature skeleton
VR10	10kΩ lin	miniature skeleton

Semiconductors:

D1—D6	Silicon rectifiers minimum rating 250mA, 100 p.i.v.
D7	ZL15 15V Zener, minimum power dissipation 300mW.
D8	ZL22 22V Zener, minimum power dissipation 300mW
D9—D10	BAY38
Tr1	OC200
Tr2	OC200
Tr3	OC200
Tr4	BSY53
Tr5	OC200
Tr6	BSY53
Tr7	BSY53
Tr8	BSY53
Tr9	BSY53
Tr10	BSY53
Tr11	BSY53
Tr12	AF116
Tr13	AF116

(See text for substitutes for diodes and transistors)

Capacitors:

C1	200μF 30V electrolytic
C2	200μF 30V electrolytic
C3	200μF 30V electrolytic
C4	200μF 30V electrolytic
C5	200μF 30V electrolytic
C6	200μF 30V electrolytic
C7	200μF 30V electrolytic
C8	200μF 30V electrolytic
C9	200μF 30V electrolytic
C10	2μF 60V Miniature foil
C11	6800pF 250V Miniature foil
C12	560pF ceramic, 250V
C13	4700pF ceramic, 250V
C14	5μF 30V electrolytic
C15	200μF 30V electrolytic
C16	5μF 30V electrolytic
C17	200μF 30V electrolytic
C18	0·22μF 60V Miniature foil
C19	0·22μF 60V Miniature foil
C20	0·1μF 100V Miniature foil
C21	56000pF 250V Miniature foil
C22	27000pF 250V Miniature foil
C23	10000pF 250V Miniature foil
C24	5600pF 250V Miniature foil
C25	2700pF 250V ceramic
C26	1200pF 250V ceramic
C27	560pF 250V ceramic
C28	270pF 250V ceramic
TC1	2–6pF ceramic trimmer

Miscellaneous:

S1	Double-pole on/off toggle switch (mains)
S2	Rotary switch, 1-pole 11-way, miniature, with control knob
P1	Mains plug
P2, P3	Coaxial sockets, panel mounting
F1	Fuse on T1, 1A
T1	Miniature bell transformer, 8V 0·5A

Cabinet, material for printed circuit, wire, solder, bolts, etc.

than precision setting of particular spot frequencies or pulse widths, it was decided to adopt an oscillator circuit which will tune smoothly in a single range from 20c/s to 20kc/s, using an ordinary logarithmic carbon potentiometer as tuning control. Similarly, the pulse width selector is a single-pole 11-way rotary switch providing 11 logarithmically staggered values from 10 microseconds to 20 milliseconds. The frequency range was chosen to cover values from half the field frequency up to at least the line frequency on both television standards. This range also conveniently coincides with the hi-fi audio range. The available pulse width values are graded logarithmically from one field period to less than a fifth of a line period. These ranges permit adequate simulation of pulse width to pulse interval ratios as encountered in normal television waveforms, and they allow strobe-trigger interpolation for examining transients at any point on the pulse intervals of line or field frequency waveforms.

The positive and negative output pulses are available simultaneously and are provided with independent logarithmic-law amplitude controls.

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TRADE NEWS • TRADE NEWS • TRADE NEWS

TRADE NEWS • TRADE NEWS • TRADE NEWS

KNIGHT-KITS

KNIGHT-KITS are easy to assemble kits which enable anyone, regardless of their technical knowledge, to construct professional standard electronic equipment. This claim is made by Messrs. Electroniques (STC Ltd) who handle the kits in Britain. They offer a wide range of units varying from little 6s. 6d. educational kits, to general coverage radio receivers and test equipment.

A free catalogue describing the whole range of Knight-Kits is available from Electroniques (STC Ltd.), Edinburgh Way, Harlow, Essex.

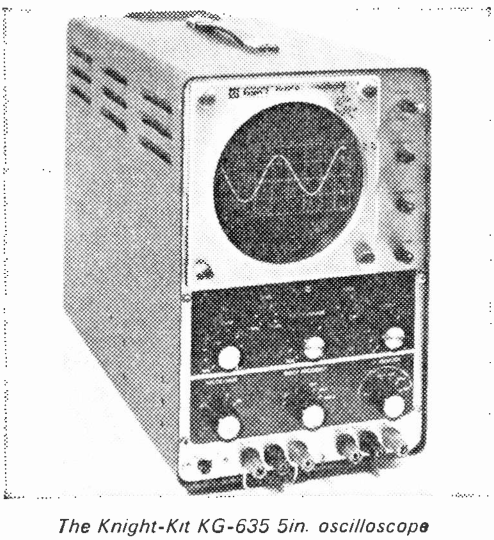
Below, we show a picture of the Knight-Kit oscilloscope, and give the manufacturer's specification.

Vertical

Sensitivity: 17 mV rms/inch (7 mV rms/cm) minimum. Calibrated at 0·05 X p-p/inch. **Response:** ±1·5 dB, DC to 5·2 Mc/s. **Colour Bandpass:** ±0·5 dB. **Overshoot:** less than 6%. **Rise Time:** 70nsec. **Input Impedance:** 3 Mc/s shunted by 35 pF. **Positioning:** ±2 inches. **Attenuator:** frequency compensated, calibrated 0·95, 0·5, 5, and 50 volts p-p/inch.

Horizontal

Sensitivity: 0·6 V rms/inch. **Response:** ±1·5 dB, 1 c/s to 400 kc/s. **Expansion:** 2 times. **Positioning:** all parts visible. **Input Impedance:** 7 MΩ shunted by 25 pF. **Inputs:** internal timebase, 50 c/s phase controlled, and external. **Linear Timebase Ranges:** (5) 10–100 c/s, 100–1,000 c/s, 1–10 kc/s, 10–90 kc/s, 90–400 kc/s. **Synchronisation:** internal plus and minus, 50 c/s, and external. Sync limiting provides semi-automatic operation with level control. Locks from waveform fundamentals up to 5 Mc/s, and display amplitudes as low as 0·1 inch. **External Sync Sensitivity:** 150 millivolts rms at 1 kc/s. **Line Sync:** phase variable.



The Knight-Kit KG-635 5in. oscilloscope

General Characteristics

Calibration Voltage: 50 c/s sinusoidal, 100 mV p-p, ±5%. Voltage calibrator output available at front panel jack. **Z-Axis Input:** 10 volts negative for beam cutoff. **Input Impedance:** 1 MΩ. **Valve Complement:** 9, plus 5in. CRT; 2 rectifiers. **Size:** $11\frac{7}{8}$ x $7\frac{7}{8}$ x $15\frac{3}{8}$in. **Power Requirements:** 230–250 V, 50 c/s AC; 112 watts.

ELECTRICIAN'S KIT FOR CHRISTMAS

THE Bib Home Electrician's Kit, marketed by Multicore Solders Ltd. is now available as a Christmas gift. It is contained in a plastic wallet which folds down to 4 x $5\frac{1}{4}$in. Largest component in the kit is the Bib wirestripper and cutter. This has a selector for different wire thicknesses and apart from stripping insulation it will cut wire and split twin flex.

To keep flex, cables, leads etc. tidy, there are three Bib flex shorteners. The Ersin tape solder supplied melts at the touch of a match and no extra solder or soldering iron are needed.

Also included is a screwdriver, fuse wire for 5 and 15 amp fuses and a reel of insulating tape.

The kit can be supplied with a green and white tag printed with a holly symbol and the slogan "With Best Wishes". There is a space for the names of the recipient and sender.

BBC-2 TELEVISION TRANSMITTING STATIONS

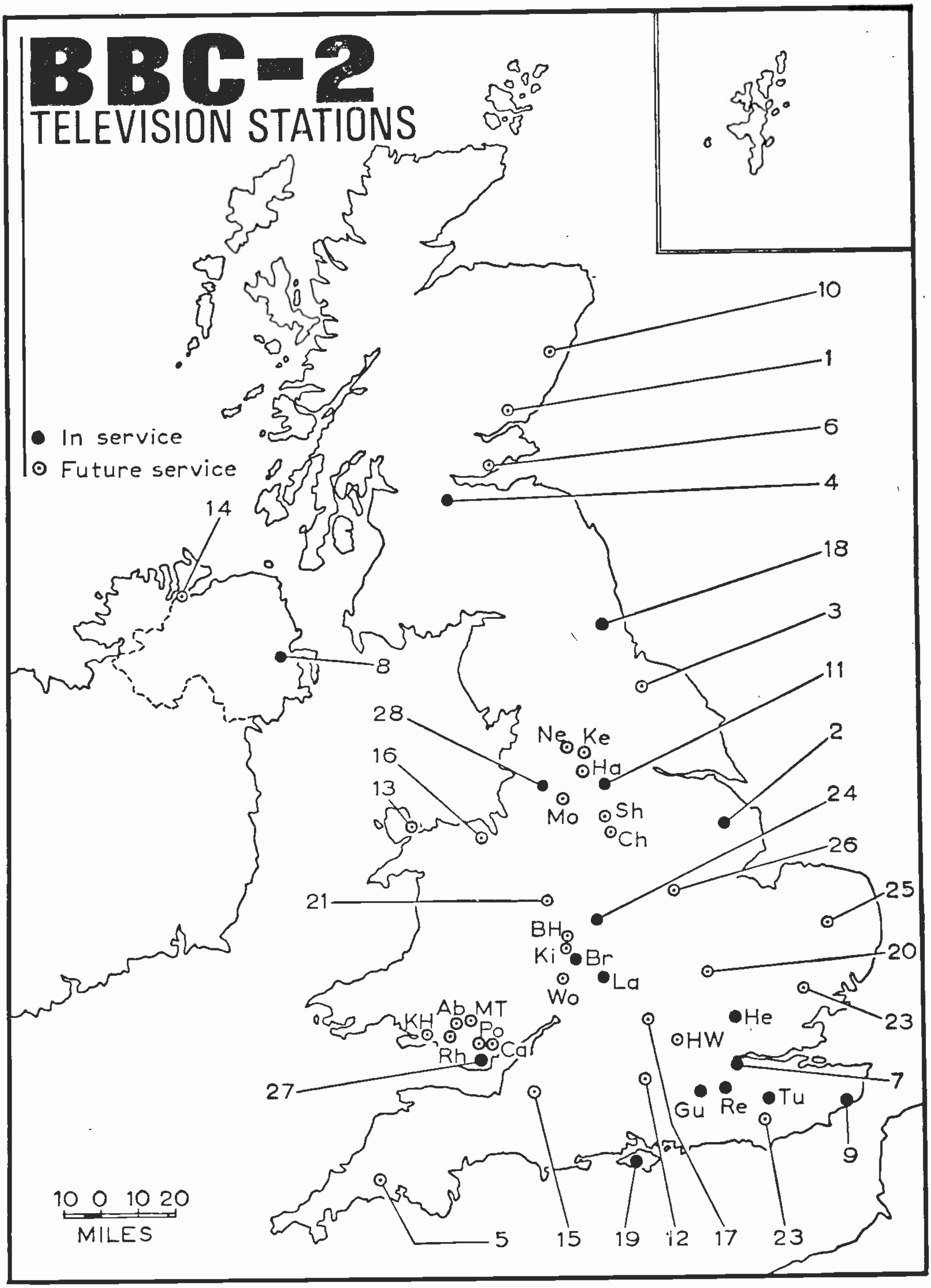
		Station	BBC-2 Channel	Other UHF Channels Assigned	Polarisation	Rated Vision ERP
1	†	ANGUS	63	53 57 60	H	100kW
2		BELMONT	28	22 25 32	H	500kW
3	†	BILSDALE WEST MOOR	26	23 29 33	H	
4		BLACK HILL	46	40 43 50	H	500kW
5	†	CARADON HILL				
6	†	CRAIGKELLY	27	21 24 31	H	
7		CRYSTAL PALACE	33	23 26 30	H	500kW
		GUILDFORD	46	40 43 50	V	2·5kW*
		HERTFORD	64	54 58 61	V	500W*
	†	HIGH WYCOMBE	62	55 59 65	V	
		REIGATE	63	53 57 60	V	2·5kW*
		TUNBRIDGE WELLS	44	41 47 51	V	4kW*
8		DIVIS	27	21 24 31	H	500kW
		LARNE	45	39 42 49	V	
9		DOVER	56	50 53 66	H	100kW*
10	†	DURRIS	28	22 25 32	H	500kW
11		EMLEY MOOR	51	41 44 47	H	1000kW*
	†	CHESTERFIELD	62	55 59 65	V	
	†	HALIFAX	26	23 29 33	V	
	†	KEIGHLEY	64	54 58 61	V	
	†	SHEFFIELD	27	21 24 31	V	
12	†	HAMPSHIRE				
13	†	LLANDDONA	63	53 57 60	H	100kW*
14	†	LONDONDERRY	44	41 47 51	V	
15	†	MENDIP	64	54 58 61	H	500kW
16	†	MOEL-Y-PARC				
17	†	OXFORD	63	53 57 60	H	500kW
18		PONTOP PIKE	64	54 58 61	H	500kW
19		ROWRIDGE	24	21 27 31	H	500kW*
20	†	SANDY HEATH	27	21 24 31	H	
21	†	STAFFORDSHIRE				
22	†	SUDBURY	44	41 47 51	H	250kW
23	†	SUSSEX (Heathfield)				
24		SUTTON COLDFIELD	40	43 46 50	H	1000kW
	†	BRIERLEY HILL	63	53 57 60	V	10kW*
		BROMSGROVE	27	21 24 31	V	4kW*
	†	KIDDERMINSTER	64	54 58 61	V	2kW*
		LARK STOKE	26	23 29 33	V	
	†	WORCESTER	62	56 66 68	V	10kW*
25	†	TACOLNESTON	55	59 62 65	H	250kW
26	†	WALTHAM	64	54 58 61	H	250kW
27		WENVOE	51	41 44 47	H	500kW
	†	ABERDARE	27	21 24 31	V	125W*
	†	CAERPHILLY	26	23 29 33	V	500W*
	†	KILVEY HILL	26	23 29 33	V	2·5kW*
	†	MERTHYR TYDFIL	28	22 25 32	V	
	†	PONTYPRIDD	28	22 25 32	V	500W*
	†	RHONDDA	26	23 29 33	V	1·25kW*
28		WINTER HILL	62	55 59 65	H	500kW
	†	MOSSLEY	45	39 42 49	V	
	†	NELSON/COLNE	45	39 42 49	V	

* Directional aerial.

† Station not in service at time of issue of this sheet; where channels or ERP are not shown, these are not finalised.

RELAY STATIONS

Ab	Aberdare	HW	High Wycombe	Po	Pontypridd
BH	Brierley Hill	Ke	Keighley	Re	Reigate
Br	Bromsgrove	KH	Kilvey Hill	Rh	Rhondda
Ca	Caerphilly	Ki	Kidderminster	Sh	Sheffield
Ch	Chesterfield	La	Lark Stoke	Tu	Tunbridge Wells
Gu	Guildford	Mo	Mossley	Wo	Worcester
Ha	Halifax	MT	Merthyr Tydfil		
He	Hertford	Ne	Nelson/Colne		


BBC-2
TELEVISION STATIONS
In service
Future service
10
1
6
4
18
3
11
2
24
26
25
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23
7
9
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28
16
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MILES

UNDERNEATH THE DIPOLE

AS we come to the end of 1967, we all realise that it has been a momentous year in Britain for at least one industry: television. You may prefer to call it a creative art, a craft, a medium of propaganda and entertainment—but I look upon it simply as a show business industry, which suffered growing pains in 1967 when the whistle blew at half-time to change ends.

I refer particularly to the major changes of chairmanship of BBC and ITA régimes, the arrival at long last of colour television, and the influences both are having on every television production organisation, be it from BBC-1 and 2, major ITV companies and so on, down to the smallest commercial regionals. The shape of things to come and in store for viewers was partly disclosed at the International Broadcasting Convention, which clearly indicated the international character of a medium which so emphatically carries out the original BBC motto "Nation shall speak peace unto Nation".

We must congratulate ourselves on the situation. The BBC has achieved tremendous advances in colour techniques in collaboration with several British Electronic companies, notably Marconi and EMI plus some from abroad. New studios, control rooms, telecine, film and sound techniques are all on the way with immense rebuilding afoot by large, medium and small television companies, following research contributions in colour techniques, especially on both PAL and SECAM by ABC TV.

Planning is also going ahead at full speed in the new ITV areas; indeed, building has already commenced in Leeds for the new major company, Yorkshire Television. In Birmingham, ATV will replace the present Aston studios, which was converted from a theatre, with an elaborate production complex of several stages and lush trimmings, likely to be one of the architectural landmarks of the city. ATV and its associated Grade Organisation companies have also established an enormous export market in all parts of the world for their colour television series on 35mm. films, but these may continue to be made in film studios in the London area.

Even the smallest of regional companies will need to prepare to play their part and make colour contributions to the ITA network with material, live, taped or filmed. Television of the future is now being shaped mainly by engineers or by production executives who are fully acquainted with the technical problems. The proposed National Film School, if it ever becomes a practical proposition, should be integrated into a National Film and Television School, because a large proportion of its students are likely to find positions in television rather than film studios, a point which should be noted by the Lloyd Committee in its next report.

El Alamein

The twenty-fifth anniversary of the turning point of the second world war—El Alamein—was a subject eminently suitable for television. It is not surprising that there were at least three separate TV organisations anxious to present their versions of the great battle of El Alamein. By visually re-creating from film the strategy of preparation and the development of tactics, from the wealth of British, German and Italian film material actually photographed in the battle, plus modern interviews and commentaries, they produced their separate versions.

Such an important event can, of course, be presented in different ways; by variations of its basic format, by its visual continuity, by its sound, music and effects counterpoint and by the multitude of technical gimmicks now available (and sometimes used *ad nauseam*). It is these optical tricks which so often dazzle and confuse viewers. Television producers and their film editors who have repeatedly seen "rough cuts" during the editing process are often punch drunk by the time the final edition is viewed. At that stage, they are able to see and absorb flashes of scenes of far shorter duration than viewers who see them for the first time. This is a fault which occurred occasionally in all of the Alamein TV versions, which had much film material in common and a multiplicity of ways of using it.

The BBC had the advantage of a filmed interview with Field Marshal Montgomery, on the occasion of his recent revisit to the battlefield, in their Monty Returns to Alamein. As a prelude to Monty's lucid interview, director Ray Colly introduced several minutes of Bach-like visual patterning of dissolves, overlay, and other technical gimmickry. The Field Marshal's clipped and concise exposition could not have been bettered, but his sun-tanned face was often in shadow against a light background so that (especially on a.g.c.-type receivers) his face was so black that you couldn't see it. It was a pity that the director hadn't placed him in front of something darker. This, however, is an all-too-frequent error on interiors as well as exteriors. In 1912, Cecil M. Hepworth instructed his cameramen "Don't shoot faces against the sky—they go black". This rule still holds good.

ATV's Battle for the Desert did not have the advantage of an authoritative military explanation from its commander: nevertheless the sequence of events was presented clearly and with chronological continuity. The programme was smoothly edited with film material from many, many sources together with interviews, commentaries (and even thumbnail travelogues of Cairo) cleverly integrated by director Peter Batty with straightforward cutting and non-stylised editing—excepting on the opening titles. Gimmickry was used with night shots of barrage-bursts between the credit titles. This turned out to be a perfect documentary approach, a classic of its kind. Unfortunately, I missed the third Alamein TV presentation by Granada in All our Yesterdays, which in its October 1942 dateline dealt with Stalingrad as well as Alamein.

Star dressing rooms

The star system has been in existence in theatres for well over two-hundred years, even before the days of David Garrick and Sarah Siddons. It came in the great days of the actor-managers who owned or leased theatres, built up their personal reputations and the size of their audiences. For the benefit of visitors behind the scenes (particularly the local press reporters) a star was painted on the numbered doors of their dressing-rooms. Their star dressing-rooms were better than the others—which meant in those days that the washbasin had running water and a waste plug!

Music hall acts became star turns when they moved out of public houses into luxurious variety theatres with (sometimes) even more luxurious dressing-rooms and larger enraptured audiences. Principal actors in films remained anonymous for years until film producers imported stars from the stage, including comics like John Bunny, Charles Chaplin and Max Linder. The "television personality" was the earliest development of the star system in television, which started up in 1936 with unstarred dressing-rooms of primitive type, which have since progressed to suites of luxurious rooms (with all mod. cons.). In film studios, the bigger the star the greater are the demands for repainting and or refurnishing the dressing-room suites made by stars, their managers or agents. Often it is not the star artiste who asks for such changes but their associated advance representatives. It has not been unusual for a dressing-room to be repainted in a different colour three times before the occupier had even seen it!

On the other hand Hollywood studio managements themselves have used similar dressing-room techniques for their own contract star players, as part of a plan for impressing press interviewers and others with the importance of their stars—and also reminding the star himself of his own importance and the necessity of playing the part off the screen as well as on the studio stage. Competition between stars led to the introduction of mobile bungalows or caravans as subsidiary star dressing-rooms-cum-rest-rooms. When two or three of these were wheeled on to a studio stage, valuable working space for scenes and settings was taken up.

Fortunately, this is a situation which television studio management cannot permit. Every square foot of stage space must be ready for the rapid change of scenery for different productions. A video taped television production of 50 to 60 minutes' duration is often accomplished in only two days' use of a TV stage, with the whole floor occupied with several small sets or one or two large ones—to which must be added about ten days of pre-rehearsal by the actors in a rehearsal room plus, possibly, exteriors photographed on film.

For the comfort and morale of their principal actors and actresses television managements have provided dressing-room accommodation of a very high standard. This applies to nearly all television studios, large or small, major or regional. Thus the stages themselves are kept clear of the impedimenta which litters film studios all over the world. The linoleum-covered concrete floors, in fact, are clean enough to eat your breakfast off if you feel that way inclined.

Iconos

WIDE RANGE PULSE GENERATOR

—continued from page 172

The average impedance is about 600Ω, and internal preset controls are adjusted to give exactly 5V pulse amplitude with the amplitude controls set to maximum. The logarithmic tracks of the amplitude controls permit smooth reduction down to the millivolt range.

Operation of this pulse generator is thus extremely simple, because only four manual controls are involved. These are fully independent for their respective functions, but the pulse width setting overrides the repetition frequency setting if the latter is too high for accommodating the selected pulse width. If the pulse width setting is greater than half a period of the nominal frequency, then the highest sub-harmonic thereof with a period at least twice the pulse width setting is actually produced, i.e. the oscillator frequency is divided accordingly. For example, if the pulse width selector switch is set to 500μsec, the frequency control functions normally from 20c/s to 1kc/s, but the actual pulse repetition frequency then remains close to 1kc/s however much the nominal frequency setting is increased above 1kc/s.

CIRCUIT FEATURES

The complete circuit employs thirteen transistors and is accommodated on a single postcard-size printed circuit panel which also carries the mains transformer and rectifier circuitry. Only the output sockets and the four manual controls are not mounted on the printed circuit board.

A free-running sawtooth oscillator stage using the four transistors Tr1 to Tr4 drives a trigger amplifier Tr5, Tr6 which in turn drives the triggered pulse generator stage (univibrator) Tr7, Tr8 to produce the square pulses. The remaining transistors Tr9 to Tr13 constitute impedance step-down amplifiers (emitter followers) and a phase inverter stage. Pulses of opposite polarity are produced at the collectors of Tr7 and Tr8, but the waveform at Tr7 collector is too poor. It thus proved necessary to use only the waveform at Tr8 collector (positive pulses) and to invert this with Tr11 to obtain the negative output pulses.

TO BE CONTINUED

Book Review

THE TECHNIQUE OF TELEVISION ANNOUNCING
By Bruce Lewis. Published by Focal Press Ltd. 264 pages. Price 42s.

THIS book is in the same series as Karel Reisz's *Technique of Film Editing*, Peter Jones' *Television Cameraman* and Halas and Manville's *Film Music*.

The principal appeal of the book is for the hundreds of aspiring male and female television (and sound radio) announcers. Nevertheless, it is crammed full of professional advice on techniques in interviewing, newscasting, commercial presentations and commentating, set out in the manner of an authorative reference book. For this reason, it is likely to assist operating technicians, such as TV cameramen, lighting directors and other production personnel to detect (and remedy) imperfections in the final results of their work as seen on the TV screen.

For example, announcers who do their own facial make-up are often careless with "blue" chins, greasy faces, bad haircuts, etc., all of which are exaggerated under the lights, as seen in close-ups. Even top-line sports commentators on race-courses sometimes forget to clean up sprouting beards. Camera control and lighting engineers grit their teeth at the sight of dirty faces on their monitor, for which they—not the announcer—can be held responsible.

Sound balancers, too, are conscious of heavy breathing and bronchial wheezes, particularly noticeable when both female and male announcers get into the habit of dropping syllables. Technicians who suffer from careless announcers should not have to instruct the offender, but to refer diplomatically to the director. For this reason, the book is almost as useful for TV studio technicians as it is as a "refresher" for experienced announcers who have been long at the game and, of course, for the growing number of potential announcers, producers and floor managers who want to get "in".

Once again, we see a version of the floor manager's tic-tac signals and mime, which it is interesting to compare with the American equivalents.

Author Bruce Lewis has been in broadcasting for 25 years, producing TV shows for both BBC and ITV, after a period of announcing, commentary, and interviewing. His writing is easy to read, well set-out for rapid reference, illustrated with a number of clear diagrams and sketches.—*B.H.*

Servicing TELEVISION Receivers

No. 141 - THORN 980 CHASSIS
—continued

by L. Lawry-Johns

The tuner unit

Two troubles are likely to be met with the tuner. One is poor contact between the biscuit studs and the springs, which will not always respond to cleaning. Some of the coil biscuit studs do not have sufficient rise to make reliable contact when the springs flatten slightly.

The other trouble is associated with the fine tuner when this does not have the desired effect, or indeed any effect at all. The trouble here is that either the plastic core has fractured or the metal sleeve is loose and is not following the movement of the plastic core. In the former case the core will have to be replaced, in the latter, a light touch of glue is all that is required.

Valve functions

When servicing is carried out without the use of a service sheet the following points should be kept in mind. The audio-output valve is a 30C1 (PCF80). In the event of "no sound", check this first. The video amplifier is an EF80. We mention this because the PCF80 may be thought to be the video amplifier instead of the sound amplifier. The field oscillator-output stage is a 30PL14 whilst the ECC804 is purely the line oscillator (anode-to-grid cross-coupled multivibrator). The latter is controlled by a two-diode (W3, W4) flywheel sync circuit.

Tube

The tube bias is obtained from the cathode circuit and the grid is returned to chassis via a 10kΩ resistor across which the line and field blanking pulses are developed. Thus the brilliance control operates on the cathode which from a d.c. point of view is divorced from the video anode by C26 (0·25μF).

Receiver dead, no valves alight

Check mains input to the fuse holder. If present check at R112. If R112 is in order remember that after the rectifier (W9) the heater chain is at d.c. potential. V12 U193 (PY801) is the first heater in the chain followed by the PL81A line output pentode. Then comes R113 (110Ω) and then the 30PL14. Proceeding along the heater chain at pins 4 and 5 of each base, the fault should rapidly be located.

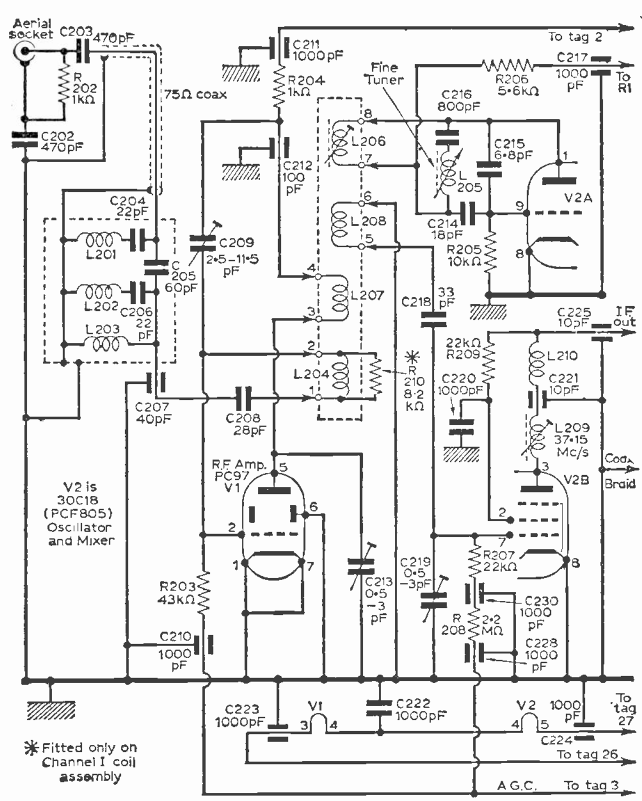


Fig. 4: Tuner unit circuit diagram

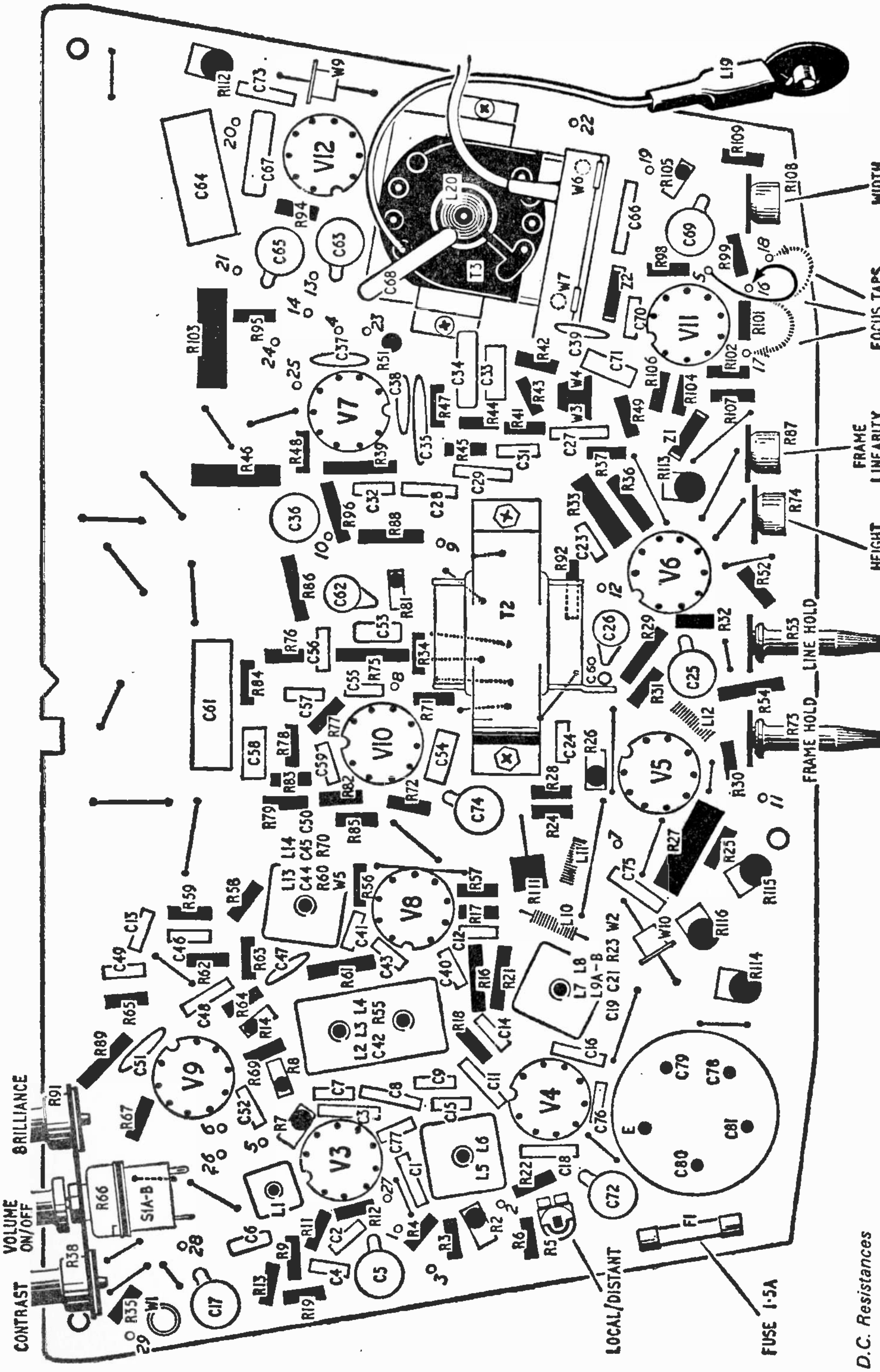


Fig. 5: Layout of the printed circuit board.

D.C. Resistances

L12	19Ω	T2 (pri.)	260Ω	T3 E–B	10·5Ω
L20	1·9Ω	(sec.)	8·2Ω	B–G	10Ω
T1 (pri.)	600Ω	T3 A–J	0·96Ω	G–W7	61Ω
		J–E	4·6Ω	D–C	0·57Ω

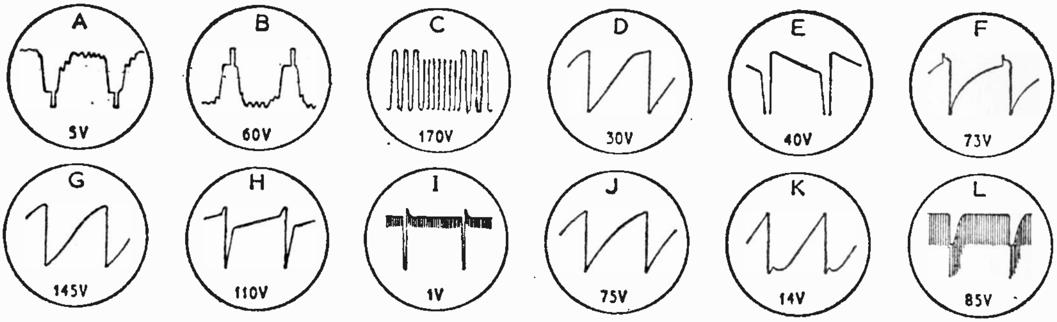


Fig. 6: Typical waveforms. For conditions see text.

Valves alight, no other sign of life

This indicates a "no h.t." condition. The fact that the valves are receiving power indicates that the circuit is in order up to R111. Check this (20Ω) and the rectifier (W10). As the output of the rectifier is split up (there are three main h.t. lines) some sign of life should be obvious in some part of the receiver if the supply is in order and the rectifier is passing current, even if it is only that the PL81A is overheating! It therefore remains to check the three main smoothing resistors, R114, R115 and R116. Their values are marked on the circuit.

No picture, sound in order

Check the PL81A. If this is overheating check the ECC804 (V7) line oscillator and associated components. Check the discriminator diodes (W3, W4) if necessary as an unbalance can put the line oscillator out of action. If the PL81A is not overheating check the h.t. at C80—R115 (HT2) and if this is in order check V11 and V12 and also C67 (0·22μF). If necessary check the line drive to V11. If this is excessive check R106 and the width circuit. In stubborn cases check C68 (120pF) which can short.

White line across screen

This indicates a failure in the field timebase. Check V10 (30PL14) and voltages to pins 6 and 9. The voltage at pin 9 (35V normal) is derived from the boost line via R75, R74 and R103 decoupled by C65 to h.t. If the boost line is right and 270V is at the height control R74, check this control and R75. If these are in order but there is no voltage at pin 9, check C54 0·01μF for shorts. This capacitor (C54) will cause loss of field hold when it becomes slightly leaky.

Poor contrast and sync

This symptom usually denotes a fault in the video circuit and the associated resistors should be checked as R26 and R27 can change value. Check L10 and L11, and L12 if necessary. If all is in order here check W2 (OA70) vision detector in the final i.f. coil can, also L9A and L9B. If the sound is also affected check V3 EF183 common sound and vision i.f. amplifier. This valve is not quite as reliable as the EF80 due to its frame grid construction which imposes more stringent limits. Check the tuner unit PCF805 and PC97 if necessary.

Oscillograms

A, B, D, E, F and G taken at line frequency, C, H, I, J, K and L at field frequency at the points indicated on the circuit diagram (Fig. 3). Voltage figures represent peak-to-peak amplitudes measured via a probe having an input capacitance or 8pF in parellel with 10MΩ. I taken with V10B control grid shorted to chassis.

Supplementary circuit data

In later models R85 is 470kΩ, a 470kΩ resistor is added in series with R85 and the junction of these resistors is taken to chassis via an 0·1μF capacitor. A 100kΩ resistor is added between the junction of C54/R71 and chassis. In some early sets R114, R115 and R116 are mounted on a tagstrip instead of on the printed board. In some models R23 is 1kΩ; R30 may not be fitted. W2 is type OA70 or GD13. VDRs Z1 type E298CD/A258, Z2 type E298ZZ/05.

981 series

The 16in. portable Models 2643 (H.M.V.) and 3649 (Ferguson) incorporate the same basic chassis as the 980 series but have a different cabinet assembly. They are fitted with type CME1602/A40—12W/S Rimguard c.r.t.s.

SERVICE NOTEBOOK

—continued from page 167

receivers, there is a capacitor connected from the rectifier d.c. output to the top end of the valve heater chain where it joins the thermistor. Its function is to reduce the residual hum level by feeding a slight out-of-phase a.c. voltage to the h.t. rail.

As you can now surmise, this capacitor had gone s/c, burning up a section of the dropper resistor, so that the rectifier was supplying both h.t. and heater circuit requirements.

The original rectifier in this model, a TV76, was the square finned Westinghouse pattern which had previously gone high resistance and simply been shunted by a BY100. In spite of this immense overload, it did not require replacement when the faulty capacitor and burned out section of the dropper were ultimately replaced.

To be continued

THE S.E.C. VIDICON

by K. T. Sterling

THE s.e.c. vidicon is a television camera tube which is hardly known outside research laboratories, yet the principles used in its construction may soon bring revolutionary advances in television techniques, infra-red detection, astronomy and nuclear research. The principle which gives the s.e.c. vidicon its name is that of Secondary Electron Conduction, and before we can understand the operation of the s.e.c. vidicon we must know something of this new method of electron multiplication which was discovered by research workers at the Westinghouse Laboratories in the USA.

NOISELESS AMPLIFICATION

Secondary emission of electrons is an effect which has been known for some considerable time and was described in detail in the article on *Storage Tubes* (PRACTICAL TV, May, 1967). Briefly, secondary emission takes place when any substance is bombarded by electrons. Between two limits of bombarding voltage, the electrons hitting the substance cause more electrons to be emitted; and at other voltages, fewer electrons are emitted. The new electrons are termed secondary electrons; they normally return to the substance which emitted them if there is nowhere else for them to go; but if a conductor at a more positive potential than the substance being bombarded is present the secondary electrons flow towards it rather than back to their source, see Fig. 1.

In the early days of radio secondary emission was a troublesome effect which caused instability (dynatron oscillations) in screened grid valves. Nowadays valves are made with gold plated grids and carbon-coated anodes to reduce secondary emission effects to a minimum, but in other devices secondary emission is used to produce effects otherwise unobtainable.

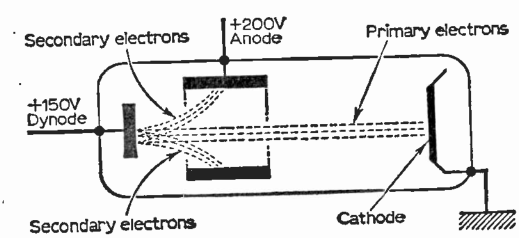


Fig. 1: Secondary emitting amplifier.

When a beam of electrons hits a substance and each electron landing causes two electrons to be emitted and collected elsewhere, amplification is taking place. In the case just suggested, the ratio of output current to input current is 2. The action of the secondary emission amplifier is similar to that of the transistor, as shown in Fig. 2. In a transistor the current flowing in the base circuit controls the current flowing between the emitter and collector (in the usual common-emitter circuit). In the secondary emitting amplifier, the current between the cathode and the secondary emitting electrode (the dynode) controls the current between the dynode and anode.

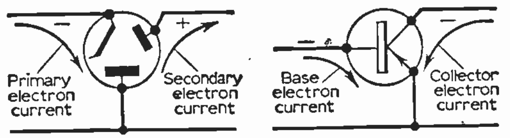


Fig. 2: Comparison of secondary emitting amplifier and transistor.

Amplification by secondary emission has one enormous advantage over any other form—it is practically noiseless. This feature is extremely valuable when we must amplify very small signals. If we were to pass the video signal from a photocell or from the target of an image orthicon into a valve amplifier the video signal would be drowned by the spurious noise of the amplifier, and the output of the amplifier would be noise only. Secondary emission amplification, however, enables us to amplify the video signal without adding to its noise, so that a much larger signal can then be presented to the valve amplifier.

Amplification using secondary emission seems so ideal that there must be some snags preventing its wider use. The snags are that the amount of amplification obtainable from each stage has been very limited up to now, and the gain stability poor. Nevertheless, the low gain may be overcome by using a large number of stages within one tube, as is used in photomultipliers and image orthicons, and the gain stability is reasonable in such tubes because the caesium vapour used to form the photocathode and secondary emitting layers remains within the tube and prevents too rapid deterioration of the secondary emitting layers.

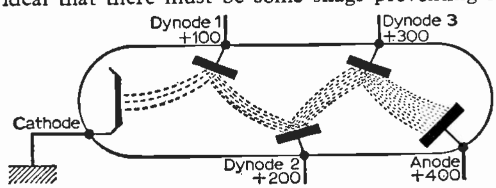


Fig. 3: Reflection secondary emission amplifier.

T.S.M. TUBES

All the early secondary emission amplifiers used reflection secondary emitters (dynodes, see Fig. 3) where the primary electrons hit a surface and the secondaries were reflected back at various angles.

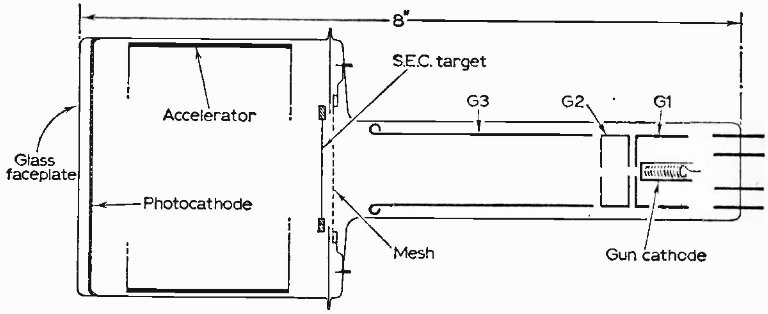


Fig. 5: Schematic of s.e.c. vidicon.

With such an arrangement it is very difficult to design the secondary emitting surfaces so that the total path length travelled by all electrons is the same regardless of the angle at which electrons strike each dynode, and it is equally difficult to make all the stages equally active.

The next development from this was the pinwheel dynode (Fig. 4) which is used in the image orthicon. In this type of secondary multiplier the electrons zig-zag from one stage to another and the changes of direction are not so violent.

The Transmission Secondary Multiplier (t.s.m.) is the next logical development. In this there is no change of direction in the path travelled by the secondary electrons. The targets used in this type of tube consist of thin films of materials which emit large numbers of secondary electrons and are sufficiently transparent to permit electrons to pass through. So far all the films used have been based on aluminium oxide and aluminium. Aluminium, along with beryllium, has the distinction of being very transparent to electrons; it is for this reason that aluminium can be used as a reflecting coating on the phosphors of cathode-ray tubes. If we use the aluminium as a support we can coat it with any secondary emitting material we choose, and use the subsequent sandwich as a film t.s.m. In practice it is better to use aluminium oxide to support the secondary emitting material, along with aluminium to which a voltage may be applied.

APPLICATIONS

Since the secondary electrons from a t.s.m. film leave in the same straight line as the entering primary electrons the t.s.m. film can be used to amplify an electron image, such as the stream of electrons coming from a photocathode on to which a light image has been focused. This enables us to amplify an image directly without scanning, and tubes using five or six stages of t.s.m. films are used as "light amplifiers". Such tubes use potassium chloride coated on to aluminium oxide as the secondary emitting layer, with a thin film of aluminium to which an accelerating voltage can be applied, and each stage has a gain of 5—7.

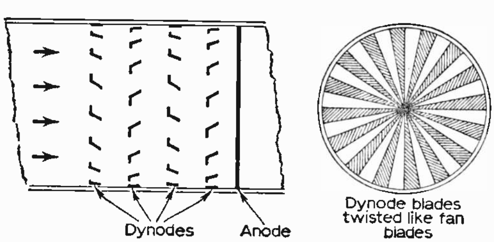


Fig. 4: Pinwheel diode.

Image orthicons have been made using several t.s.m. stages between photocathode and target, and such tubes can produce pictures in conditions which appear to the eye to be totally dark (the eye takes about 20 minutes to adapt to such conditions and can see only extremes of contrast), but the most interesting possibility from the TV point of view is the production of a sensitive camera tube using a t.s.m. target. The image orthicon uses a glass target to convert the electron image from the photocathode into a charge image. The charge image on the other side of the target is scanned by an electron beam, and the reflected scanning beam is noiselessly amplified by a secondary electron multiplier of the pinwheel type. Much of the complication of the image orthicon could be avoided if the electron mulitplication could be carried out at the target, and if the scanning electron beam were used only to neutralise the charge on the target. Such a tube has been built, and is termed the s.e.c. vidicon.

THE S.E.C. VIDICON

If a film of aluminium oxide/aluminium is coated with potassium chloride (a material similar to common salt) by evaporation in a vacuum, the gain of the sandwich film is about 5—7 as stated above, but if the coating is carried out at a fairly high pressure with the gas argon the coating is porous and the secondary emission gain is extremely high (100—400) providing that no trace of mixture is allowed to contaminate the film. It is thought that successive portions of the porous layer have high accelerating fields across them due to secondary emission charging, and that this leads to one film acting as if it consisted of a large number of secondary emitting layers.

The schematic of the experimental s.e.c. vidicon is shown in Fig. 5. The vidicon part of the name is rather misleading, the action being more like that of the orthicon (as distinct from image orthicon), but the name seems to be established now. The photocathode is a layer composed of an alloy of antimony (a substance resembling arsenic) with the light metals caesium, potassium and sodium, which emit electrons when struck by light. When an image is projected on to such a layer by means of a lens. the electron current leaving any section is proportional to the strength of the light falling on it. If the electrons can be accelerated away from the photocathode in straight lines at right-angles to the photocathode the image is preserved by the electron stream, and a phosphor screen placed in the electron stream would show an image which would duplicate that on the photocathode. In the s.e.c. vidicon, however, it is the s.e.c. target layer which intercepts the electrons. Since the photocathode is some 10kV negative to the target, the electrons approach at high energy, and a solenoid surrounding the section of tube between photocathode and target supplies a magnetic field which prevents the electron beams from scattering and becoming out of focus at the target.

When each approaching electron hits the target, the s.e.c. multiplication process takes place, and (say) two-hundred electrons leave the other side of the film. These electrons are then collected on the fine metal mesh (750 meshes per inch) which is spaced about 0·010in. from the target on the side opposite the photocathode. Where electrons leave a surface, that surface must be positively charged (since negative particles have left a region which previously had equal numbers of positive and negative particles), and so the s.e.c. target surface facing the electron gun has a positive charge which is proportional to the electron current, and hence to the light on the photocathode. This positive charge is some 200 times as great as it would have been on the glass target of an image orthicon tube, and, since the amplification has been by a secondary emission process, no noise has been added to the electrical image.

OBTAINING THE SIGNAL

The electron gun emits a narrow beam of electrons at a low speed. The speed is low at the target because the voltage between the cathode of the gun and the target is low (remember that the s.e.c. film includes a film of aluminium to which a voltage can be supplied), and, at such low voltages, electrons will land or be reflected from surfaces without any secondary emission taking place. When the beam is deflected, by normal scanning action, and lands on a portion of the target which has been charged positively by the process described above, the electrons of the beam land on that portion of the target, replacing the electrons which left due to the secondary emission process, sufficient electrons landing on the surface of the target until it is neutral again. Any surplus beam electrons are then reflected to the mesh and have no effect on the target.

We can obtain a video signal from the s.e.c. vidicon either from the target connection or from the mesh, by connecting either electrode to its operating voltage via a load resistor and connecting to a video amplifier through a capacitor (Fig. 6). Normally, the signal is taken from the target, and the current through the load resistor is proportional to the light input to the photocathode. If the signal is taken from the mesh, the current output is *inversely* proportional to the light input.

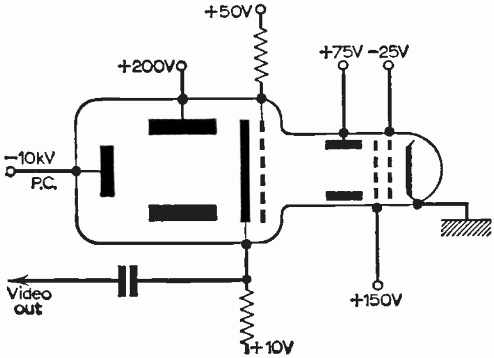


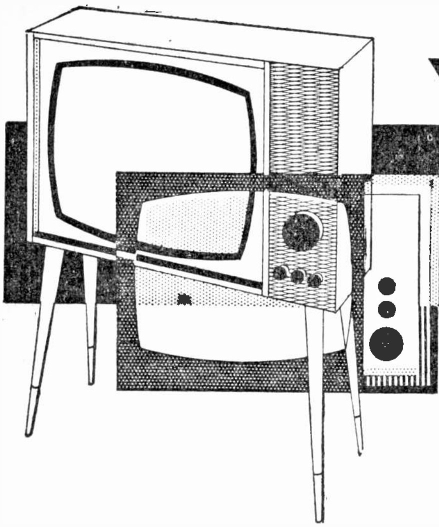
Fig. 6: Operation of s.e.c. vidicon.

ADVANTAGES OF THE S.E.C. VIDICON

The s.e.c. vidicon appears capable of giving pictures at lower light levels and with better signal-to-noise ratios than the image orthicon. The reason for this is that the noiseless amplification takes place before the scanning beam hits the target. In the image orthicon a very small signal at the target is used to reflect the scanning beam to the noiseless multiplier. The signal at the target is little greater than the noise of the beam, however, and both are amplified equally by the multiplier. In the s.e.c. vidicon the signal at the target has been amplified before the beam reaches it, and so the ratio of signal at the target to the noise of the beam must be considerably better than that of the image orthicon.

In addition, the polarity of the signal makes noise less obvious. In the image orthicon the signal is inverted due to the use of the reflected beam, so that where there is maximum signal at the target there is minimum signal at the anode. This means that there is most return beam (and hence most noise) where there is least signal and the signal-to-noise ratio is therefore poorest in the blacks and best in the whites. The lack of effective d.c. restoration in most television receivers makes this noise very noticeable in the black and grey areas of a picture. In the s.e.c. vidicon (and also in the vidicon and plumbicon) the maximum beam current occurs where there is maximum signal on the target, and maximum noise is in the peak white areas where it is almost unnoticeable on a receiver.

In the other important features of a TV camera tube—resolution, linearity, colour rendering, and lack of spurious signals—the s.e.c. vidicon is comparable with the best studio quality tubes. Its size is between that of the vidicon and the image orthicon, and its manufacture is no more difficult. At the moment, it looks as if military requirements for camera tubes capable of working at very low light levels are likely to keep the s.e.c. vidicon from the civilian market for some time, but the demand for sensitive tubes for colour TV transmissions (where the colour filters used in front of each chroma channel tube greatly reduce the available light and necessitate very wide lens apertures or very bright lighting) will surely help the development of this remarkable tube. ■



Your Problems Solved

Whilst we are always pleased to assist readers with their technical difficulties, we regret that we are unable to supply diagrams or provide instructions for modifying surplus equipment. We cannot supply alternative details for constructional articles which appear in these pages. WE CANNOT UNDERTAKE TO ANSWER QUERIES OVER THE TELEPHONE. The coupon from page 188 must be attached to all Queries, and a stamped and addressed envelope must be enclosed.

PHILIPS

This set has perfect sound on all channels, but instead of a raster it has a white horizontal line about ⅜in. high across the centre of the screen. The height potentiometer has no effect on the fault.—A. Parker (Co. Durham).

Check the continuity of the field deflection coils, the h.t. to pin 6 of the field output valve and the h.t. from the height control to the field oscillator. Since you do not supply the model number of the Philips receiver, we cannot be more explicit.

ALBA T1195

This receiver is faultless on 405 lines, but on BBC-2, 625 lines, the fault is excessive brightness. Turning the brightness control anticlockwise no longer has much effect.

I must stress that this is a fringe area for the BBC-2 transmissions.—R. Bellas (Wirral, Cheshire).

Change the PFL200 video amplifier. Change the grid leak resistor R258 from 1MΩ to 150kΩ and C249 from 22kpF to 0·1μF or 0·15μF.

ALBA T655

There is no vision owing to the absence of e.h.t. voltage to the top cap of the EY86 valve. This I thought was probably due to a break in the secondary winding of the line output transformer. However, upon measurement of this winding with an Avo Minor meter, it proved to be intact.

There is a voltage of about 250V at the top cap of the EY86.—J. Mainwaring (North Wales).

If the PL81 is not overheating, the oscillator is probably working, providing line drive to the PL81 control grid.

Check h.t. voltage to pin 8 of the PL81, which should be 140V. Then check the 0·1μF boost line capacitor and disconnect the 33pF capacitor. If these points are in order, it is fair to suspect the line output transformer.

BUSH TV56

This set is in good working order except for the tube which has been running on a booster transformer for over a year and is steadily getting worse. The tube is an MW43-64. I know that I should really buy a 43-69 but I have an almost new AW43-80 complete with scan coils which is gathering dust at the moment and I was wondering if it would be possible to swap them over.

The mechanical alterations are no problem and I notice that the pin connections are almost the same apart from the pin 6 on the AW43-80 being A2 and A4 and pin 7 on the MW43-64 being A2. If the changeover is possible and using the base connector which is in the receiver, I would like your advice on the following:

(1) Which of the above mentioned pin connections must be changed, and to where?

(2) Which is the focus pin on the 43-80 and where is there a suitable point in the receiver to obtain the focus voltage?

(3) Would it be an advantage to fit an EY86 in place of the EY51?—J. Rollins (Bournemouth, Hampshire).

Although you have an AW43-80 complete with deflection coils, it should be borne in mind that this tube is for 90 deg. scanning. The coils will not, therefore, ideally match the line output transformer.

The AW43-80 is an electrostatically-focused tube which does not require a focus magnet. Pin 6 must have a potential which can be altered. Try connecting it to pin 10, pin 11 or chassis.

There is no reason why an EY86 should not be used. Note that the EY86 has a B9A base.

ALBA T988

When a good picture is tuned in, volume drops. When the volume is tuned in, the picture quality is bad.—P. Davies (Swansea, Glamorgan).

You should prove the aerial to be efficient, then check the tuner unit valves. If these are in order, check the i.f. alignment to the maker's instructions.

EKCO T221

After this set has been running, the line oscillator will either go off or apparently change frequency, giving a rather faint picture with up to three images across the screen. This is sometimes immediately preceded by a loss of horizontal hold.

The rather harsh treatment of switching on and off quickly sometimes brings the picture back to normal for a short period.—J. Cheltenham (Preston, Lancashire).

This symptom is mostly caused by loose electrodes in the line oscillator valve. Prove by gently tapping the valve with the handle of a screwdriver while watching the effect on the picture. If this action seems to clear the fault, then the valve should be replaced.

DYNATRON TV44

The picture on this receiver loses frame sync when picture content is mainly white with very little black information.

This can be corrected by increasing the contrast but this is then too high and causes smearing on the highlights. This effect appears to be worse when the set has reached its proper running temperature.—R. Wilson-Kitchen (Beckenham, Kent).

Check the 2μF capacitor decoupling the screen supply of the sync separator. Also check the 0·1μF capacitor to the control grid and the video amplifier resistors which often change value.

FERGUSON 317T

There is a good black and white picture but with a bar about 1in. wide near the centre of the screen, with half of another picture.—A. Lawson (Derby).

This is incorrect line oscillator phasing. This adjustment is in the form of a dust iron core in the oscillator transformer located towards the top right-hand corner of the chassis, near to the line output stage assembly and width adjustment. The core in the top of the transformer is the adjustment, which should be made to eliminate the vertical bar separating the two picture sections.

FERGUSON 3634

This set displays a wavy picture. The effect is more visible on BBC-2. On BBC-2, a white horizontal line about 5—6in. in height travels vertically resulting in an uneven raster. By increasing the contrast, the waviness disappears but the uneven raster is present and altering the frame hold has no effect. A new aerial has been tried but this made no improvement.

This set also displays vertical bars on the left side of the screen. These bars are, however, not visible on a test card—only on a moving picture.—D. Jhalera (London, N.W.6).

We are not at all sure that the effects you complain of are in fact attributable to faults in the receiver. The waviness and left side bars could be due to reception conditions and unlocked transmissions.

However, you may find that replacement of the video amplifier (PFL200) may help matters. It would be advisable to check the main electrolytic capacitors.

RGD 610FM

The sound is quite normal but there is no picture or raster. When the set is switched on, the PY81 takes a long time to warm up. When it does, the whole of the valve glows red and the line output does not light up. If the set is switched off and on again quickly, the valve and the line output immediately behave normally, i.e. plenty of spark when checked but still no raster or picture.

If the set is kept on for about 20 minutes under these conditions, i.e. line output and PY81 working normally, and then switched off, the collapse of the raster can be seen very faintly and a small spot of light remains in the centre of the screen if viewed in a darkened room.

I have substituted PY81, PL81, EY86 and the tube was in good condition when tested.—N. Dyers (Poole, Dorset).

The PY81 may be overheating due to the PL81 drawing excess current. You should therefore check the line oscillator valve by substitution. Check the line output capacitors and the line output transformer.

V5 (PCF80) is the line oscillator. Check the c.r.t. first anode voltage on pin 3. If absent, check the 0·25μF capacitor.

DECCA DR41

I have obtained a u.h.f. tuner together with an i.f. strip for this set. One of the connectors from this strip is similar to a 9-pin valve base and this fits easily into a socket provided on the TV chassis. There are, however, other connectors attached to the i.f. strip and I am not able to tell just where these are connected to the TV.—J. Sloan (Lancashire).

We would advise you to contact the suppliers of the i.f. plate etc. for the maker's fitting instructions. The chassis is a Thorn 850 sch. A and details could be obtained from the B.R.C., Eley's Estate, Edmonton, N.18, if necessary.

PETO SCOTT 2128

There are about four vertical dark lines on the left-hand side of the picture.—S. Lewis (Swansea).

There is a 1kΩ resistor across the line linearity coil. Replace this component.

ALBA T655

The faults are that contrast varies when a switch in the house is turned on or off. Also, the same fault (darkening of the picture so that it is barely visible) occurs on its own accord after the set has been running for about 20 minutes.—F. Sarpson (Tadcaster, Yorkshire).

Whilst the resistors associated with the video amplifier are always suspect and must receive attention (check 10kΩ and 47kΩ) the fault need not be here. Check the contrast control and components. If it is the brilliance (not contrast) which varies, check the 0·01μF capacitor in the feed to pin 10 of the c.r.t.

FERRANTI T1011

I recently changed the U25 e.h.t. rectifier owing to severe blue flashing inside it. The set gave a reasonable picture before changing the valve but it was noticed that the line hold was partly destroyed when flashing took place, accompanied by sparking at the double wired end of the U25. Since fitting another U25, I have good sound on TV channels but distorted sound when the set is switched to v.h.f.

I have no picture or raster, line whistle is absent and cannot be heard when the line hold is operated.

I have replaced the PY32 with a PY33 and I have tried six U191's and each has become red hot within seconds of switching on.—R. Peers (Cheshire).

The linearity coil has a metal core which is connected to chassis by a lead from the top of the frame. This is on the inside of the screening box of the line output unit. Cut this lead and note if this clears the short.

K-B OV30

This set has a C17LM-R c.r.t. which has no emission. Can you state any equivalents of this tube?—M. Spieuhkowski (Huddersfield, Yorkshire).

The C17LM is a straight gun 70 deg deflection tube. This can be replaced by an MW43-69Z or an MW43-69 with an ion trap magnet. Ensure that pin 7 connects to either 10 or 11.

RGD 1756

The sound is good and the picture is of full height and width but is very pale.—H. Hyde (Wednesbury, Staffordshire).

This symptom could be caused by (a) a weak aerial signal (check the aerial system, make sure that it is pointing to the required transmitter and that the feeder is efficiently wired at both ends) or (b) lack of vision channel sensitivity.

The latter could indicate a faulty tuner, trouble somewhere in the vision i.f. channel or misalignment.

GEC BT1252

After about 20 minutes' use, the fuse blows (the one nearest the tuner). After allowing the set to cool off, fitting another fuse allows another 20 minutes' running time—then it blows again.—E. Armstrong (Lincoln).

If there is an unpleasant smell from the vicinity of the metal rectifier, change this component. If there is no smell or sign of discharge between the plates of the rectifier, try disconnecting the 0·1μF 300V a.c. capacitor which is wired across the input, fuse to chassis.

QUERIES COUPON

This coupon is available until JANUARY 19th, 1968, and must accompany all Queries sent in accordance with the notice on page 185.

PRACTICAL TELEVISION, JANUARY, 1968

TEST CASE -62

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.

? *A reader took to his own home a friend's Pye 700/D to examine for picture rolling and line pulling. Connecting up to his own aerial system he was surprised to find that the set worked perfectly normally, with solid line and field locks and no sight of pulling. The set was operated for a week under normal conditions and no picture fault developed.*

Thinking that, perhaps, the set was disturbed in some way when it was moved, and that the fault was cleared, it was returned to the owner, but on connecting up it was soon seen that the fault was present just as bad as before.

Test Card D was carefully examined and, apart from slight grain, which was not present on the other aerial system, it was virtually perfect. Good definition and contrast range, but tending to pull and locking badly in the field.

What was the most likely cause of this trouble? See next month's PRACTICAL TELEVISION *for the answer and for a further item in the Test Case series.*

SOLUTION TO TEST CASE 61
Page 140 (last month)

The field timebase generator (triode) is fed from the boosted h.t. rail through the height control and series resistor. These items checked normal, yet the anode voltage was still low, and since the picture brightness and focus were apparently correct, the technician assumed that the boosted h.t. voltage was up to standard.

Further testing, however, revealed that the boosted volts were some 200V low, and this was reflected, too, at the first anode of the picture tube. Testing in the boost circuit brought to light a slightly leaky boost reservoir capacitor, and replacing this restored normal voltage on the field triode anode and picture height. Although there was also some improvement in picture brightness, this was only slight, and by itself would not normally be considered as a defect.

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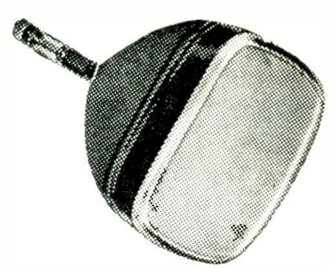

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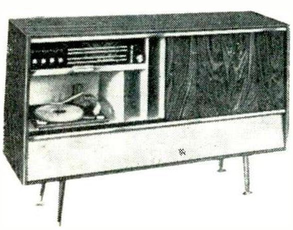

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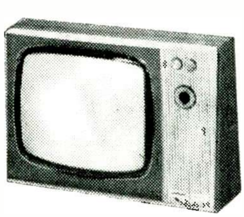

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