Practical TELEVISION

MAY 1968

2/6

Build this X-RAY RADIATION METER*

also inside START OF NEW SERIES TV TESTING TECHNIQUES

Practical Television

MAY 1968
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Who is backing whom?

READERS will be interested in hearing about a suggestion submitted to the *Daily Express* National Suggestion Box which supports the "Back Britain" movement. "Like all good ideas", said the *Express* "it was simple but effective". True enough; the suggestion was that instead of radiating Test Cards, both ITA and BBC should screen Union Jacks and "Buy British" slogans!

The mind boggles at the thought of service engineers trying to set up receivers on the National Flag. On the other hand, if we were to alter the aspect ratio, add frequency gratings, a linearity graticule, contrast wedges, a centre circle, reflection pulse lines and a few other minor refinements, no doubt the Union Jack would make an ideal test card!

Incredible as it might seem, the awards panel of the *Sell British—Help Britain—Help Yourself* campaign, to whom the idea was passed on, decided that this was the most striking idea received and "after long and deep consideration" (*sic*) awarded the originator the top prize of £100. All we can say is—good luck to the fortunate lady who had the bright idea!

The screening of "Buy British" slogans appeals to the cynical side of our twisted editorial mind. We visualise an hour or so of patriotic appeals—followed by such items as *Peyton Place, The Man from UNCLE, The Smothers Brothers, Dragnet, The Virginian, The Monkees, The Monroes, The Munsters, A Man Called Ironside, The Dick Van Dyke Show, ad inf.* and innumerable celluloid gems from the dust-covered archives of Hollywood. Buy British, indeed—don't make us laugh!

A more useful idea would be to transmit slogans to support the *Save the British TV Industry Campaign* (not yet formed!) Those who read this instructive page will remember the leader of December 1967 ("Industry in Danger"). Well, once more a Chancellor has seen fit to alter the purchase tax structure, to the detriment of the trade.

What with the increasing disincentives to buy receivers (both economic and programmewise) and the continuing telescoping of the constituent companies in the industry, we may yet live to see (no doubt by 1984) a State-owned TV industry churning out People's Sets.

W. N. Stevens, Editor.

THIS MONTH

THE NEXT ISSUE DATED JUNE WILL BE PUBLISHED ON MAY 24

Antiference to market Belling-Lee aerials

BELLING & Lee Limited and Antiference Limited have negotiated an agreement which will allow Belling-Lee Aerials Limited to withdraw from the domestic TV aerial market without disrupting continuity of service to B-L customers. Under the terms of the agreement, Antiference will take over Belling-Lee Aerials' stocks, brand name, design rights, products, tools and specialist knowledge.

The withdrawal will enable Belling & Lee to concentrate its efforts in its components and special equipment activities. At the same time, it will assist Antiference in its efforts to achieve a measure of aerial rationalisation and give a better service to the user.

A consolidated Antiference/Belling-Lee range of domestic TV aerials will ultimately be marketed by Antiference Limited, and both companies will collaborate in the technical sphere to ensure that the fusion of their joint expertise will be reflected in improved aerial products.

To minimise any possible inconvenience to Belling-Lee customers, the transfer will take place gradually over a period of some months. Detailed arrangements for the transfer will be announced at a later date. In the meantime, Belling-Lee Aerials Limited will continue to meet all orders for their aerials from existing depots.

ALL-ELECTROSTATIC VIDICON

SMALL size, excellent resolution and geometrical fidelity are outstanding features of a new vidicon camera tube developed in the EMI Research Laboratories. These characteristics have been achieved by an entirely novel system of electrostatic focusing and deflection. A paper on the new tube was given to members of the Institute of Electrical Engineers on 7th February by Dr. H. C. Lubszynski of EMI. Co-authors of the paper were Dr. B. J. Mayo and J. Wardley, also of EMI, and N. C. Barford, of Imperial College, London.

The 1in. vidicon tube, Type R.9745, employs a system of crossed planar lenses to focus the electron beam sequentially in the field and line directions—an arrangement equivalent to crossed cylindrical lenses in light optics. The characteristics of degraded focus in the corners and geometrical distortion, defects of earlier electrostatic systems using rotationally symmetrical lenses, have been entirely eliminated in the new tube.

FRENCH FIRM TO MAKE COLOUR TUBES

FRANCE-COULEUR, a newly-formed French company is to make a new type of colour TV tube. The company will take over the development and manufacture of the grille-type flat screened tube developed up till now by the Compagnie Francaise de Television.

The new tube—expected to be 23in. type will consume less current, have greater luminescence and a better image and will be able to be fitted to any sets whether they be SECAM, NTSC or PAL.

The statement announcing the formation of the new company said that further developments were still needed on the new tube which would probably be ready by the early 1970s after about another £7M had been spent on development etc.

26th Annual Conference

THE 26th Annual Conference of the Radio and TV Retailers' Association and the Electrical Appliance Association is to be held in Bournemouth from 5th to 8th May.

TV COMPONENT EXPORTS FROM INDIA?

AWAITING permission from the Indian Government to start manufacturing television parts and components for export to the Middle East and Canada, is Madras electronics manufacturer, Mohamed Ebrahim and Co. Ltd.

They already have a market in Canada for intercom sets and inter-office equipment.

TV dealers register

NEARLY 11,800 television retailing firms registered with the Post Office during January. These registrations cover some 24,000 showrooms throughout the country. From 1st February, television dealers have been sending the Post Office details of all sales and rentals of television sets. This is a further step in the campaign to reduce licence evasion.

The 1967 Wireless Telegraphy Act provided for the registration of dealers and the notification to the Post Office of sales and rentals of television sets. The Act also increased the fines for licence evasion to a maximum of £50 for the first offence and up to £100 for a subsequent offence.

The Post Office estimate that the number of evaders has been reduced from over two million to just under one-and-a-half million in the last 15 months. The loss of revenue from evasion is estimated at £7 million a year.

THE END OF THE AERIAL?

ANSWERING an MP who referred to the spread of TV aerials and the inadequacy of existing master-aerial services, Mr. Joseph Slater, Assistant Postmaster-General said that a system for wired TV and radio services was to be provided by the Post Office in Washington New Town. Further developments would then be considered in the light of this trial.

New editing process

TELPEX Ltd. closed circuit television facilities now include Electronic Butt Editing on 1in. helical scan video-tape recording.

By modifying the Philips VTR so that it can replay locked to their six studio cameras, Telpex is now able to pre-record a VTR insert and insert it in synchronisation on to the main recording as if it were telecine film. Only one edited insert per 30-second commercial is practical at this early stage of development; even so this facility increases considerably the scope of research with pilots and rough commercials in which Telpex specialises.

The secret of the new process is the extraordinary stability of the Philips VTR design achieved by the eddy current brake servo. Telpex applies its own correcting reference signals, in place of those normally derived from mains frequency, for play-back through a special processing unit. This achieves a locked signal between playback VTR, cameras and recording VTR. Extension of band width and reduction of noise by modifications to the video and modulator circuits have improved the quality of the second generation inserted tape so that it is practically indistinguishable from the main material.

Video engineers, Ken Freeman and Trevor Stockill, of Telpex, have developed this process over the past year and hope to have a system of complete post-production editing, using three video tape machines, on offer to Telpex clients soon at extremely low cost.

CHANGE OF ADDRESS

THE Wired TV product group of Thorn Bendix, formerly the Wired TV dept., of Thorn Electronics at Enfield, moved its sales offices and laboratories to the Industrial Electronics division of Thorn Bendix Ltd., at High Church St., New Basford, Nottingham, on March 1st (formerly Bendix Electronics Ltd). This marks the end of a phased operation over the last 6 months during which the production and test department have been moved. The Nottingham premises provide greater facilities for the expansion of the Wired Television department.

TV SYSTEM FOR HERIOT-WATT UNIVERSITY

HERIOT-WATT University, Edinburgh, recently inaugurated their television studios, which will be used substantially to increase the effectiveness of university teaching and the strength of its many links with industry.

This new university television system using Marconi equipment occupies an entire suite of rooms. An array of picture monitors faces the vision and sound console in the foreground, and the connecting window into the studio can be seen on the left-hand side of this control position.

Granada's colour telecines

AN order which will extend Granada Television's colour facilities for the televising of colour cine film has been won by The Marconi Company. The contract encompasses two separate telecine systems.

The two telecine machines type B3402, incorporate a colour camera unit based on the Mark VII and an optical multiplexing system which enables images from both 16 and 35mm. film projectors to be selected. The multiplexer incorporates mirrors which switch between the projectors at speeds faster than the reaction of the human eye—enabling it to be used for "on air" switching. Such is the sensitivity of the camera that with illumination from an under-run 150 watt lamp, films of almost any density can be used. Automatic stopping and "inching" facilities in the instrument enable any position on a film to be selected, enabling filmed programme inserts to be rapidly and accurately set up.

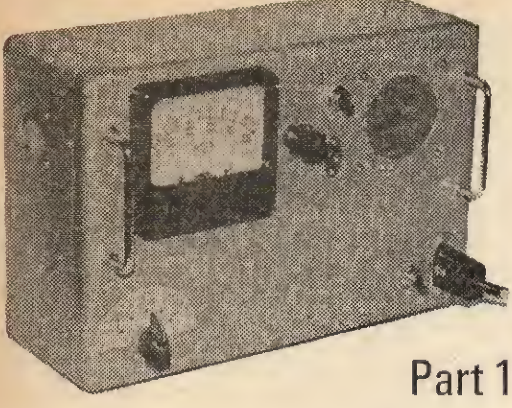
US TV CONFERENCE

FOUR sessions of technical papers in the field of television are scheduled for the 103rd Technical Conference of the Society of Motion Picture and Television Engineers.

The Conference is set for the Century Plaza Hotel in Los Angeles May 5 to 10. The television sessions are arranged for Wednesday afternoon, May 8; Thursday morning and afternoon, May 9; and Friday morning, May 10. Each session will be concurrent with a session on a different and unrelated topic. There will be about 20 papers dealing with television.

Television papers have been arranged by Topic Chairman Ted Grenier, ABC, Hollywood. Areas of discussion will include video tape, CCTV, broadcasting, slow motion and stop motion recording, television studios, and computer applications.

New television equipment will be on display at the SMPTE Equipment Exhibit running concurrently with the Technical Conference at the Century Plaza. The Exhibit will be open Monday through Thursday during Conference week.



Part 1

X-RAY RADIATION METER

by Martin L. MICHAELIS, M.A.

VERY large X-ray dose rates are produced by the shunt-stabiliser triode used in the e.h.t. section of hybrid colour television receivers so that a significant radiation hazard exists if a colour receiver is operated with the shielding cover removed from the e.h.t. compartment. The author's measurements made on a typical colour receiver with the ambient radiation meter featured in this article showed that the human tolerance limit for X-ray radiation is reached at a distance of about 15cm. from the unprotected shunt-stabiliser triode at maximum current (picture screen dark). With the shielding in position and the receiver normally housed the radiation did not exceed 2% above the ever-present cosmic background radiation at any position to the front, sides, top or rear of the receiver. This is a completely negligible level since the human tolerance level is about fifty times the cosmic background level. No significant X-ray levels were detectable on monochrome receivers in proper working order, closed or opened. Shorts in the c.r.t. anode circuit produced significant X-rays from the e.h.t. rectifier in several cases, however.

Subsequent articles will describe the nature and properties of X-rays and explain in detail the units in which they and other ionising radiations are measured, outlining the principles involved in calibrating radiation meters in terms of these units.

GENERAL PRINCIPLES

Figure 1 shows the circuit of the radiation meter in schematic form. The radiation detector is a Geiger-Müller tube (g.m. tube) of Mullard type MX147. A g.m. tube is a special type of gas-filled diode which is operated at a high voltage (450V for the MX147) just insufficient for sustaining a discharge. A single photon of X-ray radiation entering the tube through the thin mica window on the front end leads to primary ionisation in a few atoms of the gas filling. The resulting ions are multiplied at once by acceleration under the influence of the applied voltage and collision with further atoms. The effect is cumulative and leads to complete breakdown of the tube. This leads to rapid discharge of the stray capacitance across the tube so that the discharge is automatically quenched again within a short time, for this reason and on account of some special properties of the gas filling.

As soon as the discharge has been quenched, the stray capacitance across the tube commences to recharge through the high-value resistors Ra and Rk (Fig. 1a). The entire process takes about $60\mu S$ so that the net result when a single X-ray photon enters the tube is to produce an electric pulse of about 10V amplitude and some $60\mu S$ duration across Rk (Fig. 1a). The number of photons of a given X-ray radiation which succeed in producing a discharge in the tube within a fixed time of observation is directly proportional to the radiation intensity in $\mu r/h$ (microroentgen per hour). A suitable *frequency meter* connected to Rk may thus be calibrated directly in $\mu r/h$. Of course the calibration holds only for the particular g.m. tube for which it was undertaken. The complete radiation meter thus consists of a g.m. detector tube coupled to a frequency meter.

STATISTICAL FREQUENCY METER

Some special requirements are imposed on the frequency meter because the sequence of photons leading to the output pulses from the g.m. tube is statistically irregular. The frequency meter is thus not being called upon to determine some steady oscillator frequency but rather to determine the *average rate* of a randomly fluctuating sequence of pulses. A frequency meter of this kind is known as a *ratemeter*. The average rate determination takes considerable time, since it involves counting a sufficiently large number of pulses to tide over the short-term random fluctuations. An instantaneous reading is thus inherently impossible.

Instead, as shown in Fig. 1, we must amplify and reshape each pulse to a standard form and use it to pump a definite amount of electric charge via a diode into a large capacitor C. The voltage established across C is thus directly proportional to the number of pulses pumped into it, if no discharge path is provided. A voltmeter of infinitely large impedance would thus read the total pulses received if connected across C. However a high-value leak resistor R is connected across C to gradually drain the charge accumulated from successive pulses. Thus the voltage across C assumes a mean value corresponding to the number of pulses which arrive during the time constant of the circuit (given by the product of C and R). The voltmeter thus reads pulses received per unit time, i.e. the circuit then functions as a ratemeter.

INTEGRATION TIME CONSTANT

The circuit with C and R in Fig. 1a is known as an *integrator* integrating the effect of all pulses arriving within the *integration time*, which is the time constant CR.

We must next consider the magnitude of the integration time constant required to make our radiation meter give a sufficiently steady pointer deflection for the photon arrival rates involved. The cosmic radiation background is about 25μr/h, which corresponds to about 25 photons detected per minute with the specified g.m. tube. The design figure for our radiation meter specifies that a signal amounting to 10% increase over this cosmic background radiation should represent the significance threshold, i.e. the smallest signal which can just be distinguished from random fluctuations. Put another way, the average long-term fluctuations of the meter pointer after initial run-up must not exceed $\pm$ 10% of the average reading. Any larger change of the pointer reading then implies a significant *additional* incident radiation intensity above the cosmic background. An accuracy of $\pm 10\%$, i.e. 1 in 10, calls for $10^2=100$ photons which must participate in the averaging process. The mean rate being about 25 photons per minute for the cosmic radiation background with this g.m. tube, 100 photons will take four minutes to arrive. Thus the integration time constant on the lowest range of the radiation meter must be at least four minutes. It has been made five minutes here to allow a margin for localities where the cosmic background radiation is below average.

SUITABLE CAPACITORS

The demand for such a long integration time constant poses practical problems in the selection of suitable capacitors. Using a transistorised voltmeter, the highest conveniently obtainable input impedance for the low voltages involved is about $5M\Omega$. Higher impedances are possible with field-effect transistors, but these are still rather delicate and variable devices. Thus R is restricted to a maximum value of about $5M\Omega$, calling for a value of $60\mu F$ for C in order to give a five-minute time constant. We cannot use an electrolytic for C because the insulation and capacitance values of electrolytics are not sufficiently stable. A good microfoil high-insulation capacitor is essential for C, and this would be unjustifiably expensive at $60\mu F$ capacitance.

BASIC OPERATIONAL AMPLIFIER

Figure 1b shows a simple circuit which will produce a virtual $60\mu F$ capacitor with the help of a much smaller, thus correspondingly cheaper, actual capacitor. It is called an *operational amplifier* and is based on the familiar Miller effect. If a capacitor of value C is connected between the input and output terminals of a phase-reversing voltage amplifier of voltage gain G, the circuit

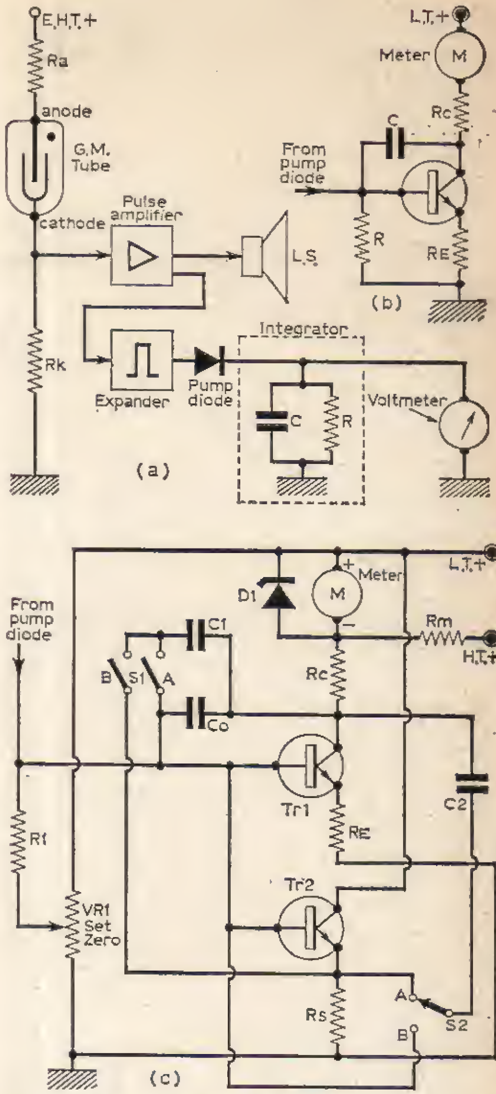


Fig. 1: (a) Block diagram of the basic direct-reading ambient radiation meter. (b) Basic operational amplifier as improved integrator. (c) Practical operational amplifier with approximator and zero-setting facilities.

behaves exactly as if a capacitor of value $G \times C$ is shunted across the input and the actual capacitor between input and output is not present.

The gain of the amplifier must be stabilised, which is achieved with the help of the negative feedback resistor R_E. It is no longer necessary to provide a separate amplifier as voltmeter: the moving-coil meter can be placed directly in series with the output load resistor R_C so that the operational amplifier functions as its own amplifying voltmeter.

The basic operational amplifier of Fig. 1b possesses a number of disadvantages as it stands. First of all, *C* is discharged at the moment of switch-on, which is equivalent to full charge on the virtual input capacitor across *R* on account of the phase reversal of the amplifier. The meter pointer will thus slam hard over beyond full scale, returning to zero in the absence of an input from the pump diode only after several times the integration time constant, i.e. after half an hour or more. Secondly, even after one has waited for the meter to zero itself after this very long time, the circuit takes *several times* the integration time, i.e. again at least half an hour, to reach a final meter reading. Thirdly, the circuit is extremely non-linear and may even be unstable in the region near zero input rate from the pump diode because *R* is returned to chassis instead of to a bias source for setting a suitable linear operating point. However, as soon as we take *R* to such a bias point instead of to chassis, the meter reads the corresponding standing current instead of zero for no input from the pump diode. Thus Fig. 1b shows only the basic principle and is unsatisfactory for practical purposes.

PRACTICAL OPERATIONAL AMPLIFIER

Figure 1c shows the modifications necessary to overcome these disadvantages. R1 is here taken to an adjustable bias source for setting a suitable operating point. The resulting standing collector current of Tr1 through the meter M is cancelled as far as the meter is concerned by injecting an opposite current from a still higher positive point through a large resistor Rm to the negative terminal of the meter. The zener diode D1 is provided to limit the current through the meter at the moment of switch-on.

Three capacitors are provided instead of the single capacitor *C*. The smallest one of these, Co, has a very low value and is permanently connected to stabilise the operational amplifier and thus prevent it running wild on surges. The integration time constant with Co alone is negligibly brief, so that the meter quickly drops to a reading near zero after switch-on and the meter reading quickly follows any change of the setting of VR1 which thus serves as the zero adjustment control. During this time C1 is connected to Rs via S1B, and C2 is also connected to Rs via S2A. Rs repeats the input voltage present at the base of the operational amplifier Tr1 at low impedance with the help of the emitter follower Tr2. Thus the larger capacitors C1 and C2 are also charged rapidly to the zero state.

After completion of the zeroing function, which only takes a few seconds instead of the half-hour or more in Fig. 1b, S1 is moved from B to A. This transfers C1 from the emitter follower output to the operational amplifier input. The value of C1 is about one-tenth of the value of C2, the integrating capacitor used for the final measurement. Consequently with C1 alone the meter will approach a final reading ten times faster, but with correspondingly greater random fluctuation. After about thirty seconds, an approximate reading will have been established. The emitter follower has in the meantime repeated this voltage across Rs, to which the main integrating capacitor C2 is still connected, so that the latter is also charged to the voltage approximated quickly with the help of C1. S2 is now moved from A to B to bring the main integrating capacitor C2 into the operational amplifier circuit Tr1. The large fluctuations of the approximate meter reading now cease and a final steady reading is established within a few minutes.

When a reading has been taken and it is desired to make the next one it is merely necessary to switch C2 back from Tr1 base to Tr2 emitter whereupon the meter will quickly approximate the new reading. After about thirty seconds in this "approximator" setting, switch C2 back to Tr1 base and a new steady reading is reached a few minutes later. This arrangement enables a reading to be taken every five minutes instead of one every hour as with Fig. 1b.

CIRCUIT DESCRIPTION

Figure 1c is the basis of the X-ray meter the full circuit of which is shown in Fig. 2. In this C10 is the small stabilising capacitor, C13 the approximator capacitor and C12 the main integrating capacitor. These three components must possess very good insulation. The switching functions are performed by a single four-section rotary switch which also selects the three ranges of 100, 500 and 1,000μr/h f.s.d. respectively by inserting different resistor combinations for R1 in Fig. 1c. This changes the integration time so that correspondingly different mean pulse rates are necessary for the same meter reading. Since, however, the integrating capacitors are the same for all ranges, any given meter reading represents the same number of pulses during the integration time constant on all ranges, so that the percentage meter reading fluctuation remains the same on all ranges. In other words, the readings are equally steady on all ranges, but are of course established faster on the higher ranges.

Tr8, Tr9 and Tr12 in Fig. 2 constitute the operational amplifier (Tr1) of Fig. 1c, Tr10 and Tr11 forming the emitter-follower of the approximator circuit (Tr2) of Fig. 1c. These transistors respectively constitute a Darlington triplet and a Darlington couple to achieve the required high input impedance at the base of Tr8 so that this input impedance is much higher than that of the discharge resistors R31—R34 switched into circuit by S3D. The first two transistors Tr8 and Tr9 are common to both the operational amplifier and its approximator emitter-follower so that the latter actually comprises a Darlington quadruplet Tr8—Tr11. Tr12 is thus the output transistor of the operational amplifier and is driven via a diode D12 from the junction of Tr9 emitter and Tr10 base. This arrangement provides highest possible input impedance at Tr8 base for the minimum number of transistors, and very low output impedances on both branches.

In principle, these five silicon n-p-n transistors could be replaced with two field-effect transistors, but such devices are still rather delicate and would lead to somewhat more sluggish zeroing action whilst possibly suffering damage on the high switch-on surge resulting if power is switched on when S3 is not in the set-zero position. With silicon n-p-n transistors, this cannot lead to damage.

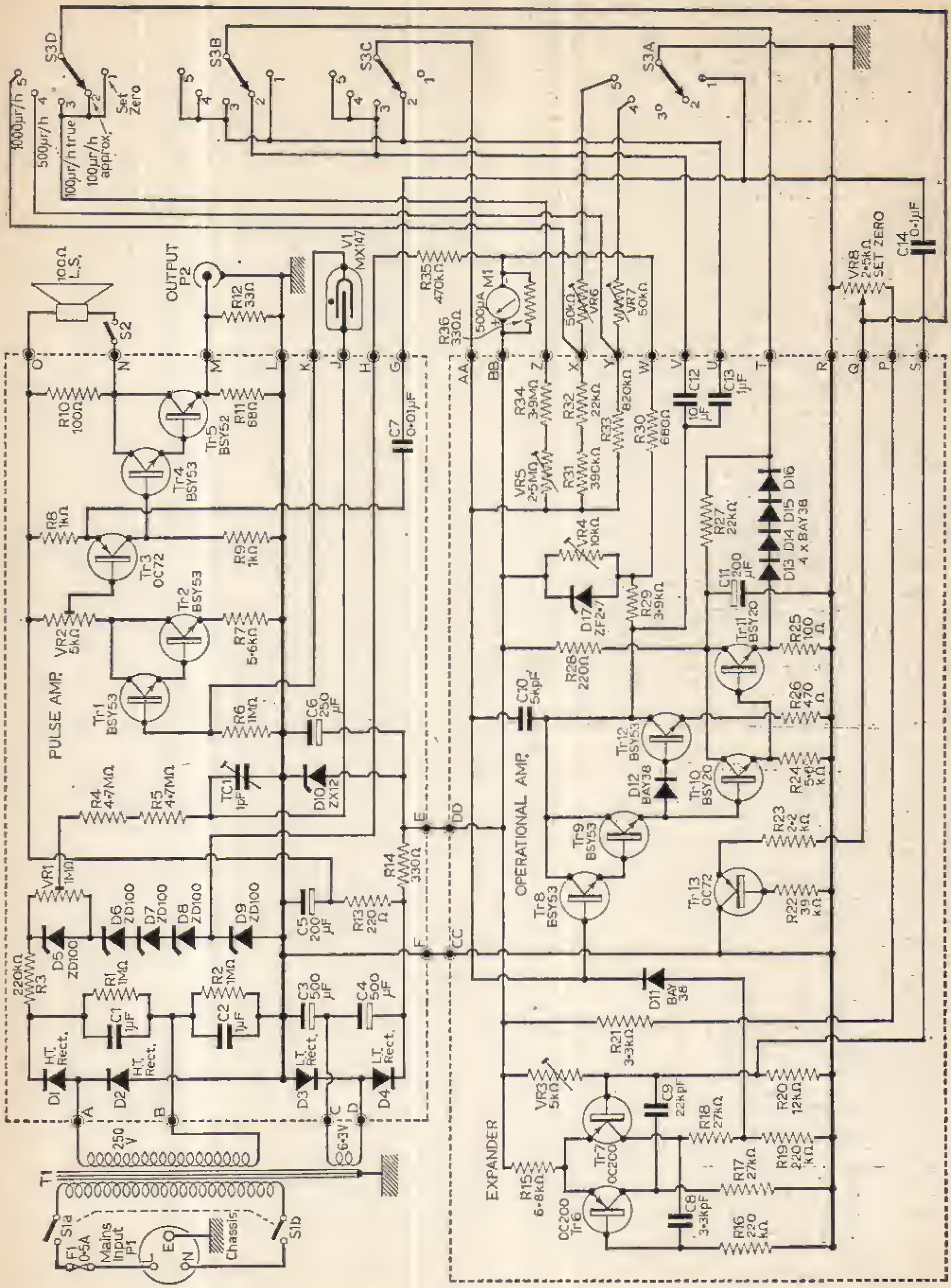


Fig. 2. Complete circuit diagram of the X-ray radiation meter.

The meter pointer then merely slams over to full-scale deflection after switching on, without damage to the meter since this is protected by the zener diode D17, the pointer slowly drifting down to near zero over half an hour or so if S3 is not moved. However, if S3 is moved to the set-zero position before or after switching on the power supply with S1, the meter pointer returns to zero *at once.* VR8 on the front panel may then be adjusted for exact zero reading on the meter. S3A1 mutes the pulse input from the amplifier circuit board to the ratemeter circuit board by shorting it out to chassis so that there is no input to the operational amplifier via the pump diode D11 when S3 is in the set-zero position.

OPERATING POINTS

The five zener diodes D5 to D9 provide a stabilised 500V supply for the g.m. tube. VR1 shunted across the top zener diode D5 enables the operating point of the g.m. tube to be set to any value between 400V and 500V. First move VR1 slider to the bottom end (junction of D5 and D6). If the g.m. tube continues to work in this setting, connect a valve voltmeter to VR1 slider and adjust for exactly 450V reading. If the g.m. tube does not work in the bottom setting of VR1, slowly advance VR1 until the g.m. tube commences to produce pulses and then take the voltage reading at the slider of VR1 with the valve voltmeter. Set VR1 finally to midway between this voltage reading and maximum, as measured with the valve voltmeter at the slider of VR1. The input impedance of the valve voltmeter must be at least 10MΩ. Together with a good oscilloscope possessing a calibrated timebase, this is the only essential equipment required for aligning the radiation meter.

The stabilised +100V supply across D9 is also used as backing source for meter M1. In the zeroed setting of VR8 on the front panel, the output transistor Tr12 of the operational amplifier is actually drawing about 25% full-scale deflection current through R26, R29, R30 and the meter M1. The backing current injected from D9 via R35 to the negative terminal of the meter deflects the pointer backwards so that the net reading is zero. VR8 is manually adjustable to make the meter reading exactly zero before taking any reading.

The actual bias voltage required at Tr8 base for exactly zero meter reading is *very strongly* dependent upon the temperature of the transistors, since the full voltage swing used at the base of Tr8 during measurements is only about 1 volt, which is much less than the combined threshold voltage of the five amplifier transistors. Temperature stabilisation is thus essential to avoid intolerable drift of the meter zero setting during actual measurements. This is provided by Tr13, which operates as a variable n.t.c. resistor shunted across the actual bias applied to the operational amplifier at VR8 slider. With increasing temperature the threshold voltage of the amplifier transistors falls exponentially, but so does the shunt impedance of Tr13 and thus the applied bias is reduced automatically to maintain the same current operating point. The values of R22 and R23 determine correct stabilisation slope, and should be found satisfactory as specified. Tr13 type is not critical; almost any small *germanium* p-n-p power type is suitable. It should be mounted on long leads and bent over so as to sense the temperature of Tr8—Tr12 as closely as possible. With this arrangement there should be little if any residual drift of the zero setting of VR8 with respect to temperature. If residual drift is excessively positive, i.e. if the meter reading creeps up from zero with rise of temperature, judiciously reduce the value of R22. If this then leads to a negative drift at higher temperatures in warm weather (test cautiously with a hair dryer) increase R23. It may be necessary to repeat these adjustments alternately, always stopping with a final adjustment of R22 at the low temperature end. For negative residual drifts, make the changes in the opposite sense.

APPROXIMATOR

The purpose of the approximator, as we saw in the basic circuit, is to provide an exact replica, at low impedance, of the input voltage applied to the operational amplifier, so that we can pre-charge the main integrating capacitor quickly to the approximate final value with the help of a much smaller auxiliary capacitor used temporarily as approximating integrating capacitor. It is clear that we are here concerned with amplification of d.c. signals, so that threshold voltages and bias points must be taken into account. The five diodes D12 to D16 are provided to meet this requirement. These must be *silicon* diodes, but type and make are otherwise unimportant. If proper miniature switching diodes are unobtainable, ordinary silicon rectifiers of any kind may serve at a pinch. The only change which may be required in this case is the use of an appropriate different number connected in series.

The threshold voltage of a silicon diode is approximately the same as that of a silicon transistor. In passing from the base of Tr8 to the emitter of Tr11 we pass four steps each equal to a silicon threshold voltage so that the actual voltage across R25 is always less than that applied to Tr8 base (by four times the silicon threshold). The four diodes D13 to D16 are biased forwards via R27, so that we once again climb up through four silicon thresholds between the emitter of Tr11 and the cathode of D16. The voltage at D16 cathode is thus a true replica of the actual d.c. potential at Tr8 base, and thus serves as our approximator output.

The switching circuitry of S3 is seen to be arranged so that unused integrating capacitors are connected to this approximator output so that they are always held charged to the integrated voltage established on the capacitor in circuit and there is consequently no waiting time when switching over to the full capacitance, and no significant change of meter reading. D12 is provided to complete the circuit symmetry, i.e. to place a total of four silicon thresholds in the operational amplifier branch too (Tr8, Tr9, D12, Tr12). Otherwise the joint temperature compensation with Tr13 would break down.

DRIVE

The expander circuit, Tr6 and Tr7, is provided in the ratemeter as driver for the operational amplifier. The amplified pulses from the g.m. tube appearing via C7 at pin G of the pulse amplifier circuit board are not suitable for driving the operational amplifier directly because they consist of exponential capacitance recharging flanks, not of proper square pulses with essentially flat roof, definite amplitude and definite duration. The purpose of the expander is to expand these recharge flanks to the required accurate square pulses. The circuit is a conventional triggered monostable multivibrator. In the stable state Tr6 is conducting because R16 is returned to the collector supply (chassis) and the resulting voltage drop across R15

COMPONENTS LIST

Resistors:

R1	1MΩ 1W	R19	220kΩ
R2	1MΩ 1W	R20	12kΩ
R3	220kΩ 1W	R21	3·3kΩ
R4	4·7MΩ 1W	R22	39kΩ
R5	4·7MΩ 1W	R23	2·2kΩ
R6	1MΩ 1W	R24	5·6kΩ
R7	5·6kΩ	R25	100Ω
R8	1kΩ	R26	470Ω
R9	1kΩ	R27	22kΩ*
R10	100Ω*	R28	220Ω
R11	68Ω	R29	3·9kΩ
R12	33Ω*	R30	680Ω
R13	220Ω 1W	R31	390kΩ 5%
R14	330Ω 1W	R32	22kΩ 5%
R15	6·8kΩ	R33	820kΩ 5%
R16	220kΩ	R34	3·9MΩ
R17	27kΩ	R35	470kΩ 1W
R18	27kΩ	R36	330Ω 1W

All ½W, 10% carbon unless otherwise indicated.
*See text.

Variable resistors:

VR1	1MΩ	VR5	2·5MΩ
VR2	5kΩ	VR6	50kΩ
VR3	5kΩ	VR7	50kΩ
VR4	10kΩ	VR8	2·5kΩ

VR1–VR7 miniature skeleton, lin.
VR8 potentiometer with knob, lin.

Capacitors:

C1	1μF 500V miniature foil
C2	1μF 500V miniature foil
C3	500μF 15V electrolytic
C4	500μF 15V electrolytic
C5	200μF 30V electrolytic
C6	250μF 15V electrolytic
C7	0·01μF 250V miniature foil
C8	3,300pF 500V ceramic
C9	22,000pF 250V miniature foil
C10	5,000pF 500V ceramic
C11	200μF 15V electrolytic
C12	10μF 100V miniature foil
C13	1μF 100V miniature foil
C14	0·1μF 100V miniature foil
TC1	1pF twisted wire (see text)

Semiconductors:

D1, D2 Silicon h.t. rectifiers, 250V a.c., 750V p.i.v., 0·25A
D3, D4 Silicon l.t. rectifiers, 100V p.i.v., 0·5A
D5-D9 100V zener diodes, at least 2mA rating
D10 12V zener diode, at least 25mA rating
D11-D16 Silicon diodes, p.i.v. ⩾ 100V, C barrier ⩽ 10pF at 5V inverse bias, e.g. BAY20, BAY21, BAY32, BAY38
D17 Subminiature 2·7V zener diode, at least 5mA rating
Tr 1, Tr 2, Tr 4, Tr 5, Tr 8-Tr 12, Silicon npn transistors with $\beta \geqslant 25$ at 1mA Ic, Vc max. ⩾ 15 V.e.g. BSY20, BSY52, BSY53. Tr 8, Tr 10, Tr 11 best available (high β at low Ic).
Tr 3, Tr 13, OC72
Tr 6, Tr 7, OC200, Selected OC72 may be used if silicon types unavailable: select for low collector leakage and reduce R19 value if necessary to preserve zero stability of meter reading. Linearity will suffer slightly, see text.

Valve:

V1 MX147 Mullard Geiger-Müller tube.

Miscellaneous:

F1 0·5A
LS1 3in. miniature panel speaker, 70–100Ω (or other impedance with transformer).
M1 500μA f.s.d. moving-coil meter. Ri ⩽ 350Ω (add series resistor to make Ri= 350Ω±10% total).
P1 3-pin mains connector
P2 Coaxial panel socket
S1 Double-pole on/off toggle
S2 Single-pole on/off toggle
S3 4-wafer, 5-way rotary with knob (preferably ceramic).
T1 Mains transformer, 250V I ⩾ 10mA, 6·3V I ⩾ 0·5A.
Material for printed circuit, cabinet, etc.

holds Tr7 cut off. Thus there is no voltage drop across the collector resistor R19 so that the anode of the pump diode D11 rests at chassis potential. On the other hand the cathode of D11 rests at the positive bias potential applied to the base of Tr8, which thus also serves as inverse bias holding D11 cut off.

An amplified pulse from the g.m. tube is fed via C7 and C14 to the base of Tr7. This positive pulse momentarily lifts Tr7 above cut on so that the roles of Tr7 and Tr6 change over by normal multivibrator action, Tr7 now conducting and Tr6 being cut off. After the elapse of a time determined by C8, R16 (about 500μS), the circuit reverts to its former stable state until the next pulse arrives from the g.m. tube. Each input pulse thus causes Tr7 to switch on for 500μS. The collector supply voltage is thus connected via R18 and D11 in series to the input of the operational amplifier for 500μS in response to each g.m. tube pulse. In other words, a *definite* quantity of charge is pumped into the virtual integrating capacitor between Tr8 base and chassis each time.

The resultant change of voltage across the integrating capacitor and consequent change of meter reading is hardly visible for a single pulse. The combined effect of about 500 pulses is required in this circuit to establish a full-scale meter deflection, i.e. a single pulse moves the pointer over only 0·2% of the scale (2% in the approximator setting). Since the background counting rate due to cosmic radiation amounts to only about one pulse in two to three seconds on average, some intervals being ten seconds or more, it is hardly possible to determine quickly whether the circuit is "working" by observing the meter reading alone. Individual pulses do *not* produce the wild kicks familiar with cheap toy Geiger counters.

ACOUSTIC INDICATOR

An acoustic indicator must thus be provided. This takes the form of the loudspeaker LS1, which may be switched off with S2 when not required. Headphones may be connected to P2 as an addition or alternative. Low-impedance phones are preferable but virtually any impedance will work. The output at P2 may also be taken over long lengths of coaxial cable to conventional digital counters or other forms of advanced radiation metering units. Thus our design is suitable for use as a head unit in advanced systems for nuclear radiation and radioactivity metering, school demonstrations, etc. The three functions (a) audible ticks in loudspeaker LS1, (b) external pulse output at P2 and (c) internal ratemeter display are *mutually independent* and may be used separately or simultaneously in any combination.

If it is desired to drive only some external equipment via P2 switch off the loudspeaker and leave S3 in the set-zero position. This is particularly advisable when using the unit to measure powerful radioactive or X-ray sources leading to meter readings beyond full scale on the highest range, i.e. when the g.m. tube is picking up more than about 17 photons per second. The tube will handle several thousand photons per second satisfactorily and corresponding outputs are then available at P2. The irregular rattle from the loudspeaker is irritating so that it is easier on the nerves to leave LS1 switched off except for brief checks under these conditions, whilst the meter M1 would stick at full scale and it is thus better to leave S3 at set zero for high-intensity measurements with external auxiliary counters. However, neither the loudspeaker nor the meter will be damaged if they are left switched on. Zener diode D17 fully protects the meter under all circumstances.

PULSE AMPLIFIER

Tr1 to Tr5 form a simple pulse amplifier for the pulses from the g.m. tube, without greatly changing their form. All five transistors operate in class B, i.e. they rest just cut off (no bias applied to their bases) and are briefly keyed-on during each pulse. Voltage gain is not required because the pulses developed across the cathode load resistor R6 of the g.m. tube already have an amplitude of at least 5 volts. The sole function of the pulse amplifier is to step down the impedance so that the pulse voltage is available at low impedance and thus can supply adequate drive current for the circuits and devices connected to the output.

All five transistors operate as emitter-followers. Tr1 and Tr2 form a common Darlington pair, Tr3 is an emitter-follower with equal collector resistor, i.e. a phase splitter producing pulses of both polarities, and Tr4, Tr5 form another Darlington pair for the output at P2 (5V positive pulses). At the same time negative pulses are fed to the loudspeaker connected in the collector circuit of these transistors, which are driven from the positive output at the collector of the phase splitter Tr3. The negative output from the emitter of the phase splitter Tr3 is used to trigger the expander on the ratemeter circuit board. This arrangement makes all outputs fully decoupled from each other and thus mutually independent. VR2 is a common preset gain control.

POWER SUPPLY

The smallest available type of mains transformer with a single 250V and a single 6·3V secondary winding should be used. The total current consumption of the complete radiation meter is only a few milliamps on both windings, so that whilst a large mains transformer may certainly be used it would make the unit unnecessarily heavy and clumsy. The anode supply for the g.m. tube is obtained by voltage-doubler rectification of the 250V a.c. transformer output, with D1, D2, C1 and C2. R1 and R2 are safety resistors to discharge C1 and C2 after switch-off. The total voltage produced across C1 and C2 in series is about 720V, which is dropped to exactly 500V across the zener diodes D5 to D9. This stabilisation is quite essential because the sensitivity of the g.m. tube changes about 10% with fluctuations of its anode voltage resulting from the normal range of variation of the mains voltage. Furthermore, the meter backing current is taken from the same supply so that intolerably large drifts of the meter zero setting would result in a random manner due to mains voltage fluctuations if stabilisation was not employed.

The l.t. supply of nominally +18V is obtained by voltage-doubler rectification of the 6·3V transformer output, with D3, D4, C3 and C4. Separate discharge resistors are here unnecessary because VR3 and R20 on the ratemeter circuit board are always shunted across this supply. R13 and C5 smooth the supply for the pulse amplifier. Stabilisation is here unnecessary. R14, C6 and the zener diode D10 smooth and stabilise the l.t. supply for the ratemeter circuit board. Stabilisation is essential here because the d.c. operating point, and thus the meter reading for the operational amplifier, is sensitively dependent upon the supply voltage. In the absence of voltage stabilisation mains voltage fluctuations would again produce intolerably large random drifts.

When making up the printed circuit boards, especially the amplifier and power supply board, remember that the circuitry carries high voltages when in use. Thus tin all printed conductors generously over their full runs after soldering components in position, and coat twice with an approved protective varnish.

TO BE CONTINUED

DX-TV

A MONTHLY FEATURE FOR DX ENTHUSIASTS

by Charles Rafarel

THE report this month is "the mixture as before", in fact little difference between the present period and the preceding one. Sp.E. reception was very poor indeed, and although there was some tropospheric activity (particularly on 28-29 February) the overall picture has left much to be desired.

I used to think that the "blackest" months for our DX screens were December and January, but now I am inclined to rate February and March as the worst. Even F2 propagation seems to have been lacking after the earlier reports in spite of relatively high sun-spot counts in late January and February. Here is the report for Sp.E., period 17/2/68 to 16/3/68:

19/2/68 Sweden, E2. 26/2/68 Czech. R1.
9/3/68 USSR R1. 11/3/68 Czech. R1.
12/3/68 Czech. R1. 13/3/68 USSR R1.
16/3/68 USSR R1.

Tropospherics, including u.h.f., were:

29/2/68 France, Holland, and W. Germany, a number of u.h.f. stations received.

3/3/68 France, and Belgium, Bands I and III.

Reports from other DXers indicate that there has been rather better reception in other parts of the country to the North and East of my location.

TOWARDS F2 DX ?

Not much progress here either, in fact the sun-spot count for 2/2/68 reached a record figure of 211, but no further F2 reports from here as yet. One further USA report however of reception over there of BBC Ch.B1, and ORTF Ch.F2 sound, but still no mention of pictures.

Most of the recent reception seems to have been along the East to West path, rather than North to South which is reckoned to be the "preferred" direction. The latest prediction is for a maximum in May.

While on the subject of F2 reception I will now classify the possible channels for reception other than the "E" channels in use in Africa and the Middle East (details are due to R. Bunney).

"A" Channels used by USA, Canada, parts of Central and South America, Near East, Far East, and parts of the Pacific.

System 525 line. Negative image. Field 60c/s. Sound, f.m.

Channel A2. V—55·25Mc/s. S—59·75Mc/s.
Channel A3. V—61·25Mc/s. S—65·75Mc/s.
Channel A4. V—67·25Mc/s. S—71·75Mc/s.

Australia

System 625 line. Negative image. Field 50c/s. Sound, f.m.

Channel 0. V—46·25Mc/s. S—51·75Mc/s.
Channel 1. V—57·25Mc/s. S—62·75Mc/s.
Channel 2. V—64·25Mc/s. S—69·75Mc/s.

New Zealand

System 625 line. Negative image. Field 50c/s. Sound, f.m.

Channel 1. V—45·25Mc/s. S—50·75Mc/s.
Channel 2. V—55·25Mc/s. S—60·75Mc/s.
Channel 3. V—62·25Mc/s. S—67·75Mc/s.

To return to F. Smale's sound reception of WLWD (Dayton, Ohio) on Ch.A2, R. Bunney suggests that this might possibly be double skip Sp.E. rather than F2. Even so, this does not in any way detract from his excellent reception.

NEWS

(1) The now defunct m.w. pirate station Radio 270 is understood to be going to the Canary Islands where it will operate on m.w. and f.m., and—what is more interesting—TV as well, so there will be a pirate rival to the commercial TVE at Azana. No details of channel and power as yet.

(2) Orders have been placed for 14 u.h.f. 2nd chain transmitters for Southern Sweden, so following the reception of the experimental station at Hörby by a number of DXers at least some of the new ones should be received here. The locations are already known, and we are awaiting details of channels.

(3) The BBC-1 Marlborough relay on B7 Hor. will go into service in the autumn this year, and this looks like trouble for the local DXers!

(4) The following Meteor Shower dates for 1968 are now to hand:

Quadrantids. 3-4 January. Peak 3rd.
Lyrids. 20-22 April. Peak 22nd.
Perseids. 27 July to Aug. 17. Peak 12th.
Orionids. 15-25 Oct. Peak 20th and 22nd.
Taurids. 26 Oct. to Nov. 16. Peak 1-7 Nov.
Leonids. 15-17 Nov. Peak 16th.
Geminids. 9-14 Dec. Peak 13th.
Ursids. 20-22 Dec. Peak 22nd.

The most important showers are the Leonids.

(5) We at last have some further news on the puzzling question of the Hungarian and Polish test cards. Bydgoszcz R1, and Warsaw R2: the card is of the "Retma" type usually originating in the Warsaw TV centre, and if so it has *White* figures in the corner circles. The main TV centre at Katowice also uses this type of card with white figures, but all other TV centres use a card with *Black* figures.

I deduce from all this that when white figures are seen the card can originate in Poland from either the Warsaw or Katowice TV centre, *or it can be Budapest* which always has white figures. If, however, Bydgoszcz is relaying a centre other than Warsaw or Katowice the letters will be black *and the card must be Polish.* This would account for the fact that we have seen black figures at times particularly from Bydgoszcz.

—*continued on page 358*

IMAGE INTENSIFIERS AND CONVERTERS

by K.T. WILSON

FREQUENCY changing and amplification of radio frequencies are such common operations that we tend to forget what remarkable processes they are. Radio frequencies are, however, a small portion of the whole range of possible electromagnetic waves, and the only fundamental difference between, say, light rays and radio waves (apart from the fact that the eye is sensitive to light rays) is their different wavelength. Frequency changing is a process which is relatively easy to carry out with X-rays, ultra-violet light, etc., providing that short-wavelength radiation is being changed into a longer-wavelength radiation. The fluorescence of substances under an ultra-violet lamp is a good example of short-wave radiation being changed into longer-wavelength radiation by interaction with a material.

This type of frequency changing is not used at radio frequencies; what we do in the case of r.f. is, in effect, to convert electromagnetic waves into electron movement in a valve or transistor, alter the electron movement by the mixing operation and convert back to electromagnetic waves in the i.f. transformer. Amplification is carried out in a similar way by converting wave motion to electron movement, increasing the energy of the electron movement and converting back to wave motion. We cannot amplify or change the frequency of light by feeding it into the grid of a conventional valve, but we can approach the problem of amplification or frequency changing in the same way.

IMAGE CONVERTERS

A frequency changer for light is termed an image converter. The change may be in either direction, and not, as happens with a passive device, in the direction of a lower frequency (longer wavelength) only. In practice, what we always want to do is to convert an invisible radiation into visible light. The first step, taking the valve frequency changer as a guide, is to convert the invisible radiation into an electron stream. Take the example of ultra-violet rays. If ultra-violet rays strike a film of gold, electrons are released in a process which is called photoemission. These electrons will be attracted to any positive electrode nearby, and if we make the positive electrode a phosphor screen of the same type as that used in cathode-ray tubes it will fluoresce where it is struck by electrons. In this way, ultra-violet light is converted into visible light.

Converting one wavelength of light into another is not a particularly useful operation unless images can also be converted. This can be done only if all the electrons leaving one point of the gold film land at one point on the phosphor, and the easiest way to accomplish this focusing operation is to surround the image converter with a solenoid, although focusing may also be accomplished electrostatically. The magnetic field of a solenoid is shown in Fig. 1 and it can be seen that the field lines, which are also the paths which an electron tends to follow, run parallel to the axis of the solenoid at points inside which are not too close to the ends. An image converter placed inside a solenoid can therefore produce sharp images on the phosphor of any objects held against the photocathode or images focused on to the photocathode.

The photocathode in the example was a gold film which was sensitive to ultra-violet (u.v.), but photocathodes sensitive to infra-red (i.r.) can also be prepared. Image converters made with either of these photocathodes and a suitable lens (quartz for ultra-violet; rock-salt for infra-red) enable us to see the effect of i.r. and u.v. just as easily as if our eyes were sensitive to these rays. Such image converters can be made quite small, even with their associated equipment, because electrostatic focusing can be used and transistor converters can supply the very small current at high voltage required by the converter. In portable form they may be used for the detection of forgery, to see hot bearings in

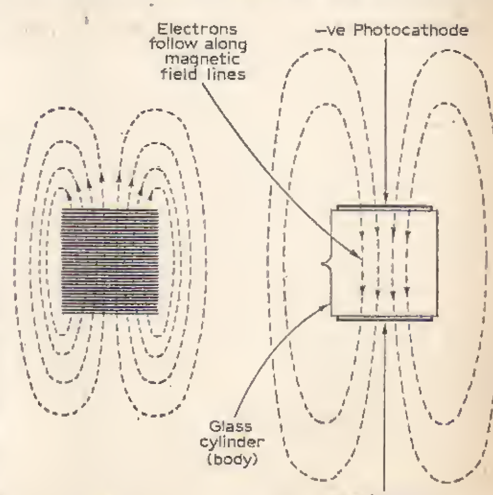
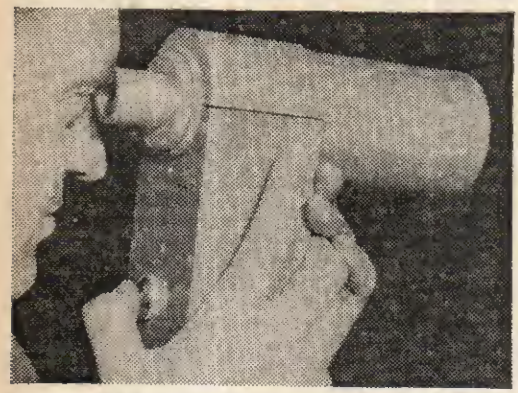


Fig. 1: (a) Magnetic field of a solenoid and (b) image converter in solenoid field.

machinery or to see intruders "lit" by heat energy in a dark space.

THE SHUTTER TUBE

Another form of image converter uses a photocathode sensitive to visible light and a blue phosphor, but is fitted with a third electrode in the form of a metal mesh (see Fig. 2). This type of image converter transmits a picture of the image on its photocathode, the difference being that the third electrode acts as a grid which can switch the electron beam on or off. This type of tube is known as a "shutter tube" because the action of the switching is exactly similar in effect to the operation of the shutter on a camera and is used for the same purposes. Camera shutters are mechanical, and their maximum speed (that is time of opening) is about 1/1,000th of a second. High-speed flash is quicker; the camera shutter is opened and the exposure lasts only as long as the flash, which may be a few microseconds. Higher speeds can be obtained using rotating prisms or mirrors, but the highest speeds so far attainable have used a shutter



Infra-red image converter for the detection of banknote forgeries, faulty bearings, failing h.t. insulators and similar applications. Uses Mullard 6929 image converter tube.

tube coupled to a camera whose shutter is already open.

Since the shutter action is that of switching a grid electrode up and down, the practical limit is set only by the stray capacitances and the current of the switching valve. By using radar pulse switching techniques such as thyratrons and delay lines, shutter tubes have achieved exposures of a few nanoseconds and have been used to film the events taking place at the instant when a nuclear explosion occurs.

IMAGE INTENSIFIERS

The third tube in this family is the image intensifier, or light amplifier. Two parts of this tube are the same as those used in the previous tubes, the phosphor and the photocathode, but to intensify the image the brilliance at the phosphor must be considerably greater than that at the photocathode.

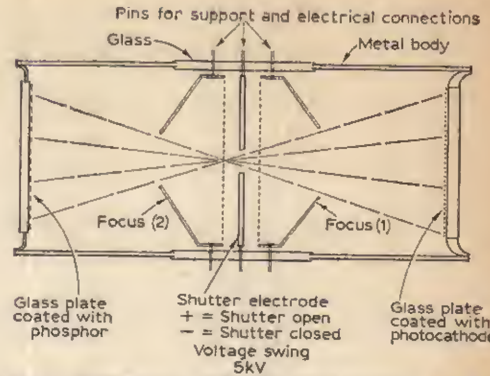


Fig. 2: Shutter tube. With this device exposures of a few nanoseconds have been achieved.

Before we can understand how the brilliance of images can be amplified, we must be clear about the processes which occur at the photocathode and at the phosphor. The photocathode converts the light image into a pattern of moving electrons, and the number of electrons leaving the photocathode per second (i.e. the current in the tube) is strictly proportional to the illumination on the photocathode. The efficiency of a photocathode is therefore quoted in terms of the current which it can produce for a given strength of illumination on the photocathode; it is important to note that the voltage used to accelerate electrons away from the photocathode has no effect on this current unless it is very low (less than a volt) or so very high that it causes field emission from the photocathode. We usually quote the efficiency of a photocathode in microamps per lumen, the lumen being the unit of photocathode illumination; the most efficient photocathode has an efficiency of over 100 microamps per lumen.

LIGHT OUTPUT

The light output of a phosphor, however, depends on the wattage dissipated in the phosphor; this is the product of the voltage between phosphor and electron source and the current flowing, and is quoted in lumens per watt. Phosphor efficiencies

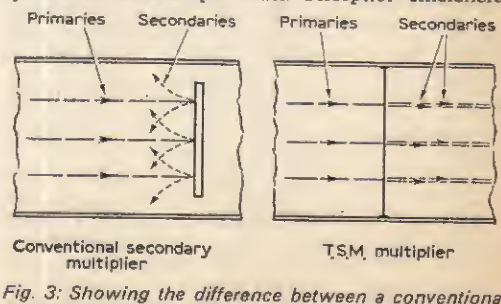


Fig. 3: Showing the difference between a conventional secondary multiplier and a T.S.M. multiplier. In the T.S.M. multiplier electrons pass through a thin film of material and secondary electrons are ejected in the same direction.

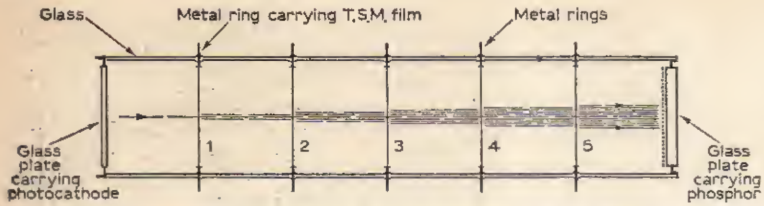


Fig. 4: Construction of a Transmission Secondary Multiplication or T.S.M. tube. Five T.S.M. films are incorporated between the photocathode and the phosphor-coated endplate.

vary from 5 lumens per watt to over 30 lumens per watt depending on the type of phosphor and its grain size.

To achieve amplification, therefore, means having more lumens output from the phosphor than were applied to the photocathode, and this means dissipating power at the phosphor corresponding to the number of lumens required. Since watts = volts x amps, we can achieve amplification in two ways: (1) by using a high voltage to accelerate the small current from the photocathode, or (2) by increasing the current from the photocathode.

These are two different approaches and have led to two quite different types of image intensifier. The first type using high-voltage acceleration was the first to be used. It was then replaced by the second type, but has recently made a spectacular comeback due to improved methods of manufacture. We shall examine each of these types in detail starting with the second.

CURRENT MULTIPLYING INTENSIFIERS

When electrons strike any substance three things can happen. Slow moving electrons strike the surface and "stick" to it, faster electrons penetrate the surface and their energy causes the atoms of the substance to break up, liberating more electrons, and very fast electrons penetrate deeply into the substance, their energy being absorbed as heat.

For a considerable range of striking energy, more electrons are knocked out of substances than originally strike them; the new electrons are termed "secondary electrons" and the whole process is called secondary emission. This process gives us the means of multiplying current since if more electrons leave a surface than strike it the current leaving the surface is greater than that striking it.

All this sounds very useful, but there are considerable practical snags. One is that the amount of multiplication (officially called the secondary emission ratio) is very small for most substances; another is that secondary electrons leave most substances in the opposite direction from the primary electrons which are striking the surface.

T.S.M. FILM

The discovery which made current-multiplying image intensifiers possible is the T.S.M. film. T.S.M. stands for Transmission Secondary Multiplication, implying that electrons pass through the thin film of material and secondary electrons are ejected in the same direction. Fig. 3 illustrates this process. This type of multiplier is ideal for the image intensifier since there is no change of direction of the electrons and no distortion of the image should take place if a thin film multiplier is placed between the photocathode and the phosphor of an image intensifier tube. This turns out to work quite acceptably in practice, but useful tubes need films which give a fairly high gain.

During the mid-fifties, much research was done on all kinds of thin films for this purpose, the technique being to prepare films of cellulose by dropping a solution of cellulose nitrate on to water, fixing them in frames, depositing various substances (carbon, aluminium oxide, silica, gold, etc.) on to the cellulose and, finally, burning off the cellulose in a furnace, leaving behind the fragile film of the substance to be studied. Ironically enough however the best films turned out to be those prepared by an entirely different technique. If a foil of aluminium (ordinary cooking foil was used extensively in early experiments!) is immersed in dilute sulphuric acid and connected to the positive pole of a d.c. supply, the negative pole being connected to a stainless steel electrode, the reaction which occurs is not that of electroplating, as might be expected, but of "anodising", that is growing a thin film of aluminium oxide on the aluminium. If the foil has been mounted in a frame the aluminium metal may then be etched away in another acid solution leaving only a very thin film of aluminium oxide which can form the basis of our multiplying film. Aluminium and aluminium oxide are ideal for this purpose as aluminium is fairly transparent to electrons. Any substance we now coat on to this aluminium oxide film forms a secondary multiplying layer, but of all the substances tested so far potassium chloride (closely related to common salt) has proved most effective, giving gains of about 6.

One more operation must be carried out before the film is usable. Since more current is flowing from the film than into it there must be some form of electrical connection to the film. This con-

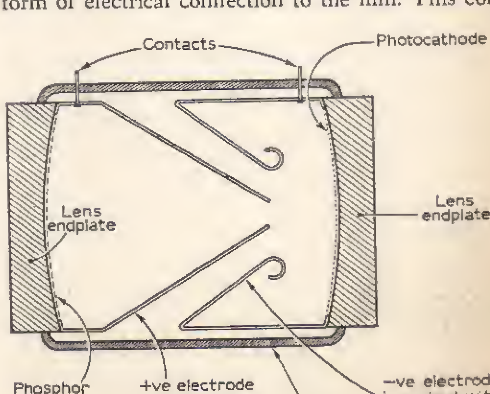


Fig. 5: Cross-sectional view of an image diode.

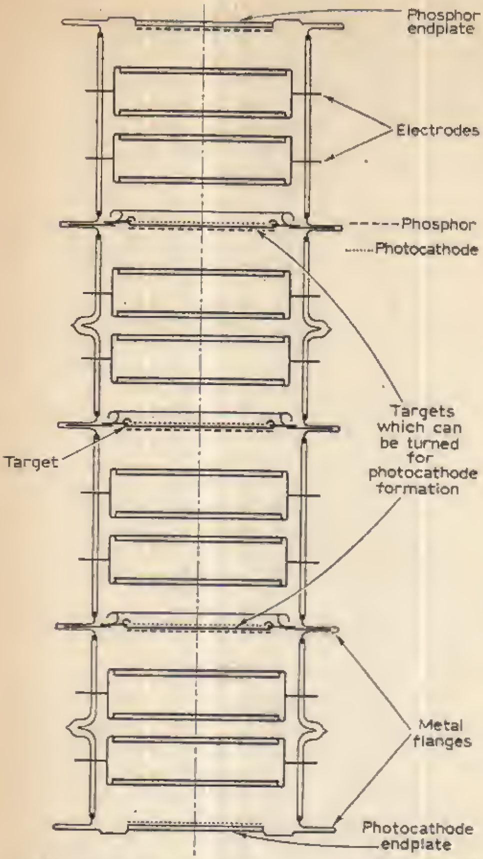
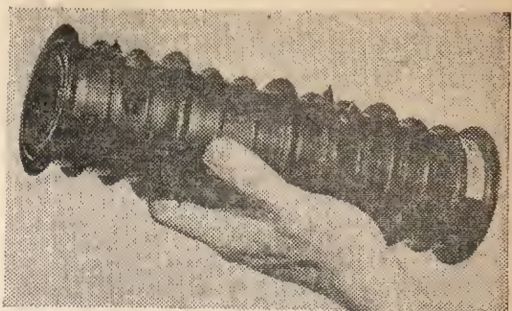


Fig. 6: Constructional details of the EMI type 9694 image intensifier.



Photograph of the 9694 tube shown in diagram form on the left.

nection takes the form of a metallic layer on the film, and, since this metallic layer must be transparent to electrons, the metal used is aluminium. It may seem rather clumsy to remove all aluminium from aluminium oxide only to add it again, but it is necessary to do this to ensure that the thickness of the aluminium layer is precisely measured.

The gain of 6 per stage may seem small but a two-stage tube has a gain of 6 x 6=36, a three-stage of 6 x 6 x 6=216 etc. Nine-stage tubes have been constructed having a gain of nearly 10,000 with 4·4kV between each stage. The whole tube has to be enclosed in a solenoid to achieve magnetic focusing and encased in a substance such as silicone rubber to avoid flashovers between the high voltage points.

The construction of such a tube is shown in Fig. 4. The films, on metal frames, are attached to the metal parts of a body made by sealing alternate glass and metal rings together. The photocathode and phosphor plates are welded in, and the whole tube evacuated carefully. During evacuation, the photocathode is formed.

In operation, the tube is most impressive. An object invisible to the viewer in the almost total darkness is focused on to the photocathode by a lens. When the tube is switched on, a bright image appears on the phosphor. The resolution is good compared to TV resolution—resolution of 40 TV lines *per millimetre* being readily obtainable.

POWER MULTIPLYING MULTIPLIERS

We saw earlier that the light input to a photocathode causes a current to flow proportional to the light, and that the light output from a phosphor is proportional to the wattage dissipated. Given suitably efficient photocathodes and phosphors, therefore, amplification boils down to a matter of using a high enough voltage between the phosphor and photocathode. For example, if a photocathode has an efficiency of $100\mu A$ per lumen and the voltage between the photocathode and the phosphor is 10kV the wattage is 1W. If the phosphor has an output of 10 lumens per watt, then the output is 10 lumens and the overall gain of the tube is 10. The figures quoted are readily attained and bettered; and the overall gain per stage can be considerably higher than that obtainable from the current multiplying type of tube.

Despite its attractive simplicity, this type of tube is difficult to make. The preparation of the photocathode involves the release of caesium vapour in the tube, and this "poisons" the phosphor, reducing its efficiency considerably; also the dimensions of the tube must be carefully controlled to avoid defocusing. The problems have been tackled in two ways.

The first is to make image intensifier diodes, each consisting of a photocathode and phosphor on glass plates along with metal extensions of these electrodes to shield the phosphor from the caesium and to act as a lens so that the electrons form an inverted image (Fig. 5). In practice, flat glass faceplates cause severe distortion of images not at the centre of the screen and curved surfaces are preferred internally as shown. The external surface is flat, so that the whole faceplate acts as a concave diverging lens. Such image diodes can be made relatively cheaply, and the best specimens can be stacked together, encapsulated in plastic material, and operated to give very high gain. If each diode gives a light gain of 100, a set of three gives a light

—*continued on page 358*

LETTERS TO THE EDITOR

SPECIAL NOTE: Will readers please note that we are unable to supply Service Sheets or Circuits of ex-Government apparatus, or of proprietary makes of commercial receivers. We regret that we are also unable to publish letters from readers seeking a source of supply of such apparatus.

The Editor does not necessarily agree with the opinions expressed by his correspondents.

CONSTANT FUSE BLOWING

SIR,—Here is a fault that may be of interest to other readers of this journal.

I had a Ferranti T1084 which suffered from "blinking" and fuse-blowing. When it blew a fuse I tested from the fuse holder to chassis and found everything quite normal. Another fuse was fitted and this blew straight away and still no fault could be detected on test.

I disconnected the fuse holder from the set and on doing so, noticed that although the rivet on this was well recessed, the cavity was covered with black powder. This I assume was the material that had been building up until it was of sufficient composition to blow the fuse. After this fuse holder had been cleaned and put back in the set, I found that the problem of "blinking" had also been solved.—J. TURNER (Bletchley, Buckinghamshire).

THIS WAS THE PROBLEM

SIR,—With regard to "Your Problems Solved" in a recent copy of PRACTICAL TELEVISION there is a query relating to the burning out of a line-output transformer in a Philco 1000.

I had a similar case with a Philco 1000, but which I did not bother to replace as the set was on its last legs. In this model the loudspeaker leads dangle from the printed circuit board mounted across the top of the case, and loop round to the loudspeaker mounted on the right-hand side, in so doing they can sometimes rest on the windings of the l.o.t., and if the insulation is poor (they are rubber covered cables) arcing can take place, which causes the burn-out.

Therefore before replacing the l.o.t. it is essential that the leads be re-routed away from the l.o.t. or the same thing may happen again.—J. E. EDMANDS (Whitchurch, Bristol 4).

BUSH TV135/138

SIR,—I would like to pass on some information concerning the above-mentioned Bush TV receivers.

More often than not, line sync trouble is caused by flywheel sync diodes. Usual symptoms are a vertical line down the screen that cannot be moved by adjustment of the line hold. Also, the line oscillator stops after the set has warmed up.

When it comes to replacing these diodes, fit Westinghouse WX6 or 39K2 types, as these seem more reliable than the originals. These same diodes can be used if the field clipper needs replacing.

If lack of field sync is experienced, only on BBC-2, suspect the screen decoupling capacitor (2μF) to the video amplifier. On early models, this was fitted immediately above the PFL200 valve and a replacement should be fitted on the reverse side of the printed circuit board.

If "lock-out" on strong 625 signals is evident, Bush offer a kit to overcome this problem.—L. ALLSOPP (Cardiff).

MURPHY 929 MODS

SIR,—In your article in the Oct./Nov. issues of PRACTICAL TELEVISION on the Murphy TV type 929 the power supply circuit was given as in Fig. 1.

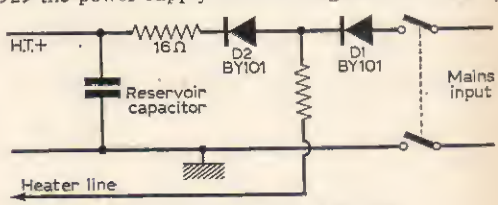


Fig. 1: The original power supply.

If diode D1 developed a short-circuit the heater line would rise in voltage causing the valves to be over-run. You state that to prevent this, the screen of the sync separator valve is fed from a tap on the heater line and uncontrollable frame hold would occur if the heater line became a.c. This would lead to a call for service and the overdriven valves noted.

There is a further possibility which does not appear to have been recognised. Recently we had a TV for repair which had been running for some time with an over-run heater line. This was caused by a short-circuit in D2. This had the effect of connecting the reservoir capacitor to the junction of the two diodes and raising the heater line to greater than 250 volts. As the valves were still d.c. heated due to D1, the "safety device" did not operate and the valves were over-run until the line-output valve failed. After replacing this and D2 it was necessary to replace other valves which had lost their emission due to being over-run.

To obviate this fault we strongly recommend that the circuit be modified to that of Fig. 2.—C. G. WEEKS, F. A. BAILEY (Pontypool, Monmouthshire).

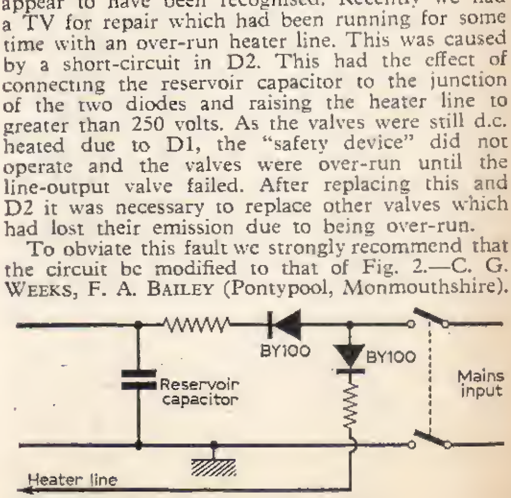


Fig. 2: The modified circuit.

fault finding

PART 2

SOUND-ON-VISION

BY S.GEORGE

THIS common fault probably leads to more instances of pointless i.f. slug adjustment than any other defect, for in almost all cases the cause of the complaint is not misalignment but wrongly set user controls, defective components or faulty valves. Only extremely rarely do i.f. transformer cores materially drift from their original settings, and till proved otherwise their adjustment must be considered correct.

However, should alignment be suspected as being incorrect due to inexpert adjustment, checking Test Card resolution and physical inspection of the cores will soon confirm or disprove the suspicion. On Test Card reception if both sound volume and picture definition peak at the same fine tuner setting and the high frequency gratings are well reproduced with little ringing and with outlines clear cut it is safe to assume that the alignment is within acceptable limits.

Where, however, sound-on-vision is caused partly or wholly by insufficient a.g.c. bias, thus permitting the controlled valves, especially the r.f. amplifier, to run at full gain, it will be difficult to make a fair assessment due to the resultant overloading. In such cases, therefore, the best way of checking is to operate the set from an indoor aerial sited so as to just comfortably drive the picture to optimum contrast and note if the above Test Card requirements are present. In many instances it will be found that the sound-on-vision is caused by signal overloading and vanishes when the receiver is fed with a reduced input.

Sound-on-vision symptoms can be divided into two categories and when investigating complaints it is vital to note which type is present immediately. The first and by far the most common is evident irrespective of volume levels, while the other is dependent on the volume control setting, often reducing to negligible proportions when the volume is low.

To take the former and main type first. In most instances this trouble in modern high-gain receivers will be found to be due to an over advanced preset sensitivity control resulting in front-end cross-modulation. These preset controls are miniature potentiometers usually mounted on the printed circuit i.f. panel, close to the common first i.f. stage and often indicated by adjacent lettering or by a diagram pasted inside the cabinet. Attendant symptoms with sound-on-vision produced by cross-modulation—and there nearly always are coincident symptoms with sound-on-vision—are an excessively contrasty picture with a possible tendency towards vision-on-sound "buzz", according to picture content.

If adjustment of the preset fails to clear the trouble and it appears that such adjustment produces little if any variation in gain, however, the most likely conclusion is that there is insufficient a.g.c. voltage, since these sensitivity controls generally set the delay point at which a.g.c. is applied to the r.f. amplifier valve. Naturally it is important to make this adjustment on a strong input signal when a correspondingly large a.g.c. voltage is developed. Absent or greatly reduced bias to the r.f. amplifier will instigate sound-on-vision that cannot be eliminated later.

The idea behind a.g.c. delay, which is almost universally employed in modern receivers, is to apply a.g.c. directly and in full to the i.f. stages and thus keep the r.f. stage free of bias to maintain the best signal-to-noise ratio for weak signals, then gradually applying a.g.c. to the latter when the strength of the incoming signal would otherwise overload and/or introduce cross-modulation. In this connection it is an interesting experiment to vary the settings of the contrast and preset sensitivity controls in a receiver and note the effect on signal-to-noise ratio as their relative settings are varied. It will be found that decreasing front-end sensitivity by decreasing the delay potential will increase the noise level, but that increasing front-end sensitivity by holding off the a.g.c. bias for maximum delay introduces the tendency to cross-modulation on strong signals. The term "delay" used in this connection is somewhat of a misnomer, for it does not refer to any time difference but to the fact that the application of a.g.c. is held off or delayed till the signal reaches a predetermined value, the actual voltage being determined by the preset sensitivity control.

Insufficient or zero a.g.c. voltage, allowing the r.f. amplifier to operate flat out, can of course spring from many causes, for instance a short from the actual a.g.c. rail to chassis, an open-circuit a.g.c. feed resistor, or a defective sync separator or video amplifier stage since almost universally the source of the a.g.c. supply is the negative voltage developed in the grid circuit of the sync separator valve. In all 405-only, and in most dual-standard models on v.h.f., the video amplifier is directly fed from the video detector and therefore biased well back to accommodate the positive-going video signal. The lowest amplitude sections

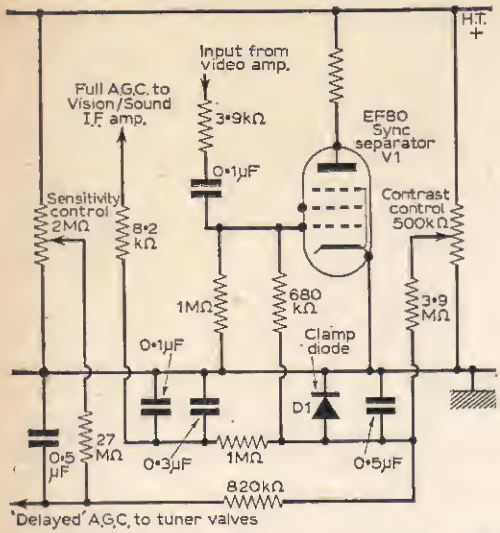


Fig. 5: Typical contrast control system of a modern dual-standard receiver. The potential on the a.g.c. rail is determined by the amplitude of the negative voltage at V1 grid and the setting of contrast control. A.G C. is not applied to the tuner valves till it exceeds the delay potential tapped off via the sensitivity control. Over advancement of the sensitivity control is a common cause of sound-on-vision through cross-modulation in the tuner.

of the composite video waveform, the sync pulses and darker picture tones, will therefore be applied to the valve on or near the curved base of its Vg/Ia characteristic. Amplification at this point must be somewhat less than that given to higher amplitude (light picture tone) signals which drive the valve to the straight and more vertical part of its characteristic. The more nearly vertical the characteristic, the greater the "slope" of the valve and, other considerations being equal, the greater the amplification achieved.

Save for a tendency to produce a restricted tonal difference between black and near-blacks, however, this characteristic is not of great importance in video stage design. Should video valve bias increase beyond the original values, on the other hand, resulting in these lower amplitude signals and sync pulses being placed still further down the Vg/Ia curve, towards cut-off, amplification will severely suffer resulting in sync pulses of reduced amplitude and with little definable difference between black and near-blacks. If sync pulse amplitude is reduced so will be the negative voltage developed at the sync separator grid and therefore, also, the a.g.c. voltage.

Thus if the video valve becomes excessively biased, the following three symptoms will coincide: it will be almost impossible to separate the two darkest squares on the Test Card; sync locking will be impaired; and on strong signals the reduced a.g.c. voltage can introduce sound-on-vision. When present these symptoms are usually the result of a decrease in value of the bias stabilising resistor connected from the h.t. rail to the valve cathode, thus increasing the voltage drop and therefore the bias across the valve's cathode resistor. However, the possibility of an increase in the value of the actual cathode resistor must not be overlooked.

While the voltage developed across the cathode resistor will vary from one set to another, and can only be checked by reference to the appropriate service manual, it is always possible to make a quick check to see if the valve is being over-biased by paralleling the suspect with one of about 300-400Ω and noting if the three coincident symptoms listed above reduce. However if any of the resistors in the video cathode circuit are discoloured they are sure to have changed in value and their replacement should be automatic. As always, visual inspection can often save much actual diagnosis and voltage checking.

Should sound-on-vision be present with impaired sync but with normal picture tone gradation, the sync separator circuit and not the video amplifier could be at fault by failing to develop the normal negative grid voltage. The cause of this would lie in the grid circuit of the valve—a faulty grid feed capacitor or grid leak resistor.

If sync locking is normal but restricted or zero range of a g.c. control suggests a fault confined to the a.g.c. circuit alone, first replace all controlled valves since if any are drawing grid current this positive voltage can outweigh the negative a.g.c. potential. If their replacement fails to effect a cure it may be that there is a short on the a.g.c. rail

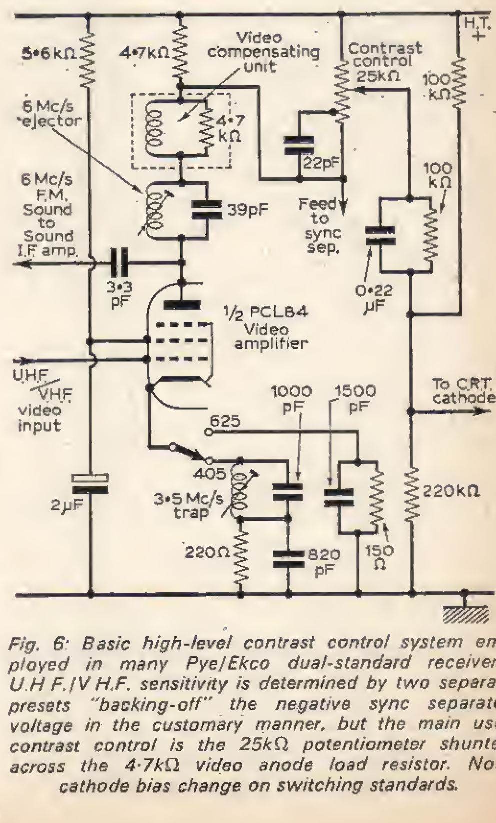


Fig. 6: Basic high-level contrast control system employed in many Pye/Ekco dual-standard receivers. U.H F./V H.F. sensitivity is determined by two separate presets "backing-off" the negative sync separator voltage in the customary manner, but the main user contrast control is the 25kΩ potentiometer shunted across the 4·7kΩ video anode load resistor. Note cathode bias change on switching standards.

to chassis. Naturally with a.g.c. voltages being so low actual failure of the associated decoupling capacitors is extremely rare and such short-circuits when present are usually due to shorting solder blobs on printed-circuit panels, or, often overlooked, a short-circuit in the a.g.c. clamp diode. This is the miniature diode (see Fig. 5) connected with its anode to the a.g.c. rail and cathode to chassis so that it will conduct should the a.g.c. rail actually go positive, thus clamping the rail to chassis. This risk, slight though it may be, is always present because in almost all sets contrast control is effected by backing-off the negative a.g.c. potential with a positive voltage tapped from a high value potentiometer connected between the h.t. rail and chassis. Even in those models made by the Pye/Ekco group which utilise high-level contrast control (see Fig. 6) separate u.h.f. and v.h.f. sensitivity presets operate in similar fashion, with the main user contrast control consisting of a 25kΩ potentiometer shunted across the 4·7kΩ anode load resistor. As the u.h.f. intercarrier sound signal is handled with the u.h.f. vision signal right through the vision strip to the anode of the video amplifier, high-level contrast control has the advantage that the amplitude of the sound signal is unaffected by user picture contrast changes.

Having eliminated excessive input or failure of a.g.c.—the most probable causes of sound-on-vision—and it is apparent that receiver i.f. alignment is within limits check whether the tuner unit adjustments are "out" and possibly over-emphasising the sound frequencies. In most tuners (see Fig. 7) there are several core and trimmer adjustments that may be made from the exterior and which if wrongly set can produce sound-on-vision even when the alignment of the actual receiver section is perfect. These are, in order of importance in this respect, (a) the i.f. output adjustment, (b) mixer grid coil, and (c) the cascode anode coil in the usual double-triode r.f. amplifier arrangement.

Undoubtedly the i.f. output adjustment is most important and usually most often maladjusted since it is generally easy of access without removing the chassis from the cabinet and is always mounted close to the i.f. output coaxial lead. Any core or trimmer that appears to be still sealed or firm in its setting however should be left severely alone: try others that may have been maladjusted for, as with receiver strip i.f. transformer cores, all

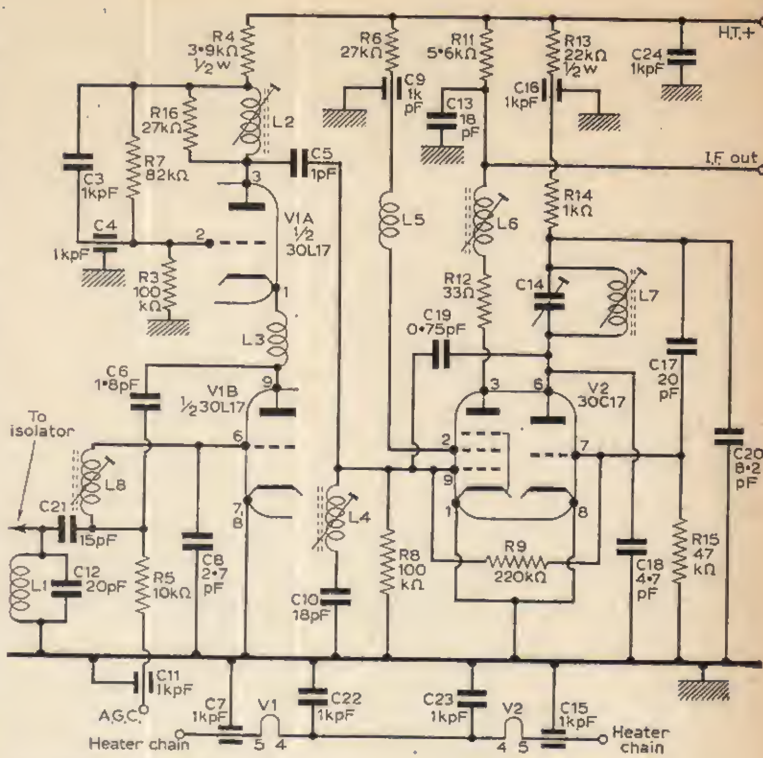
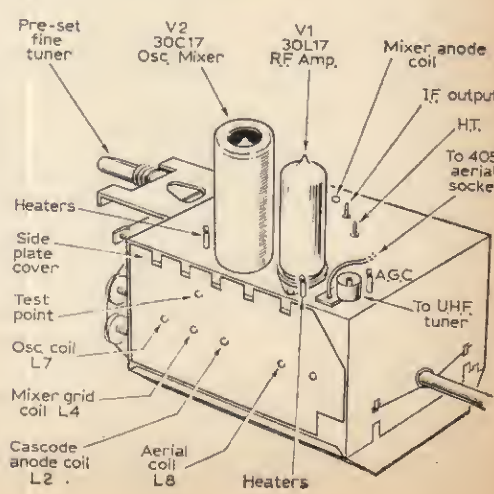


Fig. 7: (above) Circuit diagram of a modern v.h.f. turret tuner employing a cascode r.f. amplifier stage (V1) followed by a triode-pentode frequency changer stage (V2). The fine tuner C14 is preset. (Below) Layout of the tuner unit, showing access to coil adjustments.



factory set adjustments are sealed in one way or another so that actual drift is very rare indeed. Do not overlook the possibility that component value changes can occur, especially in miniature picofarad capacitors associated with the various coils, that can produce similar effects to misalignment.

Use only the correct non-metallic trimming tools to avoid damaging cores or delicate internal coil threads, making adjustments strictly on Test Card only, and repeatedly changing from Band I to Band III when making alterations to the i.f. output coil. Should any adjustments appear to have negligible effects, return them to a midway position. Use only a good outdoor aerial, for experience shows that most instances of tuner maladjustment stem from an effort to improve the gain or sound/vision balance from an inadequate signal input.

Finally as every receiver incorporates a sound rejector coil in the vision i.f. circuit it may be advantageous—having positively identified it, and I emphasise positively—to retrim it on the Test Card tone signal.

Of course all the foregoing remarks are only applicable to v.h.f. tuners. U.H.F. tuners must not be readjusted in any way even by retailers' service departments, but must be returned *en bloc* to the manufacturers. Fortunately, sound-on-vision is almost exclusively a v.h.f. defect due to the completely different nature of the intercarrier signal and its coincident handling with the u.h.f. vision signal right up to the video stage.

The second type of sound-on-vision, that which can be eliminated by reducing volume, is really a symptom of a microphonic valve or deficient a.f. decoupling capacitor. Naturally replacement of the suspect valves must be the first step, although in most instances a tap on the glass envelope of the faulty valve will soon show up any microphonic tendencies. However a perfectly sound i.f. valve with impaired decoupling and close to oscillation will produce symptoms hardly distinguishable from those of a truly microphonic valve, for it will ring when tapped and be extremely sensitive to handling. The apparent microphony results from the fact that tapping the valve slightly varies electrode spacing and thus the valve's characteristics. In most cases the basic cause is a dry-jointed or open-circuit anode, screen or cathode decoupling capacitor, easily found by bridging each suspect in turn with a good replacement.

If valve replacement fails to effect a cure the only remaining possibility is an open-circuit or heavily reduced capacitance electrolytic decoupler in the h.t. supply circuit to the a.f. valve or valves. Some early 17in. Bush receivers were prone to this defect, but when it occurred the resulting slight increase in hum level made diagnosis easy.

TO BE CONTINUED

IMAGE INTENSIFIERS AND CONVERTERS

—continued from page 353

gain of 1,000,000. This approach has proved possible, but it is extremely difficult to obtain good resolution over the whole picture, the problem of interference between phosphor and photocathode still exists, and the glass and plates introduce lens distortions. American researchers have used end plates of glass fibres fused together to form a perfect non-distorting lens, but these have the disadvantage of transmitting less light and being extremely expensive.

The other approach to the phosphor-photocathode method of intensification has been perfected by EMI in their type 9694 image intensifier (Fig. 6). In this tube the photocathodes and phosphors are deposited on opposite sides of circular mica sheets, and three such sheets are incorporated in one tube. The interaction between phosphors and photocathodes has been avoided in a characteristically ingenious way. Two of the mica targets are arranged so that they can be turned round within the tube (by using a magnet) to have their photocathode surfaces facing each other. In this positon the photocathode is deposited on two surfaces at once, and the phosphor surfaces are screened by being turned away. Preparing the photocathode involves alternate evaporation of antimony, caesium, potassium and sodium vapours, and these are introduced through side tubes which are later sealed off. When the photocathodes have reached the desired sensitivity the tube is sealed off from the pumping system and the side tubes are sealed off from the main tube. At this stage the two mica discs can be turned back again and locked in place.

Although practically all the image converters and intensifiers produced to date have been used for research, either in nuclear physics, spectroscopy, or astronomy, their effect on television should not be ignored. With the tubes which can now be made, there is no such thing as an "untelevisable" scene. Using the image converter, human bodies may be televised by using their own body heat. Using an intensifier, the only limitation on the level of light (or rather dark) which can be used is the requirement that enough electrons should leave the photocathode to build up a complete picture within a field time. This restriction may seem an incredible one, for a current of one microamp represents ten million million electrons leaving the photocathode every second, but it is possible with an image intensifier to see individual spots of light due to the emission of single electrons from the photocathode.

It is no exaggeration, then, to claim that we can now televise anything from the disintegration of a single atom to the formation of a distant galaxy. ■

DX-TV

—continued from page 349

We have another C/DX report, this time from J. Eyre of Chelmsford who had colour pictures from W. Germany (Torfhaus) Ch.23, and Aachen Ch.27, also Holland Lopik Ch.27. For monochrome DX, the log includes W. Germany Monchau Ch.21, Aachen Ch.24, Dortmund Ch.25, a "new" one Hochsuerland Ch.27 (we are looking into this not listed as yet), Feldburg Ch.34, Marienburg Ch.47, and Feldburg Ch.54. For France he has Lille Ch.21, and Mezières Ch.23, in all a very nice log for 29/2/68.

More C/DX this time from J. Ferguson of Sheffield on 28/2/68 who had good colour reception from Holland Lopik Ch.27 and a number of unidentified W. Germans between Chs.21 and 35. D. Richard of Stafford also had Dutch colour from Lopik Ch.27, and several other unidentified stations.

OLD & NEW
AT THE
IDEAL HOME EXHIBITION

Radio Rentals stand features Baird Museum and commercial colour TV

AT this year's Ideal Home Exhibition at Olympia, the public were able to see what commercial colour television will look like when it eventually comes.

Radio Rentals' engineers and their Baird colour experts had compiled a special commercial-type programme in colour and of the type expected to be produced by the Independent Television contractors for screening within the next few years. Also, visitors were able to see an adventure in the Avengers series which was screened in colour.

A film about Trinidad and Tobago was shown together with films about painting through the ages and the working of the motor car. A cartoon film, with Donald Duck, explained in layman's language the workings of colour TV.

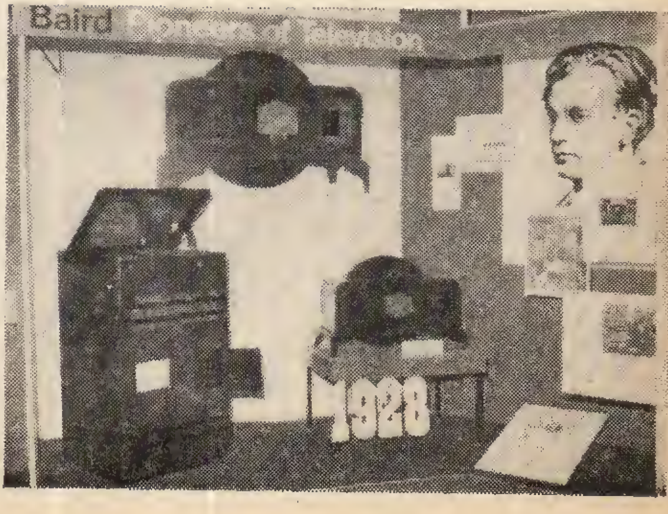
Colour advertisements for cheese, butter, drinks, cars, banks etc. were also shown.

In the Baird Museum on a part of the Radio Rentals' stand, visitors were able to see how television has developed over the years. There was a 1936 Baird receiver with an upright mounted tube and a mirror in which the picture could be viewed, together with a model of an original Baird 30-line receiver of 1928 vintage. This used rotating discs for scanning, the principle being described by H. W. Hellyer elsewhere in this issue.

Here can be seen part of the £70,000 Baird control room which was responsible for putting out at the same time two colour programmes (BBC-2 and a simulated commercial show complete with advertisements). Third from the left is the Baird Chief Development Engineer, Bill Elliot.

First TV play

On the mock-up of this model, see our photograph, a shortened version of Pirandello's *The Man with the Flower in his Mouth*—the very first play ever put on television—was shown. This play was produced in 1930 by Lance Sieveking, and was recorded recently by some Inner London Education Authority teachers on a 30-line TV camera made up of original Baird parts.



The Baird exhibition of the development of television over the years. On the left is a pre-war television receiver with the mirror viewing screen. This receiver was working in conjunction with a closed-circuit television camera mounted on the top of the Baird stand.

On the right, arranged around the picture of John Logie Baird, can be seen reprints from pages of "Television"—the journal of the then Television Society—describing the processes of early television transmission and reception.

TELEVISION RECEIVER TESTING

Part 1

THIS new series of articles will concentrate not too much on the actual servicing of television receivers as on the ways in which the various sections of the receiver and the voltages, currents and signals therein can best be tested. It is thus a series essentially on testing rather than servicing. While, however, the series will reveal the test procedures adopted by the professional service technician, it will also very much highlight less scientific methods of testing that can readily be practised with the basic minimum of equipment by the enthusiastic amateur and which are practised by the professional *field* service technician whose job it is to locate the fault in the shortest possible time with little more than a wet finger, a multi-range testmeter and an intuitional sense developed from years of servicing experience.

Moreover, since one must have a fair idea of where in the receiver complex a fault lies—as indicated by the symptom—in order to perform a series of logical tests, the series will have a strong bias towards providing information on fault diagnosis as well as on testing. For instance, one must know that the trouble lies in the field timebase when the symptom is a bright, horizontal line on the screen in place of the picture, and that testing must be directed to that section, there being absolutely no point at all, for example, in testing, say, the aerial signal!

In some cases, therefore, sound and vision symptoms will be used as pointers for testing in the various sections, while in other cases the nature of the testing will be directly related to the symptom. Let us take the first test, which is that for aerial signal. What symptoms would lead us to check this?

The main ones (there are others as we shall see) would probably be snow-covered pictures on one or all channels and poor, interference-laden or "hissy" sound. The reasons for these symptoms are as follows. Any television set generates its own signals, called noise signals, mostly in the tuner, and these show on the picture as background grain and accompany sound as a hiss when the strength of the aerial signal is below the level necessary to mask them. The ratio of aerial signal strength to noise signal strength is called the signal-to-noise ratio, and to obtain noise-free reception this ratio needs to be at least 200 to 1 on monochrome transmissions and 300 to 1 on colour transmissions.

Clearly, then, a grainy picture and hiss on sound would first call for a test of aerial signal. It may only be one channel that suffers in this way, and the most vulnerable is a u.h.f. channel in Bands IV or V, carrying the BBC-2 programmes. Figure 1 shows a typical BBC-2 noise symptom caused by a weak aerial signal. V.H.F. channels, carrying BBC-1 and ITV, are less affected by noise effects for two reasons: (a) because v.h.f. signal fields are generally stronger in fringe areas than u.h.f. ones and (b) because the set itself generates a stronger noise signal on the u.h.f. channels than on the v.h.f. ones.

The best way of testing aerial signal is by means of a signal-strength meter. This has a moving-coil meter movement calibrated directly in terms of microvolts and millivolts. The meter is activated from a detector or signal rectifier which is fed from tuned and amplified signal injected from the aerial downlead. The front-end of the instrument is, in fact, very similar to the front-end of a television set, and instruments designed to measure u.h.f. as well as v.h.f. signals are usually equipped with two tuners in the same way as a dual-standard television set.

Some models, though, are specially designed to tune continuously over Bands I, II, III, IV and V; an experimental model is shown in Fig. 2,

Fig. 1 (left): A noisy Band IV colour test card due to a weak aerial signal.

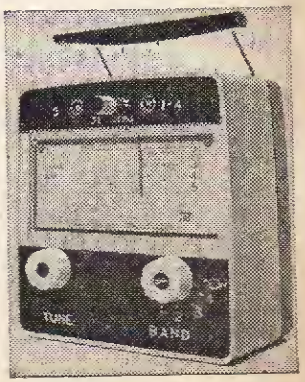
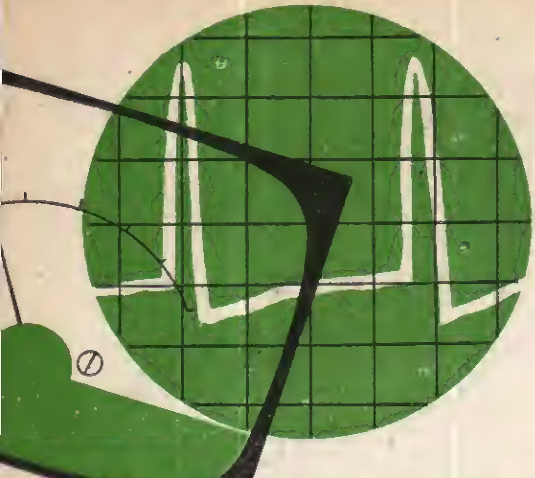


Fig. 2 (right): Experimental all-Band transistorised battery-operated signal-strength meter.



by Gordon J. KING

designed by John Fielden. The read-out meter is located at the bottom left-hand corner of the dial, the top sections of which are calibrated over the five bands just mentioned. This is a transistorised instrument and the meter pointer is first set to zero by the knob at the top on the required band as selected by the right-hand knob, and the required channel tuned by the knob on the left. This causes the pointer to deflect from its zero setting to read-off the signal voltage direct.

There are many variations of this kind of instrument, many of which are in current production and readily available, and the vast majority of them work along the lines shown by the block diagram in Fig. 3. Here the tuner produces an intermediate-frequency signal from the vision input signal as tuned-in, and this is amplified in the i.f. channel and then applied to a signal rectifier. The magnitude of the d.c. voltage produced by the signal rectifier is thus related to the amplitude of the i.f. signal and hence to the aerial signal. This d.c. voltage is fed back to the i.f. amplifier as a bias, and the stage which receives this bias has its anode or collector current read by the meter. When there is no bias (i.e. zero aerial signal) the meter has a maximum deflection which is adjusted by the set-zero control to read zero signal voltage on the calibrated scale. When a signal is applied from the aerial the bias produced by the rectifier causes the i.f. channel current to fall by an amount depending on its strength, and this is indicated by the meter in terms of aerial signal voltage. Thus a very strong signal will almost completely bias-off the i.f. channel and give towards zero current reading on the meter, this condition corresponding to *maximum* aerial signal.

Owing to the curvature of the characteristic of the valve or transistor which is controlled by the d.c. bias, the meter has a non-linear deflection which shows by low-amplitude signals being expanded, so to speak, at one end of the scale and high-amplitude ones being compressed at the other end. To some extent this is desirable because it allows small amplitude signals—often down to about $10\mu V$ —to be indicated.

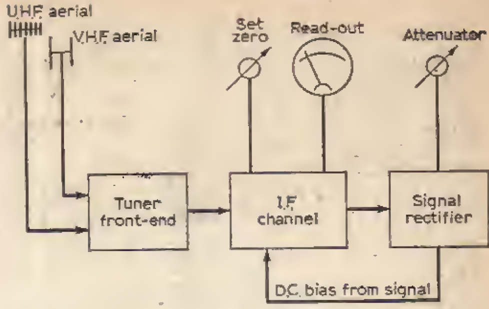


Fig. 3: Block diagram of the arrangement used in the majority of signal-strength meters.

To provide more accurate read-off of higher amplitude signals, however, many signal strength meters incorporate an attenuator either in the d.c. bias circuit from the signal rectifier (Fig. 3) or in the aerial input circuit (sometimes in both positions). This idea puts the higher-amplitude signals at the higher-curent end of the i.f. channel's controlling characteristic. An aerial attenuator also avoids overloading in the tuner or i.f. channel. Figure 4 shows the basic nature of the non-linearity of this type of meter.

This, then, is the professional way of testing signal strength, but even when a signal-strength meter is available one must have an idea of what represents the *minimum* signal strength for good reception. This, of course, is very much governed by the sensitivity and noise performance of the set, but based on a set of average performance, made within the last two or three years, Band I v.h.f. channels require about $300\mu V$, Band III v.h.f. channels about $500\mu V$, Band IV u.h.f. channels about 1mV and Band V u.h.f. channels about 1·5mV. A good set fed with inputs at these sort of levels will be working just about on the subjective noise threshold, meaning that the aerial signal is just about strong enough to balance the set-generated noise signal.

However, a set whose sensitivity and noise performance are impaired for any reason—because, for instance, of low-emission tuner valves or misalignment—will require aerial signals of greater strength than those specified—often twice the strength or more—to produce the same noise performance. A set working through a good low-

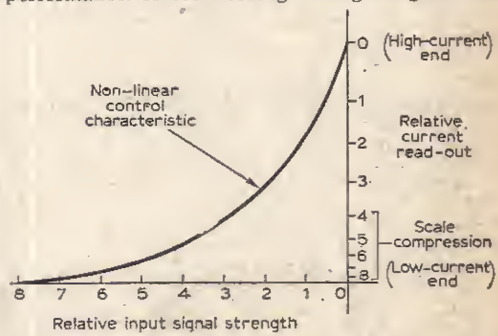


Fig. 4: How the scale is compressed at the high-signal, low-current end of the characteristics and expanded at the other end.

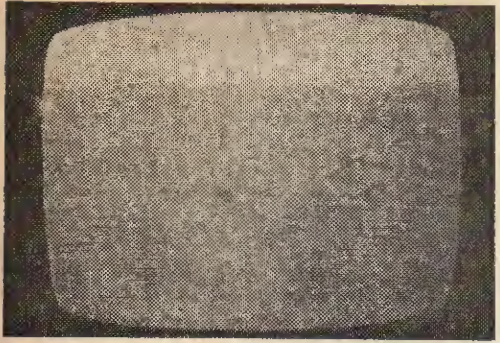


Fig. 5: A noise-laden raster like this should be expected when the set is without signal or switched to a blank channel.

noise aerial preamplifier might well, on the other hand, yield a comparable performance with signal strengths half those specified, especially if the preamplifier uses transistors and the set's tuner valves.

Colour sets generally need a signal about 50% greater than that required for monochrome to yield a similar subjective noise performance. Thus such a set working on a Band IV channel would need a minimum of about 1·5mV and on a Band V channel a minimum of about 2·25mV.

The greater signal-strength requirements of the higher frequency channels are reflected in the greater complexity of u.h.f. aerials compared with their v.h.f. counterparts. While this is in part due to the increase in noise signal with rise in channel number, it must also be borne in mind that for a given field strength the e.m.f. induced at the centre of a half-wavelength dipole decreases as the frequency is increased. This is one of nature's laws which is based on the fact that to keep the dipole in tune its length must be reduced as the signal frequency is increased. Compensation is provided, however, by the gain of each array rising progressively from low to high channel numbers or, at least, from low to high Band numbers, which is why u.h.f. aerials feature a greater number of elements than their v.h.f. partners, and why Band III aerials have more elements than Band I aerials.

In so-called areas of minimum protected field strength, the gains relative to a half-wavelength dipole expected from normal commercial aerials in the four television bands are Band I 3dB, Band III 6dB, Band IV 10dB and Band V 12dB. It is not intended here to delve into ways and means of improving the aerial signal, since this subject was covered in the March 1968 issue, under the title of "Obtaining the Best Signal", and readers who feel that their poor reception might be caused by a weak signal should refer to that article.

We are concerned right now with how to measure or test for aerial signal. So far we have seen that an absolute measurement requires the use of a signal-strength meter, but not many of the enthusiasts among our ranks will have such an instrument sitting around waiting to handle the odd signal-strength test! So most of us will have to devise some other scheme for testing.

Let us suppose that we are faced with noisy reception (Fig. 1) on all channels. This could be caused by trouble in the aerial or trouble in the set. A signal-strength meter, of course, would soon prove which is responsible; but if such a meter is not available the next best thing is either to test the performance of the suspect aerial system with a friend's set or the suspect set on a friend's aerial system. This will certainly prove whether or not a weak aerial signal is responsible for the noisy reception. The same test can be adopted if only one channel is affected, for something could happen to one aerial only or to the diplexer if used, but it must be realised that it is perfectly normal for an unmodulated raster to display a background of grain. This happens when the aerial is removed from the set or when the set is switched to a blank channel, especially a u.h.f. one, as shown in Fig. 5.

Some field service technicians carry in their kit a set-top aerial as an aid for testing suspect aerials. If, for instance, the symptom is a noisy picture, it is quite a simple matter to plug in the set-top aerial to see whether this gives a better or worse performance. Of course, under normal conditions the performance of the set-top aerial would be well below that of the proper aerial system, especially if roof- or chimney-mounted, so it would be fairly definite that the main aerial is at fault if the set-top aerial provides equal or better reception than the main aerial.

The author has found that simple dipoles made of ordinary stranded, insulated wire tuned to the local channels and loaded into coaxial cable at their centres are even better than a set-top aerial for determining the efficiency of the main aerial. These can easily be hooked around the room or even stuck to windows with suction pads, and since they are tuned they provide a better comparison signal than most set-top aerials. Dipole lengths are given in Table 1.

Most television sets can be arranged in con-

TABLE 1
TEST DIPOLE DIMENSIONS FOR HALF-WAVELENGTH WORKING

Channel or Group	*Dipole Length (in.)*
1	127
2	111
3	101
4	92
5	85
6	31·5
7	30
8	29·5
9	29
10	28
11	27·5
12	27
13	26·5
A (red)	10·8
B (yellow)	8·45
C (green)	7·15

Coaxial cable should be connected in the physical centre in the ordinary way.

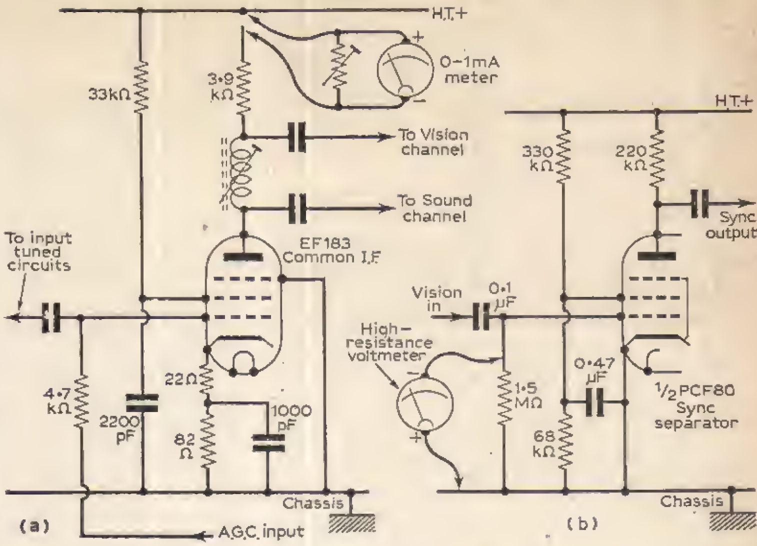


Fig. 6: Testing for relative signal strength in a receiver (a) by indicating the change of current in a controlled stage, and (b) by indicating the change in negative potential across the grid leak resistor of the sync separator valve.

junction with a meter to provide, at least, comparative signal-strength tests. The most convenient set-up is shown in Fig. 6(a). Here is shown the common vision-and-sound i.f. amplifier stage, with a.g.c. bias fed to the control grid. Now, the idea is to read the anode current of the valve by interposing a milliammeter in series with the *top* of the anode circuit, as shown. Since the deflection of the meter is more important than the actual anode current reading, a variable resistor is connected across the meter, and this is adjusted to give full-scale deflection when the aerial is removed from the set. Thus when the aerial is connected and the set tuned to the required channel the valve will be biased by the a.g.c. potential and the anode current reading will fall, the *amount* by which it falls being a measure of signal strength. This, of course, is the practical arrangement of the scheme shown in Fig. 3 block diagram.

An alternative arrangement is shown in Fig. 6(b), but here it is the voltage developed across the grid leak resistor of the sync separator valve that is measured. This voltage goes more negative as the input signal amplitude increases, and is generally the source of the a.g.c. bias. It is rather difficult to achieve a set-zero feature in this part of the circuit, though, but if a valve voltmeter is used for the read-out this can be set to a zero reference by its own set-zero control, and then all deflection in a negative direction is attributable to signal strength. Since the voltage across the sync separator grid leak resistor is not very high at the best of times, and since the impedance or resistance is also high, it is necessary to use a sensitive, low-reading meter for testing or comparing signals by this means.

Neither arrangement provides an absolute signal value read-out, but the set-up in Fig. 6(a) could be calibrated against a signal-strength meter if such an instrument could be borrowed for a couple of hours. An input signal from a generator would also be needed to calibrate in steps from very low to very high signal inputs.

The author has fitted a 2½in. 1mA meter movement to the top of a 9in. portable set, wired as shown in the circuit. The meter was calibrated against the standard of a professional signal-strength meter, and the set-up has proved of immense value for checking the actual aerial signal strength while at the same time monitoring the picture on the screen for spurious interference effects and ghosting troubles which the meter itself would fail to reveal. This has been used for field surveys to establish sites for television relay master aerials.

It should be noted, however, that it may be desirable to change the fixed cathode bias resistor on the controlled stage (i.e. the 82Ω resistor in the circuit) to a variable one. This can then be used for zero setting while that across the movement (which can be a preset) is used for padding so that full-scale deflection is achieved with the set-zero cathode variable at range centre—that is, of course, with zero input signal.

A very good idea of the balance between the aerial signals over the various channels can be gleaned by the arrangement at (a) or (b) in Fig. 6. If the deflection is substantially the same on all channels, then one can be pretty sure that the gains of the aerials increase progressively from the low to the high channels, as already detailed. If, on the other hand, the Band III deflection is half the Band I deflection, and bad noise is troubling the Band III channel, then attention should be directed towards improving the Band III aerial signal until the deflection is equal to that of the Band I channel, either by re-orientating the aerial or employing one of greater gain. If, however, unbalance *is* revealed but there is no apparent Band III noise, the set's a.g.c. system is compensating for the unbalance automatically.

Sometimes, though, a signal of excessive strength can cause overloading, shown by the symptoms of sound-on-vision and vision-on-sound, which cannot be tuned out. If such symptoms are present on Band I but not on Band III when the degree of unbalance is as just mentioned one can be fairly sure that the twice-as-strong Band I signal is overloading the set. In this event steps should be taken to attenuate the Band I signal until the Band I deflection is no greater than that on Band III.

TO BE CONTINUED

VIDEO TAPE RECORDING

PART 8

H.W.HELLYER

VIDEO tape recording has many advantages in education, industry and commerce, not the least of these being its use in the closed-circuit television field. Regular readers of PRACTICAL TELEVISION will be no strangers to this branch of the subject. During the past ten years tremendous advances have been made and some applications undreamt of when television broadcasting first became widespread are now part of our everyday life. The watching eye in the supermarket; the police supervision of busy crossroads; several classes of students sharing a single hard-pressed tutor, often miles away; a white-collared technician calmly watching the fury of some furnace from the safety of his desk; even the producer whose bank of monitors in the control room has become familiar to television viewers: all are versions of the closed-circuit method. And all depend initially on the seeing eye—the camera.

There is no need to go into any great detail on the subject of the principles behind camera design, though this will not prevent us indulging a penchant for passing on items of odd information, and nothing could seem odder to modern eyes than the original arrangement used by Baird to achieve his flickering electro-mechanical image. Baird worked on the problem of converting light into electric signals and back. It was as straightforward as that and like most simple ideas amazingly hard to develop. Friese-Green had already established the technique of cine-film presentation, but Baird saw that the transmission of information would always involve bulky transportation problems as long as film was the medium. He wanted to adapt the cinematic technique to the conventional medium of wireless transmission, so at some point there had to be a transducer to convert the observed image to electric signals, and some similar transducer was required at the other end to change the signals back into light variations to produce an image.

The photocell is one obvious form of transducer for this purpose, and Baird experimented with these, allying them with the Nipkow disc, a large, flat plate containing a spiral of small holes working inward from the periphery. Eventually he managed to focus the reflected light from his subject in a regular enough pattern to be transmitted and reproduced. A brief look at the closed-ciruit method he demonstrated will help to underline our subject. As shown in Fig. 27 the Nipkow disc was mounted on a horizontal axis and turned by an electric motor. As each hole "scanned" the subject the light from a small area was focused on the photocell, boosted by an amplifier and the resultant signal used to vary the output of a lamp. This lamp could then as shown be placed behind a similar Nipkow disc so that a viewer, strategically placed to see the holes through the lens, would receive an impression of the original subject. The limitations were awsome. To begin with the system relied on persistence of vision. The speed of the disc's rotation traced out a line of the image as each hole swept diagonally across the viewing space, and as persistence of vision lasts for about a tenth of a second sharper image tracing, which would need shorter periods, would tend to become blurred when eventually viewed. More than this, the photocells themselves have some persistence or lag in response, as also does the lamp, and mechanical speed regulation is an additional problem to be overcome to prevent further blurring of the image. To make matters even worse Baird employed audio amplification systems for his closed-circuit arrangement so that the available bandwidth, about 11kc/s, prevented any detailed resolution of a large-screen picture. We have seen in earlier sections how important the "dots per second" factor is in obtaining a reasonable television picture.

Small wonder then that Baird's efforts were succeeded by purely electronic techniques, which brings us to the alternative transducer and the concept of the television camera. It is a long step from the three-foot diameter disc whose outer edge was spinning at some 600 miles per hour to the sophisticated electronics of the six-camera set-up of the Ranger Spacecraft which recently took those revolutionary pictures of the moon's surface, yet the principle of the modern camera is much the same as those used in the early days of TV.

Television cameras vary widely between the tiny, hand-held types such as the

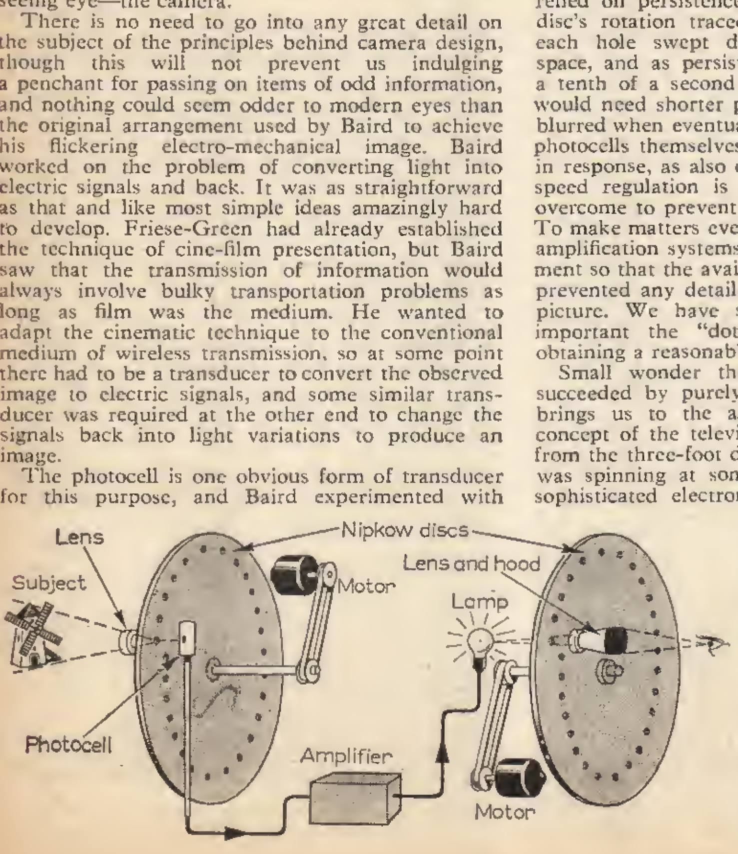


Fig. 27: Primitive closed-circuit TV involved rapidly spinning discs, photocells, lenses and a limited bandwidth amplifier.

Shibaden HV-50, which weighs only 2·7lb. and is smaller than many a cine-camera and certainly easier to use, right up to the motor-transported monsters we see trundling about the television studios. As we might expect, the tubes they use also differ, and to keep prices down to reasonable limits (£165 for the HV-50) the smaller types employ vidicon tubes. Larger cameras use image orthicon or Plumbicon tubes, costing many times as much, which have a number of advantages but also involve more stringent specifications in the associated circuits. We are only concerned here with the types used in closed-circuit and video recording apparatus so the discussion must be limited to the vidicon tube.

For convenience we may begin by regarding it as a kind of miniature cathode-ray tube since it has a heater to energise its cathode, uses high-voltage acceleration electrodes, and relies upon electromagnetic deflection for beam scanning. But at this point we depart from the analogy, for the vidicon receives a light signal which it converts to a series of electrical impulses—just as Baird's photocell did, in fact, but in a more precise manner.

The light-sensitive element (see Fig. 28) consists of a glass faceplate with a transparent conducting film on the inner side and then a thin layer of photoconductive material. In Fig. 28 this is shown in exaggerated form. The lens acts just as in any camera: in fact with the type of camera we shall use as an example, the Sony CVC2000B, the lens is a standard C-mount and several alternatives from the better-class photographer's stock can be fitted.

Light from the object viewed by the lens falls on the target—the layer of conductive coating—and an electron beam inside the tube scans the inside layer, moving diagonally across the target under the influence of the magnetic fields developed by the deflection coils. Just as in a receiver tube the beam is accelerated to its "striking point" by anodes at high potential relative to the cathode. In this case the final anode, just inside the target itself. is at 250 volts, creating an electrostatic field which, combining with the effect of the external focusing coil, helps to focus the scanning beam. (We must all be familiar with the defocusing effect of failing e.h.t. on our receiver tubes: the principle here is similar, and to regulate focus we have only to vary the current through the external focus coil

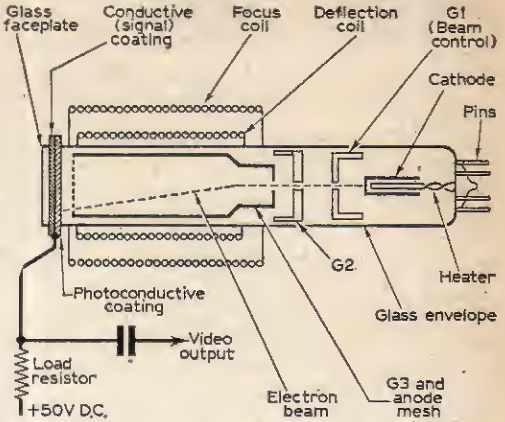


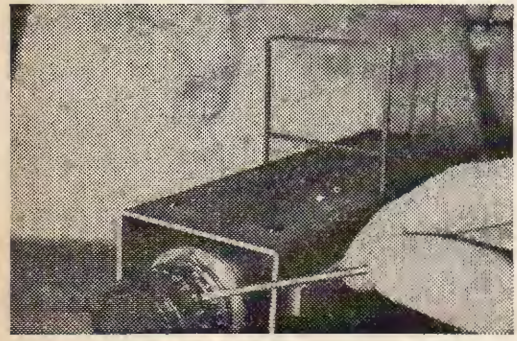
Fig. 28: Basic vidicon tube arrangement as used in most inexpensive closed-circuit and video tape recorder cameras.

by means of a manual control at the rear of the camera.)

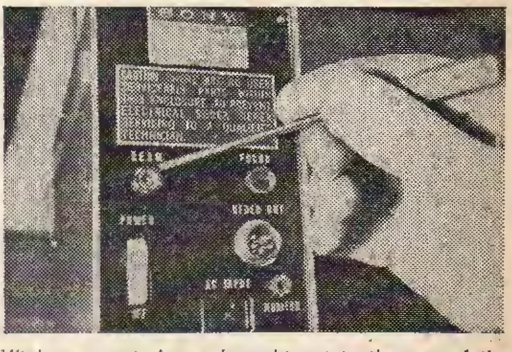
The other anodes, or more properly grids, are accelerators, the second also being fixed at a positive potential, of 300-350V d.c., while the first is supplied with a variable negative voltage, from 0-100V, and is used as a beam setting control with a preset also brought out to the rear of the housing.

If we regard the scanning beam as part of a series circuit consisting of beam, target, and load resistor at the "target-out" pin, the operation is easier to visualise. Changes in light intensity result in greater current flow because the photoconductive material changes its ohmic value with the light striking it. Resistance decreases and current rises in (for all practical purposes) inverse ratio to the increase in light intensity. As the beam is constantly scanning the face of the target the result is a signal across the load resistor which is in proportion to the light at any picture element that is scanned. Actual current output is very small, in the region of 0·2-0·4μA peak-to-peak, and this has to be amplified up to the required 1V by the video amplifier circuits.

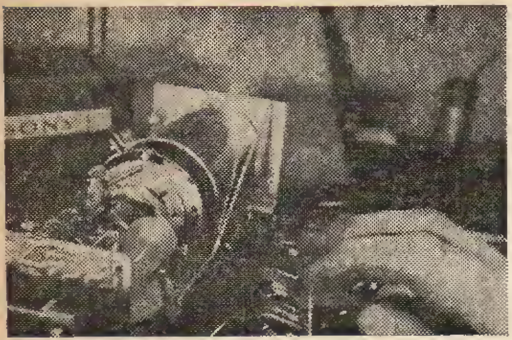
However, there are some important things to



Conventional stopping and distance setting is used in the C-mount lens of the Sony cameras.



Vital user controls are brought out to the rear of the camera. Beam control is a recessed preset.



View of camera with one panel swung out for service and adjustment.

consider before the signal is amplified. First, because the signal is so small we must take great care not to impair the signal-to-noise ratio; next, because we are dealing with video frequencies, the capacitances of the tube electrodes, structure, and related circuit must be taken into account. As the whole equipment is transistorised—the tube itself being the only thermionic item—the input transistor has to be particularly good, and although it is the same type as used in several other stages of the equipment it is actually chosen from a batch for its best signal-handling performance. It is connected in a grounded-emitter circuit and the input resistance is very high, so the vidicon tube can be regarded as a virtual constant current source. Its load and stray capacitances, all being well, should work out to about 10pF, and this is also the input capacitance of the transistor, allowing for the Miller effect. So, operating at an emitter current of some 150μA and a collector-emitter voltage of a little over 7V we shall get quite large high-frequency attenuation (almost -6dB at 100kc/s). This means that linear amplification is out of the question. Some compensation will be needed, not only to regain the higher frequencies but also to ensure that the middle frequency range is at the correct level relative to the rest of the signal.

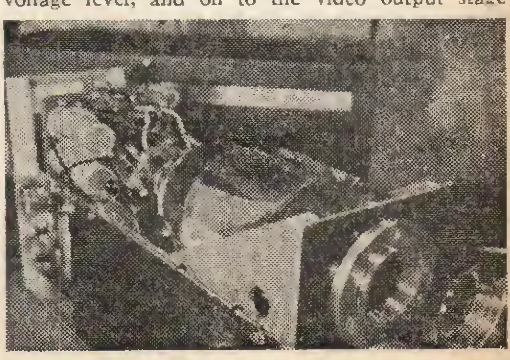
The middle frequencies, from 100-300kc/s, are the most important for TV picture quality. Poor middle-range response will give us eventual streaking. So the amplifier circuit contains a number of peaking networks not always obvious in their operation. Indeed the block diagram shown in Fig. 29 should be sufficient to demonstrate that there is a little more in this video amplification business than would appear at first sight!

After amplification by Tr1 and Tr2 the signal receives its first tailoring, a 500-ohm variable resistor in the emitter of Tr2 acting as middle-band compensation. This control is set when viewing the monitor screen for the clearest picture—in theory! In practice, it is too easy to oversharpen the monitor picture and then on playback to get evidence of ringing. There is a position when the right-hand edges of vertical lines just show overshoot on the monitor where the adjustment is at optimum, and playback circuits provide their own compensation. It is also necessary to practice a little with this kind of adjustment, especially if made on site, because to carry it out we have to swing one of the printed circuit boards out slightly, provide an earthing link, and then obtain access to the preset. In this condition, i.e., with the eventual shielding removed for service, external fields, especially strong broadcast signals, can cause beat effects that are apt to be disconcerting. You can twiddle all day and not get rid of them until you reassemble the camera!

Returning to our block diagram we next note another compensating device, a 68μH coil in the collector circuit of Tr2 which, in conjunction with the 100μF decoupling capacitor for the 8V rail of this section, provides some high-frequency peaking. More compensation is applied in the emitter circuit of Tr3 and the signal is then coupled to the base of Tr4, with yet more peaking in the collector circuit of this stage. At this point the amplification through the four stages should be sufficient to give us our needed 1V video signal, and the response should now be flat.

Two output paths split are taken from Tr4. The high frequencies are coupled to Tr5. This is to separate the d.c. component, which contains little noise—as usual "grass on the top" is what bothers us most. So the h.f. signal is passed via Tr5 and a noise limiter consisting of a pair of back-to-back diodes (see the section on noise limiting in Part 6 of this series, which dealt with the circuits of the main machine). The output, when a pair of diodes is connected like this, consists of positive and negative pulses with periods of zero voltage between and during this crossover period, the noise being suppressed. The resultant signal is fed via the wideband amplifier Tr10 to the mixing point. Here I must apologise for some simplification: the true mixing is done in a combination of Tr8 and Tr10 circuitry, not at a single point as illustrated—but the diagram makes the principle clearer.

Meanwhile back at the branch in the signal path the low frequencies have been fed from Tr4 via a low-band amplifier Tr7 and Tr8 to the mixing point, where they are mixed at a level some 10dB lower than the high frequencies. This is to give a sharper picture and to allow also for the effect of sync mixing which, it will be noted, also takes place here. We then follow the straight and narrow path through phase inverter Tr11, sync limiter Tr12 which clamps the sync tip at zero reference voltage level, and on to the video output stage



Showing the method of lens mounting and the external shield of the vidicon tube.

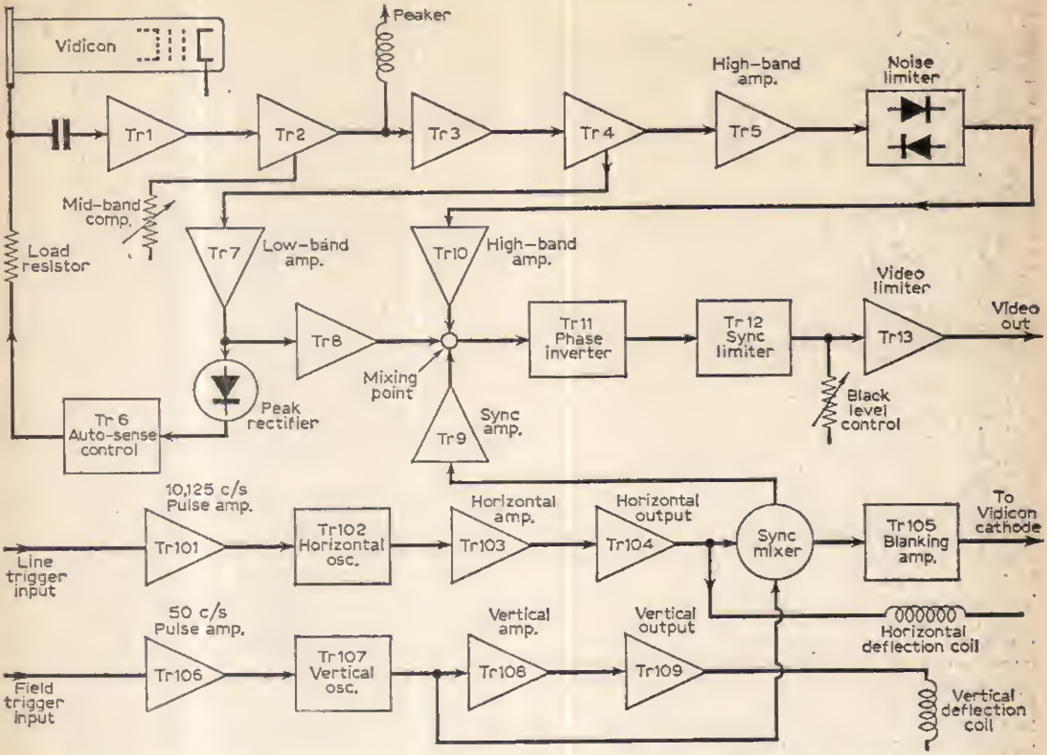


Fig. 29: Block diagram of the circuits involved in producing a video signal, correctly scanned at 405 lines, with free-running or triggered timebases, as used on the Sony CVC2000B camera.

Tr13. Some sync adjustment is necessary because of the cut-off effect of the base and emitter of this circuit, and a variable resistor acts as a black-level control at this point.

Next we require an automatic sensitivity circuit. This feeds back to the target part of the peak rectified video output tapped off at Tr7. With a vidicon operating over a light range of 6,000 to 1 and expecting a horizontal resolution better than 400 lines in the screen centre some automatic control is imperative. The range, with f1·9 lens, is from 100 lux to near infinity, for the benefit of the photographers in our midst. As an example of its practical effect if the lens aperature is first set to 4, then to 1·9, the video level should be restored automatically to the former level (assuming that the subject and lighting remaining unaltered) within 3 seconds.

This controlling is done by rectifying part of the peak output of Tr7, providing a d.c. voltage for the base of Tr6. The collector of this stage has about 80V applied to its load resistor and the target is fed, via a time-constant network, from this collector. As more light falls on the target the video output current increases, more voltage is dropped across the collector load of Tr6, the collector voltage drops and the circuit has little effect on the vidicon operation. But when the amount of light is reduced, opposite conditions obtain, and the control takes over. The reason for the time-constant network 10MΩ and 0·05μF, is to prevent hunting, i.e. to smooth out the variations, hence the 3-second delay. This can be very noticeable under certain operating conditions, and one has to learn camera technique to take full advantage of these sophisticated circuits.

Deflection circuits, though they take up a lot of space on the block diagram, need not occupy us much in the text, being fairly conventional. Conventional, that is, for this application of closed-circuit television, but not so easily recognisable as the simple oscillator-amplifiers we are accustomed to in our domestic receivers.

The horizontal deflection frequency is 10,125c/s and the vertical frequency 50c/s in the Sony CVC2000B, with trigger pulses at these frequencies coming from the video tape recorder when this is switched to the camera-record mode. However it is not a difficult matter to arrange things so that the clamping is done by timebase signals from a monitor receiver so that, with a little juggling, one can bypass the recorder and rig up a simple closed-circuit television system quite cheaply. From the block diagram we can see why this is so: Tr102 and Tr107 are the two oscillators, designed to operate at a basic frequency within 1% of that stated even with no trigger pulse applied.

In the case of the horizontal oscillator negative pulses are clipped and only positive pulses go to

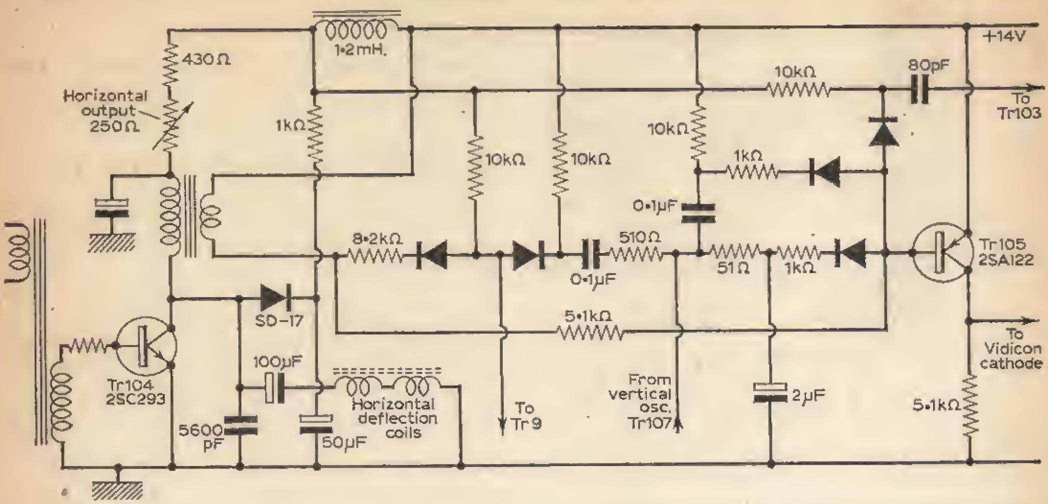


Fig. 30: An idea of the detailed design necessary to achieve retrace blanking is given by this circuit. Diodes all type IT-22 unless otherwise indicated.

Tr103, with an inductor in the emitter circuit of Tr102 regulating the basic frequency and adjustable within small limits. From Tr103, which is non-linear, shaping the pulse into a square wave (though it needs an extremely good scope to show this!), the pulse width being 15μS, the output amplifier Tr104 is driven. Transformer coupling is used. Some care in the design of this output stage was necessary to avoid small steps in the starting voltage of the waveform of the current applied through the deflection coils, including damping across the output from Tr104 and additional regulation of the power supply. Alteration of component values in this stage can have drastic effects on the line sweep. Amplitude adjustment is effected by varying the collector voltage with another preset, a conventional width control.

From the collector circuit of this stage via a transformer pulses at 10,125c/s are applied to the sync mixer stage, after some quite complicated networks to achieve the correct differentiation. As an example of the amount of thinking that has to go into designs of this nature, this section of the camera circuit is given in Fig. 30, with the blanking amplifier portion included, for this is again a departure from the usual type of circuitry.

But before going on to blanking we must consider the vertical pulse. This can be the most touchy part of these designs, with poor signal conditions or severe interference trying hard to trip the field, which rolls sluggishly through one pulse lock and annoys the viewer if nothing else. So the basic blocking oscillator Tr107 is arranged with a time-constant circuit to maintain lock within quite good limits even in the absence of a trigger pulse. One vital component in this circuit is a 22μF tantalum capacitor from the power line to the emitter of the oscillator. At this point a sawtooth waveform is taken to drive the amplifier Tr108, with variable and fixed controls inserted for linearity. Further control of the waveform is achieved by making Tr108 and Tr109 a combined feedback amplifier, with diodes in the emitter circuits for temperature compensation and yet more controls for linearity and amplitude. A very regular and shapely sawtooth of 3·5V peak-to-peak with 21·3mS periodicity is fed to the deflection coils.

There are one or two setting-up tricks which can bear a mention to help readers who are playing about with similar circuits. First, always set up with the monitor that is going to be used. Even in the best families, rogues can occur . . . there must always be small discrepancies between timebase characteristics, even though silicon planar transistors are used throughout, and great care taken with compensation against temperature and humidity variations. Secondly, set the basic timebase frequency of the vertical oscillator a little below 50c/s so that a slowly rotating picture can be locked on the monitor when switched over to off-air and back to camera. Adjusting the other way causes the field to flip rather than roll, and the blanking pulses cannot be observed so easily. Finally, having coupled up the whole equipment with the video tape recorder make sure that the operation of servo circuits by switching the motor on does not upset the triggering.

The blanking circuits must next be considered. We are accustomed to simple retrace blanking circuits in TV receivers, even so elementary as a single capacitor from the field amplifier to the cathode-ray tube grid or cathode. Here we have to drive the cathode potential of the vidicon positive during the blanking period, but, because the camera may be self-generating, or locked to an external sync, we cannot simply apply a field pulse. So horizontal pulses from Tr104 and vertical pulses from Tr107 are mixed at Tr105, amplified and then applied to the vidicon cathode. Figure 30 shows that this is again not so simple. Waveshaping is provided by the diodes and other components in the base input circuit of this stage.

TO BE CONTINUED

INSIDE tv TODAY

PART 8 **M. D. BENEDICT**

OUTSIDE BROADCASTS—1

OF all programme sources perhaps the best known to the general public is the outside broadcast, since nearly everyone has seen one at work at one event or another. Mobile control rooms cover a magnitude of events ranging from coronations and general elections to specially arranged quiz shows.

Outside broadcasts are defined as broadcasts taking place outside the television studio. In the early days of broadcasting, in the Alexandra Palace era, many outside broadcasts were arranged to take place in Alexandra Park, which surrounds Alexandra Palace. This allowed cameras to be wheeled outside on to the balcony or lowered to the ground (the studios were on the second floor) where they took shots of various events brought to the Palace although taking place in the open air. Horse racing from Alexandra Park racecourse was, of course, an exception but other specially staged events included flying model aircraft, gardening and various sporting events. These were not outside broadcasts as we know them today, since the cameras used worked with the studio vision and sound equipment.

Cable Transmission

The first true outside broadcast (o.b.) was the coverage of George VI's Coronation on 12th May, 1937. Three cameras were used, feeding into control equipment mounted in a van, and the important development was the sending of the vision signal by video cable many miles to the studios and transmitter at Alexandra Palace. Techniques for sending the signal over long lengths of cable without loss of high-frequency components had only just been developed in time for this broadcast. In fact these techniques are used today when all the natural loss of high-frequency components that takes place in cables is made good by a special equaliser unit incorporated every few miles. The original link to Alexandra Palace was extended to loop around the centre of London with branches off to important buildings and strategic points where o.b.s might be required. Balanced-pair cable similar in principle to microphone cable was used; modern cables however are of the coaxial type and are more interference-free. In spite of the age of this original balanced pair it is still in use for many items although it has not got the bandwidth required for 625-line use.

Cameras for Outside Broadcasts

Using this network and more sensitive camera tubes (Super Emitrons with an image-intensifier section) many types of o.b.s were undertaken. Flexibility was increased by using a vision transmitter with a power of 1kW, allowing a range of 20 miles or so. Signals from all over the London area could be sent to the studios to allow coverage of programmes within that area.

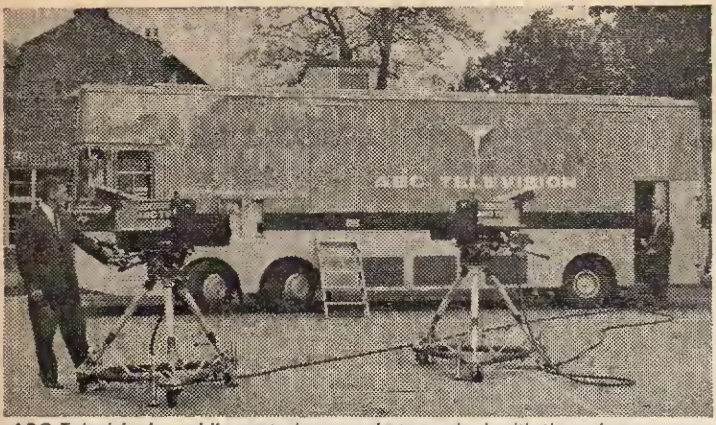
After the war much more sensitive types of cameras and camera tubes were introduced; firstly, the C.P.S. Emitron, then later the image orthicon that is now used in most studio cameras. A coaxial link to studio centres in the north and west extended the areas that an o.b. can work so that it is now possible for an o.b. to take place anywhere in the country, and up to 200 miles out to sea, as the coverage of the return of Sir Francis Chichester in *Gipsy Moth IV* showed.

Mobile Control Room

Today's o.b. unit, both for the BBC and ITV, is based on a four- to five-camera unit mounted in a specially built vehicle about the size of a large coach. In attendance are two vehicles carrying ancillary equipment, of which there is a surprising amount. The main vehicle is called the mobile control room (m.c.r.). Within the m.c.r. are carried the camera control units, connected by camera cable to the cameras via a special plug panel on the side of the m.c.r. A rack of preview monitors face the vision control operators and, as the lighting conditions on o.b.s are less controllable than in the studio, it is usual to have two operators as more adjustment of cameras is required. Behind these operators, viewing the same monitors, sit the production team, consisting of director and producer's assistant.

In front of the director are the vision mixing controls, simplified by studio standards, as the director is usually required to vision mix as well as direct the cameras. Next to the production team sits the sound supervisor, behind his sound mixing panel. The senior engineer sits next to the sound supervisor to supervise technical arrangements and look after the communications. These are necessarily complex as it is a requirement for the engineers to talk to the studios as well as several switching centres *en route* to the studio, whilst the production staff often want to talk to their opposite numbers in the studio. In more complex set-ups, remote cameras, roving eyes, and many other sources have to be interconnected.

All connections into the m.c.r. are made via the plug and socket panel on the camera cable panel. Hence each camera, microphone, connecting point, mobile video tape or roving eye is connected via this panel which carries programme sound and vision as well as talkback, intercommunications and telephones. Outgoing telephone



ABC Television's mobile control room, photographed with the colour cameras. (ABC TV photo)

lines back to the studio are fed to a specially rigged termination point connected by the Post Office, who are usually responsible for all sound links including the programme sound back to the studios.

Camera Links

Like a studio centre, each m.c.r. has a set of sync pulse generators to drive the cameras. Unfortunately, owing to the delay caused by the camera cable in sending line drive pulses to the camera head to initiate line scan and then return in the form of signals from the camera, it is not possible to use very long cables. Advancing the start of line drives by $4\mu S$ to $6{\cdot}5\mu S$ before the line sync starts allows cables of up to 2,000ft. to be used. However this is often not long enough so remote cameras may be used. With these a complete camera, camera control unit and sync pulse generator are placed at the remote point and the resultant signal fed by cable link to the m.c.r.

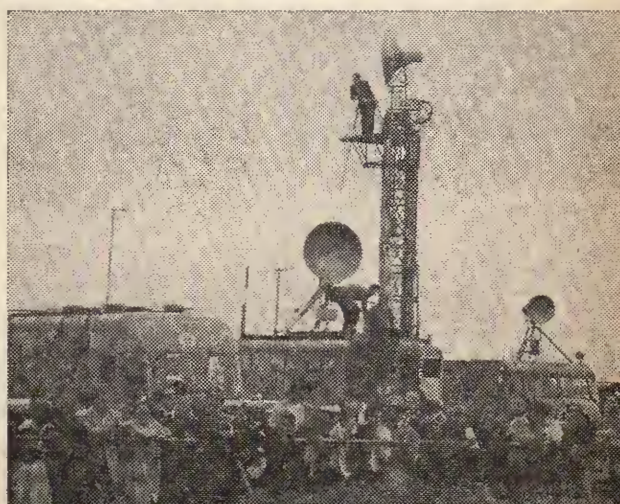
As with all m.c.r. cameras, talkback from the director is fed to the remote cameras in addition to a special 50c/s reference signal from mains to the sync pulse generator with the remote camera, allowing the remote pulse generator to remain in field phase if fed from a mobile power generator as is sometimes the case. In some cases it may be possible to "genlock" to the remote camera, particularly if the link is reliable, in which case no reference signal would be needed. New developments with stable crystals, operating at colour subcarrier frequencies, allow "slavelocking" of the remote pulse generator by the scanner, as well as locking to scanner pulses at the studio. These techniques will be discussed in a later article.

Naturally each programme authority has its own engineering departments and these have differing ideas about the layout and design of equipment. ABC TV, for example, have concentrated on getting the maximum into a normal sized vehicle by using the most modern image-orthicon camera channels (Marconi Mark Vs) and transistorised equipment. This has resulted in the best equipped monochrome m.c.r. in this country. In many respects, facilities are better than those in several studios! On the other hand, ABC TV has completed a smaller vehicle with simpler facilities but including a fully professional four-head videotape recorder to be used on smaller and simpler coverages or as a roving eye.

The BBC scanners are now several years old and are being replaced by colour equipped vehicles. ATV also have a colour m.c.r. BBC scanners take four cameras with facilities for a fifth, as well as inputs for a mobile videotape recorder, remote camera, radio camera and other external sources.

O.B. Sound

Sound mixers for o.b.s have to be capable of handling the most complex shows, including the coverage of operas and pop shows, yet be compact and easy to operate. Ideas vary as to the number of microphone channels required but mixers with 25 or 32 channels seem to be the latest trend. In order to expand facilities, the BBC operate a special sound control vehicle with a large capacity sound mixer, for use on the more



Radio link in use with an o.b. of a sporting event. (ATV photo) complex shows. It is often used at the Promenade Concerts from the Albert Hall, for example. Operating techniques for an o.b. sound mixer vary much more than the equivalent studio equipment and operating staff require the ability for at least first line maintenance—one cannot sit back and await maintenance staff when one breaks down 200 miles from base!

Radio Cameras

Radio cameras are a specialised development of remote cameras in which the camera and pulse generator have been made small enough to be portable. In addition to these a small vision transmitter is carried allowing the cameraman to carry his equipment right into the centre of action. In many cases the transmitter unit and some of the c.c.u. equipment can be fixed and connected by cable to the m.c.r., leaving just the camera head to be carried by the cameraman. Hand-held cameras or radio cameras allow remarkable shots to be achieved from places where a normal camera could never reach. A particular case where the radio camera comes into its own is the fascinating rock-climbing coverages where ordinary cameras provide wide-angle shots of the complete mountain whilst the radio cameras carried by climbing teams who scramble to the most unlikely positions provide close-up shots of the main climbing teams. In more commonplace programmes these cameras are used to provide closeups of engine details before the start of a motor race as well as in the pits during racing; starting gates at a horse race; closeups of golfers on the green; and many other special shots which could not be obtained by normal cameras.

Roving Eye

Big brother to the radio camera is the roving eye. These are usually one, two or three cameras mounted on vehicles with full control equipment and a power supply. The BBC for example has an elderly Marconi Mark III camera mounted on the roof of a Humber Hawk estate car. Power is supplied by a towed motor-generator set mounted in a trailer. This can be seen at Aintree for the Grand National as the road circuit follows much of the National course and the moving camera holds station with the galloping horses. ATV operate a single camera unit for a completely different purpose. The Monoculus, as it is called, consists of a camera and a videotape recorder and is used to record external sequences for plays and serials. These are recorded shot by shot and assembled by skilful editing to give a complete sequence. Sequences recorded in this manner often match the rest of the play better than film cameras and telecine, as the cameras produce a similar tonal quality which cannot be achieved with film.

Other roving eyes have two or three cameras and are capable of producing a complete programme if necessary whilst on the move, using a transmitter and a steerable aerial to keep in contact with a fixed station. More often they are used for simple o.b.s not requiring the complex (and expensive) four- or five-camera units, or as part of a very complex transmission where the output of the roving eye feeds the main m.c.r. providing extra cameras to cover action over a wider area.

Radio Links

Radio links are usually used to feed the vision signal from remote cameras and roving eyes to the m.c.r. and often from the m.c.r. to studio centre. What type of link is used depends on distance, terrain to be covered, existing facilities and many other considerations. Connections to the studio are the responsibility of the GPO, from whom facilities must be requested. They often use special equalisation techniques in order to utilise ordinary telephone cables for the purpose. From the termination box at the o.b. site they feed signals via ordinary telephone lines to the local exchange. Special techniques are used to avoid interference with the telephone service, as well as providing equalisation. From the local exchange the signal is similarly fed, along with all the sound lines, to the nearest TV network line route or inter-city trunk telephone link. Trunk calls are usually sent via wideband links carrying many calls at the same time and these links can be given over to carry television signals. If the GPO cannot deal with the signal in this way, then they allow a radio link to be set up.

Along with the m.c.r. and tender the programme authority will own several link vehicles. From the m.c.r. the signal is fed to the first link vehicles consisting of a u.h.f. link transmitter and parabolic reflector, often mounted on a tower. From this the reflector sends the signal to the next link vehicle, 20—50 miles away, usually parked on the highest convenient hill top. From here the signal is received and retransmitted to the next point, and so on until a suitable insertion point on the permanent television distribution network is found.

Often this is at a transmitter so that a remotely controlled receiving aerial is often mounted on the transmitter mast and can be pointed in any direction by remote control from the ground. Many permanent Post Office links include a steerable parabolic reflector for receiving radio link signals. The Post Office tower in London is so equipped and, similarly, facilities are now provided in many large cities. The number of links required depends on the nature of the terrain to be covered and the height of each link position relative to surrounding hills. It is interesting to note that the frequencies previously used for radio links (the first link was at 64Mc/s) have been taken for broadcasting, first Band III, then IV (Bands IV and V). This has reduced the effective range of long links as the higher the frequency used the more directional is the signal and hence it is liable to obstruction by tall buildings and other structures.

Another problem with radio links, particularly the mobile link, occurs where the transmitter and receiver aerials are not made very directional. Although there may be no obstruction in the direct path there may be one not far away and signals bouncing off this obstruction will be reflected towards the receiver arriving after the direct signal. If this signal is strong, then a bad echo will be seen on the received picture, and this causes many problems which may be as serious as a complete breakup of the picture or multiple sync pulses, a condition which fools even the best stabilising amplifier used to clean up syncs before transmission. Multipath propagation, as this condition is called, is particularly troublesome with roving links as with most fixed sites it is possible to cheat the beam from the very directional aerials used away from the offending obstruction. However, radio cameras moving close to buildings and roving eyes working in city streets may suffer badly.

At the last General Election the BBC had a one-camera roving eye following the Prime Minister from his Birmingham hotel to the station, where a two-camera roving eye would cover his departure to London and victory celebrations. Unfortunately traffic stopped the larger roving eye getting to the station on time and the single-camera roving eye had to drive into the station where it stopped exactly on the correct spot for multipath propagation so that the viewed picture simply broke up. No alternative shot was available and the "eye" could not manoeuvre!

French broadcasting authorities often use a helicopter for covering the Monaco Grand Prix and the Le Mans 24-hour race. This helicopter often suffers from multipath disturbances as it twists over the hills and houses at Monte Carlo. Multipath propagation can often be avoided, as the BBC showed with its programme from a B.E.A. helicopter flying over the Whitsun traffic jams. In this case alternative link receiving points were provided, and a great deal of careful thought when siting the links eliminated this problem.

As well as carrying the vision signals, the link can carry programme sound, but other arrangements for sound are usually made as several control or telephone links have to be provided to the m.c.r. and the extra sound line is easy to provide. Short links from remote cameras may be by a long coaxial cable, but often low-power links are provided.

TO BE CONTINUED

Servicing TELEVISION Receivers

No. 145 - EKCO T368, T371 SERIES
—continued

by L. Lawry-Johns

Valve voltages

The readings in the following table were measured with 230V a.c. mains input, the controls set for normal operation but no signal input, using a 20,000 ohms/volt meter.

Valve	Va	Vg2	Vk
V1A	165	—	—
V2A	172	165	—
V2B	30	—	—
V3	142	55	0·4
V4	123	123	0·4
V5	168	165	1·5
V6	168	165	1·5
V8	174	182	2·54
V10A	188	—	98
V11	174	194	12·2
V13A	175	190	15
V15	190	—	—
V16	—	120	—
V17B*	160	25	—
V17B†	95	—	5
V19†	162	35	—

* Standard models. † Fringe models.

Bottom compression

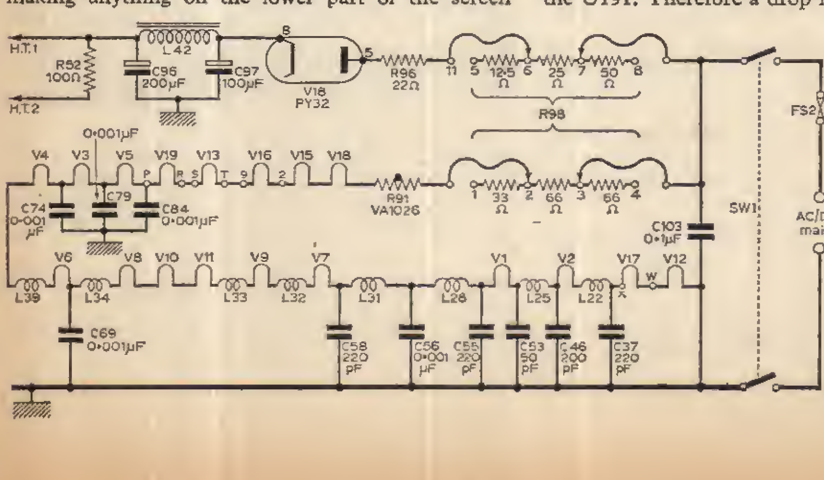
A common symptom of trouble in the double capacitor C78, C101 is when the bottom of the picture rises making anything on the lower part of the screen appear very squat and distorted. C78 500µF can be checked by connecting a similar value capacitor (25V) from pin 2 of the 30PL13 (V13) to chassis. If this doesn't help matters the valve itself (30PL13) is most probably at fault. Replacement of either the valve or the capacitor will probably necessitate readjustment of both the height and vertical linearity controls. The latter is on the top right side as viewed from the rear. Changes in the characteristic of the 30PL13 can cause loss of field hold but if valve replacement doesn't help, check R80 and C87 (standard models, R76 and C92 on fringe versions).

Bottom fold up

When the bottom of the picture is not only compressed but is accompanied by a white band where the picture is folded upward attention should be directed to the 30PL13 which may be drawing grid current or to C88 coupling capacitor which may be leaky. In either event the 30PL13 will have passed more than normal current and it is therefore prudent to ensure that R72 270Ω (fringe models R75) has retained its correct value.

Lack of width

The width control consists of three resistors R81, R83 and R87 wired in series from h.t. to the anode of the U191. The junctions are brought out to tags on the lower centre under the PY32 (PY33 may be fitted) h.t. rectifier. A flylead is provided to short out these resistors as required and thus increase the h.t. to the U191. Therefore a drop in the available h.t. will



Electrolytics

C24, C80	16µF + 16µF, 275V
C64	50µF, 25V
C78, C101	500µF + 2µF, 50V
C96, C97	200µF + 100µF, 275V

Sound I.F. *38·15Mc/s*

Vision I.F. *34·65Mc/s*

Fig. 4 (left): Power supply and heater chain circuits, fringe versions.

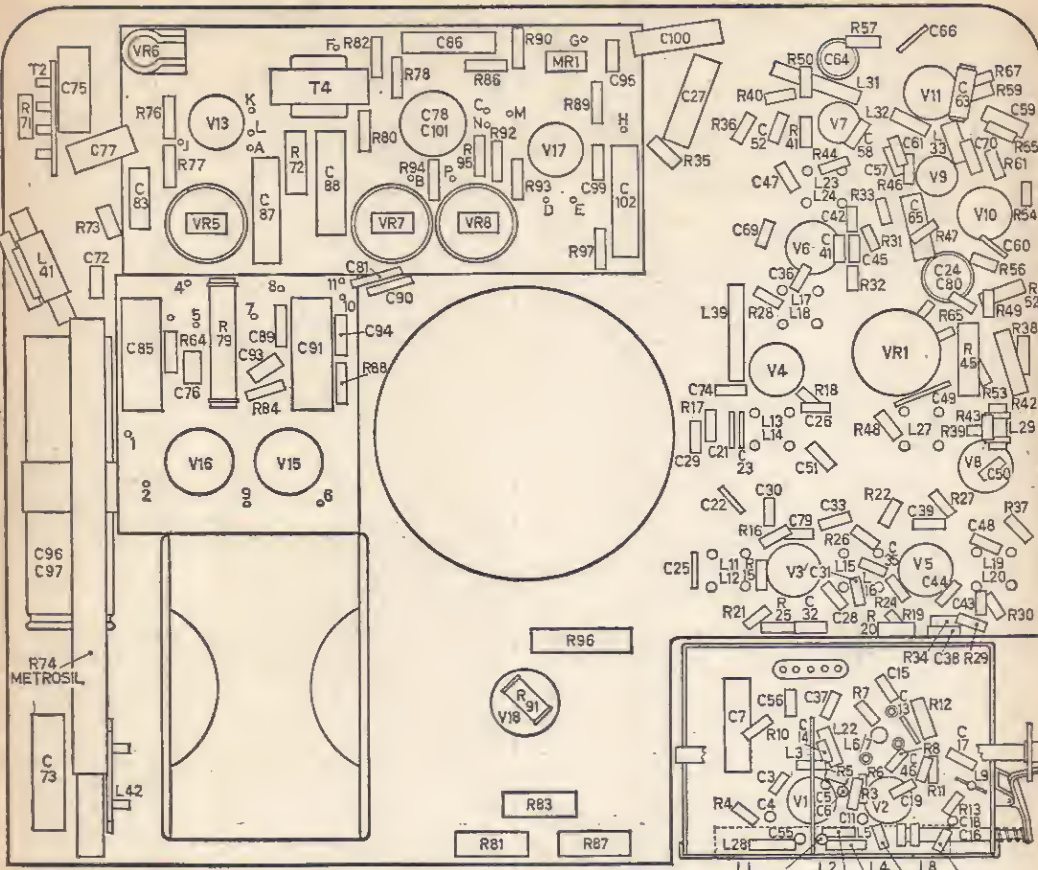
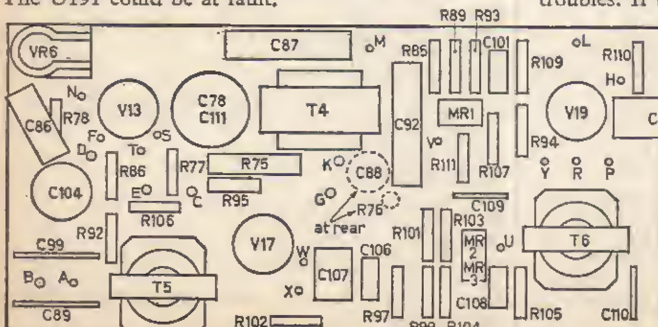


Fig. 5: Component layout diagram, standard chassis.

produce the symptom of failing width. The height would also be affected but not to such a marked extent. A voltage check at the high end of the width tags or at the FS1 fuse (separate fuse for the line output stage only) should be up to 190V on a 230V a.c. mains input. If the h.t. is low, replace the PY32. If the h.t. is not low check the 30P4 line output valve and R79 (4·7kΩ) screen feed resistor to pin 4. The U191 could be at fault.



Line hold

We have already mentioned R79 which can cause premature failure of the 30P4 if its value drops to any marked extent. This does not always apply to standard versions, however, as it is then intimately bound up in the line oscillator circuit where any significant change of value would cause line hold troubles. If the line hold control is at the end of its travel check V17 30FL1 (standard models) R79 and R93 (270kΩ). In fringe models the same symptoms should direct attention again to V17, which in this case is a 6/30L2.

Weak tube

The symptoms of a failing tube are too well known to warrant any long discourse in

Fig. 6 (left): Layout of the timebase printed board, fringe models.

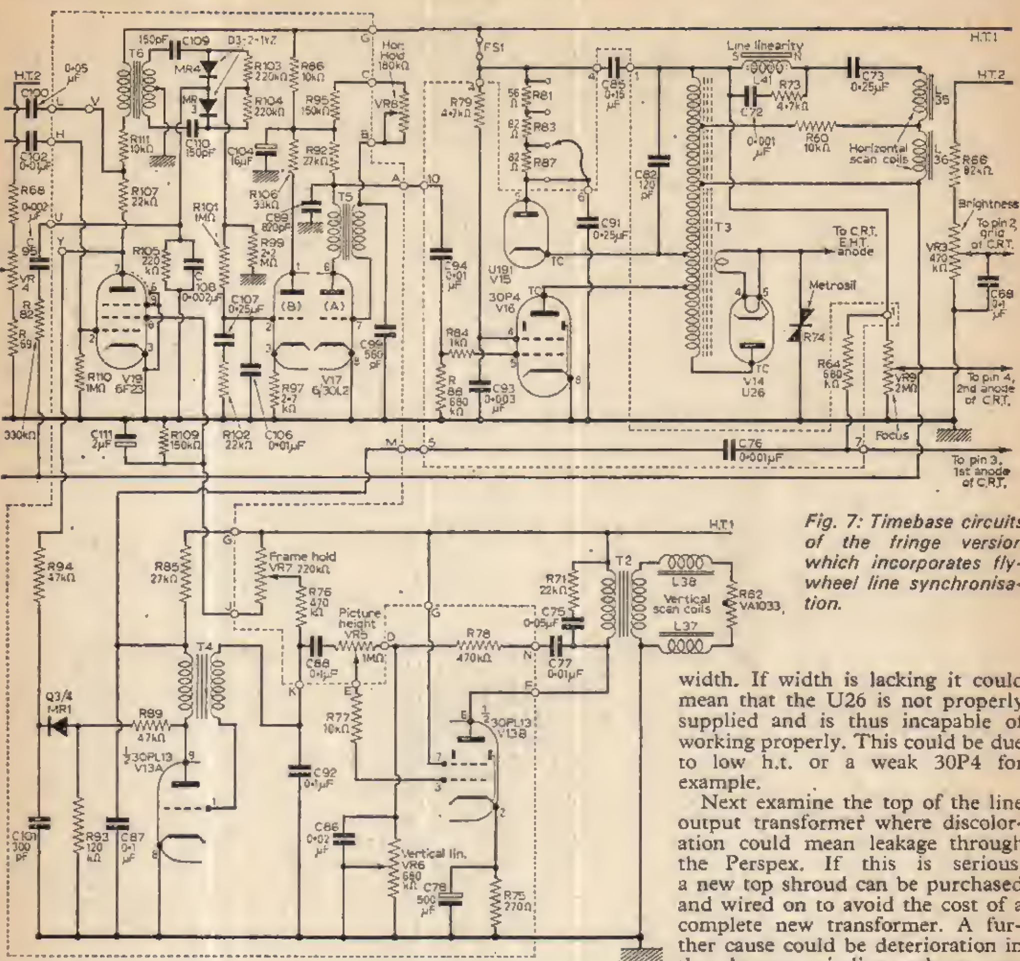


Fig. 7: Timebase circuits of the fringe version which incorporates flywheel line synchronisation.

this article. In short there are two symptoms to watch for, one the usual loss of highlights where they tend to become satiny and negative, the other where highlights blush out and defocus. The former denotes loss of emission, the latter an impaired vacuum where the vacuum is no longer as hard as it was. The symptoms of a low-emission tube are often aggravated by a weak 6F23 video amplifier (V8) so that even when the tube is replaced the picture still lacks good contrast. Quite often a general check on the video stage, valve and resistors, will restore a goodly amount of contrast into a picture which is not 100% due to a weakening tube.

Low e.h.t.

The symptoms here are of a normal-sized picture when the overall brilliance is low but which expands with loss of focus as the brilliance is advanced. This indicates that the U26 is unable to cope with an increase in beam current and normally a new U26 is required. It is as well however to check one or two other points first. When the brilliance is low and the picture is at its smallest, check that it is of adequate width. If width is lacking it could mean that the U26 is not properly supplied and is thus incapable of working properly. This could be due to low h.t. or a weak 30P4 for example.

Next examine the top of the line output transformer where discoloration could mean leakage through the Perspex. If this is serious, a new top shroud can be purchased and wired on to avoid the cost of a complete new transformer. A further cause could be deterioration in the heater winding where any inspection will probably result in the wire completely parting. The metrosil R74 need not be viewed with suspicion. The writer has never had the occasion to replace one in this range of models.

No results, no valves alight

Check mains to FS2 fuse, then to mains dropper. If present at fuse but not at any point in dropper, check on/off switch. Check down sections of dropper. If one tag is not registering check value of open circuit section and replace. If all sections show mains check all heater chains, first PY32 heater pins, then U191 and 30P4 and so on until break is found. The valve most likely to be open circuit is 6D2 on the left side.

Valves lighting

If the heaters are glowing but there is no other sign of life, check upper sections of dropper and 22 Ω wire-wound resistor to pin 5 of PY32 base (be careful not to break or strain the heater circuit thermistor

—*continued on page 377*

TIME marches on and the outside broadcast season for television is with us again. ITV, BBC; CBS and ATV (of USA) will all be hard at it, with complex plans for live, taped, filmed and satellited picture (and sound) reportage of sporting events on both sides of the Atlantic. Colour will be a big factor for a small but enthusiastic audience who will (some of them) be twisting, turning and re-siting their BBC-2 aerials to obtain stronger signals. Of course, one of the most important jobs for viewers is to rewire the aerial lead with genuine low-loss coaxial cable.

Zoom lenses

This is the day and age of the zoom lens, whether used on television or motion picture cameras. It was television which forced the pace, enabling the cameramen to swing from a long shot of a football field to a close-up of a defeated goalkeeper, without swinging over from one lens to another. Firstly with a five and a half to one ratio, later increased to 10:1, then 16:1—and now even 20:1. The latter can start with a wide-angle acceptance showing the entire cricket ground, stands and all—at Lord's—and zoom to a close-up of an umpire's triumphant expression as he loudly announces: "L.B.W.!" This rapid change in angle and perspective used to give the effect of the "victim" being brought towards the camera instead of the camera being rapidly tracked *towards him.* There is quite a difference in the changing perspectives from the camera (and viewer's) point of view. We have all got used to the zooming effect by now, but nevertheless it confuses and strains the viewer's eyes if carried out too quickly; on the other hand, it would tend to disorganise an innings if a camera has to be tracked across a pitch!

Lens turrets

For years and years motion picture lenses of different focal lengths were mounted on revolvable turrets on the front of the camera. The same arrangement of lenses was later applied to television cameras. It is the reproduction of colour on television receivers which has called attention to the differences in colour balance between one lens and another. While slight differences in this colour balance barely show on a cinema screen, the colour TV receiver screen reveals a kind of "whiter than white" effect which varies from lens to lens and from camera to camera. The importance of colour balance continuity is now being recognised. When photographing a colour film for television on a motion picture camera, the cameraman prefers to use one lens throughout, changing the focal length according to requirements of close-ups, mid-shots and long shots, rather than changing the fixed focal length lenses on the revolving turret. A change of lens sometimes gives an effect similar to a change of colour film stock. Both may look all right in themselves, but the change of colour balance continuity is noticeable on both colour and black-and-white TV receivers.

Royal close-ups

The first outside television broadcasts by the BBC were in 1937 at the Coronation of King George VI which was covered by a fixed lens camera at Apsley Gate, Hyde Park. The same camera was also used in the grounds of the Alexandra Palace, picking up long shots of the races at the Alexandra Park racecourse. The early Emitron camera used then seemed to be marvellous and we gazed rapturously at the results on tiny little TV screens in darkened rooms.

Today, thirty years or so later, those old Emitron cameras seem almost as primitive as a daguerreotype "tin-type" still camera of more than a hundred years ago. With one lens, no "zoom", no viewfinder, insensitive iconoscope camera circuitry, and with tripods improvised from film studio equipment, the BBC did outside broadcasts which were great pioneering achievements.

Film telerecording

Continuing on this nostalgic note, there were at Alexandra Palace the first film telecine machines, which were adapted from the Austrian "Arcadia", an unorthodox film projector in which the pictures from continuously moving film were "arrested" by a circle of continuously moving mirrors in front of a beam of light from an arc and which was then projected through a lens on to a cinema screen. It was a brilliantly conceived idea, operating silently and smoothly but far too delicate for the wear-and-tear of a busy cinema, the strong light and the mist troubles of dozens of mirror surfaces. However, it fulfilled the optical requirements of putting the picture on to the target of an Emitron camera tube. All British television engineers still have a liking for the continuous motion film travel method instead of the usual film projector intermittent film traction.

This led to the flying-spot method, a sophisticated film telecine introduced by Rank-Cintel, the earliest models of which, though about twenty years old, still give the finest black-and-white 35mm. film reproduction on the BBC and, strange to relate, on Westward Television.

Today's Cintel machines have

many refinements in addition to the solid state circuitry now expected for stability in colour reproduction of films. With alternative R, G, B or encoded output, this is a really exotic and beautiful colour machine, in demand from all parts of the world and with an order book exceeding about £1 million. Colour films for television ought to be viewed at film studios and film processing laboratories for checking with colour monitors side-by-side with black-and-white monitors. This system is about to be introduced at Pinewood Studios, where film series for television are produced on some of the stages in addition to films for the cinema.

Referring back to the early Alexandra Palace days it is astonishing to recall that telerecording of live television was carried out almost from the very start. A simple adaptation of a Vinten 35mm. motion picture camera was run at 25 frames per second and synchronised to photograph one of the interlace scans per field. Thus carefully phased, it photographed about 200 lines of television picture on the screen of a high-quality TV monitor. Later the line structure was reduced by the introduction of "spot wobble", a system later introduced on a vintage year of Ekco television receivers — a model which also had a very high-class d.c. restoration circuit. To this day these sets give magnificent pictures even if the 12-year-old picture tubes are not as bright as everyone now expects.

Telerecording was not only used in the early TV days for recording outside broadcasts on film. It was also used for making film records of important studio events and shows. These were particularly successful when the EMI C.P.S. Emitron was introduced. This was a much more sensitive camera than the Emitron or the Super Emitron, though quite insensitive compared with the 4½in. image orthicon or Plumbicon of today, which are also "sharper". Nevertheless, their excellent grey scale and absence of ringing or halo-effects have never been excelled, particularly on close-ups of faces.

S.M.P.T.E. convention Los Angeles

Talk about taking coals to Newcastle! The British Kinematograph Sound and Television Society have organised a group visit of about sixty of their members to attend the May Convention in Los Angeles. This is not just a one-way street, with the British contingent picking up crumbs of information in the veritable centre of American television, American films for the cinema or films for television. Some members of the British group will be reading papers, as they did at the New York S.M.P.T.E. Convention in April 1967

At the Los Angeles Convention there will certainly be a two-way traffic of ideas, with an exhibition of British equipment and gracious interchange of courtesies with the highest standard of diplomatic protocol.

A recent headline in a Hollywood film and TV paper had a headline "The redcoats are coming to our convention". Los Angeles beware—the redcoats are coming and so is Iconos!

Iconos

SERVICING TV RECEIVERS

—continued from page 375

VA1026 which is very close by). If the resistor is in order check the PY32 itself.

Sound delayed, picture more so

If the sound takes a few minutes to come through and the picture much longer the usual cause is a faulty PY32 rectifier. A PY33 should be fitted.

The use of silicon diodes

We are not wildy enthusiastic about fitting a BY100 or similar silicon rectifier across the valve base of the PY32 as a quick (cheaper) replacement. The reason is that the set has been used to a gradual build up of h.t. to say 190V. The sudden appearance of up to 300V on the h.t. line, quietening down to say 240V, does not do much to prolong the working life of the h.t. components and timebase valves. The writer prefers to fit a thermistor in series with the diode if and when one is used in an older set so that the h.t. build up is gradual. One similar to the VA1026 or VA1015 may be used.

Sound in order, no picture

Check h.t. voltage. If in order listen for line whistle and check e.h.t. If absent check FS1 fuse and line timebase valves. If in order remove top cap of U191. If line timebase starts up replace C85 (0·15μF).

Horizontal white line

Check 30PL13 and valve base voltages: h.t. at pins 6 and 9, bias voltage at pin 2. If a 30PL13 is not available a PCL82 may be used for test purposes althoug this may not be wholly suitable.

Vision OK, no sound

Check 30P12 (PL82) and associated voltages if there is no sign of sound at all. See that the loudspeake leads are connected! Check 6D2 and V4, V6 6F23 i. amplifiers.

Sound OK, raster visible, no picture signal

Check V3, V5 and V8. Examine resistors R45 and R39 particularly. If R38 is damaged change V8 and check MR2 vision detector diode which will almost certainly have been damaged. This happens when V develops a screen-to-grid short, where the hea current finds an easier path through MR2 than it d through R37 (which should also be checked).

Raster OK, noise in loudspeaker, no signals

Check aerial input. If in order check tuner un valves and valve base voltages. If resistors are foun burned ensure valves are in the correct position an check decoupling capacitors.

Next Month: SOBELL/G.E.C. 1000/2000 SER

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The rapidly increasing demand for a complete range of new tubes of the very highest quality is now being met by the new Lawson "CENTURY 99" range of television tubes.

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The new "Century 99" range of C.R.T.s is the product of Britain's premier C.R.T. manufacturers. All types are exact replacements, manufactured to the original specification but incorporating the very latest design improvement to give superb performance, coupled with maximum reliability and very long life.

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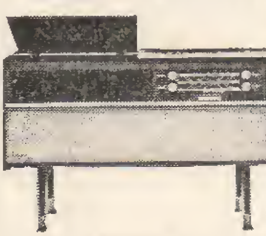

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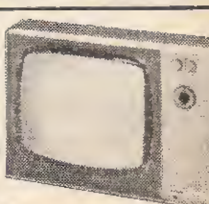

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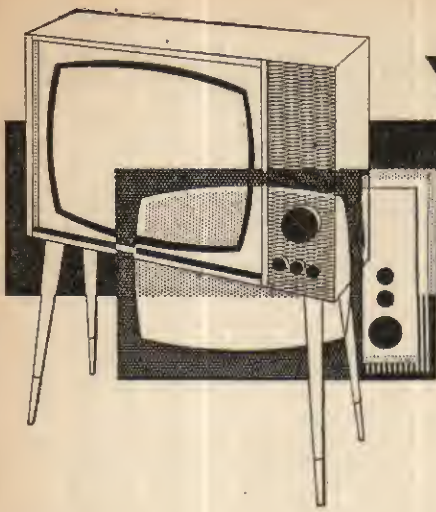

Your Problems Solved

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 381 must be attached to all Queries, and a stamped and addressed envelope must be enclosed.

REGENTONE 10-4

There is no sound or vision at first. If the set is switched off, then on, the sound and vision return for about three minutes. After this time, there is a "phut" and they disappear again.

I have replaced V1 (30L15), V2 (30C1), V3 (EF80), R4, R6, C13 and C3 but to no avail.

With the outer braid of the aerial coax soldered on to the can of V1 (can raised slightly from the chassis) I get perfect sound and vision on BBC and ITV comes on with some sound and poor vision. I found this method after touching V1 with my hand and finding that some vision appeared.

The raster and scan lines are perfect.—I. Bave (Hammersmith, London W.6).

There is certainly trouble in the tuner and it could be in the signal circuits (i.e., coils and tuning capacitors) rather than in the d.c. circuits. This would mean that the d.c. conditions would test normal with a voltmeter or current meter. A signal generator would be necessary to locate the signal in the defective section and to ensure that the r.f. circuits are tuning and coupling correctly. The fact that reception is possible by the means of coupling described in your letter, indicates that the frequency changer is working and that the trouble lies in the cascode r.f. stage. Are you sure this valve is all right?

DECCA DM45

The picture does not fill the screen, there being a gap of 3in. at the bottom. There is a loud buzz on the sound which disappears upon decreasing the height of the picture and which comes louder when trying to fill the screen by means of the height control.—E. Welch (Bristol).

The field output valve is the PL84 (V16) located at bottom centre of the chassis. The PCL84 to the left of the output is part of the field oscillator, as also is the ECL80 directly above the PCL84. All these valves should be checked. If the fault persists check the 500μF electrolytic on pin 3 of the PL84 and the components related to the field form and vertical linearity presets.

GEC BT318

Can you say how I may be able to obtain a little more gain from this set? I think it would help if this is possible, because the contrast is not all that good. I have had all the valves tested and the tube also seems to be in good order.—W. Hale (Chesterfield).

It is possible that the tube is low emission or the aerial signals weak or, even, that the overall sensitivity of the set is failing due to component deterioration and/or alignment drift. Unfortunately, there is no simple way of boosting gain apart from, perhaps, the use of a transistor booster between the aerial and the set, but if the tube is weak this will worsen the picture.

EMERSON E429440

When this set is first switched on, the picture comes on a little ahead of the sound, which when it does come on, is very weak. After about an hour or so it strengthens but does not reach a satisfactory level.—J. S. Kelly (Liverpool, 18).

It would seem either that the i.f. sound channel is drifting and needs checking for alignment or that one or more of the valves in the sound channel is low emission and that the emission gradually improves as the set warms up. It would pay to have the valves checked by a dealer with a good valve tester and replace any in the sound channel which are low.

PHILIPS 9148

The picture remains stable for about an hour after switch-on. Then, sections of it start pulling to the left, especially during a dark scene. Some nights, this seems worse than others, happening on both channels.—H. Nutley (Brierley Hill, Staffordshire).

This symptom could be caused by an inter-electrode leak in the picture tube, as the tube warms up. It can also be caused by trouble in the video amplifier or sync separator. It would seem that a valve is responsible (or something affected by temperature) since the symptom occurs only after an hour's operation.

GEC 2000DST

In order to locate the front panel oscillator trimmer more easily, I want to remove the band change knob which has around it the 405-line tuning ring. Can you say how these should be removed please?—H. Leslie (Wimborne, Dorset).

There have been a number of structural and styling variations of this range of chassis, but in general, the channel selector knob arrangement was similar in them all. The knob should pull off, but is invariably a tight fit.

Perhaps the best method is a piece of flat linen tape, about ¼ in. wide, looped to cross under the knob, then pulled off with a straight and steady pressure. This spreads the pressure against the underside of the flange and prevents the splitting of the inner portion that usually occurs when one tries to remove by prising off with a screwdriver blade.

Beware of the fine tuner control. On several models, this cannot pull off, having an internal flange, and the support panel must be released from inside. This is a bit tricky until you successfully locate the four 4 B.A. cheesehead screws, after which it is plain sailing.

FERRANTI 17T5

There is a sparking from the secondary of the line output transformer to chassis. I have replaced valves V14 (PL81), V15 (PY81) and V16 (EY86) and also capacitor C125. Even with the e.h.t. lead to the c.r.t. removed, the fault still persists. Also, I have replaced the primary and secondary windings of the line output transformer.—H. Curry (N. Ireland).

This range of models has a particularly "fierce" e.h.t. and great precaution must be taken to avoid solder spikes, poor insulation, etc., when working around the line output transformer.

The trouble you describe is most likely caused by the transformer itself, but could also be due to the aquadag coating on the c.r.t. being inefficiently returned to chassis, and you should check the brush point and its security.

It is worth noting that the arcing will always be worse with load removed—this is quite normal.

A smear of silicone grease over the e.h.t. points will help cut down corona—always provided the connections have been properly made off.

DECCA DM55C

The trouble on this receiver is insufficient height and depth of picture. I have renewed valves ECL80, PCL84, field oscillator and output together with PL84 video output but no improvement was noted. The picture is also slightly cramped at the top and the whole picture moves up and down the screen as much as ½in. The linearity control only increases the top of the picture and makes very little alteration to the bottom.—R. Bellamy (Warrington, Lancashire).

The trouble you describe can usually be traced to the feedback capacitors in the field shaping circuit, C74, a $0{\cdot}22\mu F$ and C77, a $0{\cdot}03\mu F$. You should also check R69 and R70, $330k\Omega$ and $4{\cdot}7M\Omega$ respectively, especially the latter, which is the anode feed to the second triode of the multivibrator, and which tends to go "high".

FERGUSON 306T

This set has bad ringing in the line output stage. Could you explain where the fault may lie?—T. Farham (Watford, Hertfordshire).

As mentioned in the article, a number of possibilities of line scan ringing exist and it is impossible in your case to say exactly which component might be responsible. Checks will have to be made in the line output stage of the resistors damping the inductive elements. The line output transformer itself could be in trouble, and its loss inductance may be ringing. If the line amplifier is run hard in an endeavour to maintain full width when the stage efficiency is low (due, say, to a weak line output valve or booster diode), ringing of the nature described can result.

K-B KV003

This set is used on 405 only and has developed a line fault. The timebase has become unstable during the warming-up period (about 20 minutes). As soon as the picture appears, the line hold has to be reset to obtain a lock. The picture then moves slowly over to the left until it slips out of sync and has to be set again. This occurs several times until the set has properly warmed up. Once warm, however, it remains stable for the rest of the evening's viewing, although changing channels sometimes causes it to lose lock.—C. Nicol (Newcastle upon Tyne).

The fault you describe with your K-B Featherlight Portable TV is generally caused by the $3{\cdot}3k\Omega$ 4W resistor to the screen grid, pin 8, of the PL81 line output valve going high. There should be 180V at the screen grid of the PL81 during 405-line operation.

Note also that the line oscillator, PCF802, is fed via a $1{\cdot}8k\Omega$ resistor from the h.t. line, and there should be 220V on the triode anode, 120V on the pentode anode of this valve.

PHILIPS 23TG170A

On 405, both BBC and ITV, the picture seems blurred with a lack of fine detail. On the test card only the top two frequency gratings appear clear—the others are blurred and out of focus.

On all channels, when the brightness control is increased, the picture "blows up" in size, altering the shape of the objects on the screen.

On 625, there is "buzzing" on sound. This is hardly noticeable on the test card, but alters in tone and volume during programmes, according to picture content—becoming louder with dark pictures.

The valve PFL200 was replaced some time ago and this made a temporary improvement but the above mentioned faults have now occurred again.—H. Peech (Mansfield, Nottinghamshire).

You should check the h.t. voltage, which is quite important with this receiver. Overall voltage trouble causes the "blow-up" of raster with varying brightness, but there is also a possibility that the boost voltage is low and e.h.t. will be affected.

As your whole trouble could be a common h.t. fault, we would advise this line of approach, checking variations at different selected functions for a clue to the origin of excessive drain.

PYE V700D

The picture collapsed to a four-inch wide strip across the screen, with the field rolling. After a time, the screen went blank and no raster could be seen.

The sound is good. I have put in a new EY86, PY800 and PL36 and find that it is possible to obtain a spark from the top cap of the EY86. It is also possible to faintly discern a line whistle. —T. Roberts (London, S.E.6.).

Your trouble could be a faulty 405/625 changeover switch, faulty main or secondary smoothing, or a faulty PCL85 field output valve on the right of the chassis as viewed from the back.

EMERSON E707

When first switched on, the picture is perfect, then after about ten minutes, lines begin to appear across the screen.

Everything seems OK but there is one valve I think may be at fault. It is the PCF80 in the tuner, one half of which gets very hot and appears to change colour. Also, the heater of this valve glows very brightly.—J. Evans (Blackheath, Birmingham).

If the PCF80 is unevenly heated, change it. If the lines you mention are white and diagonal, check the field oscillator output valve and the sync separator valves.

ULTRA 17/74F

Since fitting a new tube, I cannot obtain a full scan on line or field—the picture keeps varying in size. The h.t. is OK and I have changed V7, V8 and V9 but this has made no difference.— N. Hill (Manchester 22).

From your description of the fault, it seems possible that the deflection coils have not been pushed fully up the neck of the tube after the replacement of the latter. Under these conditions, we would expect corner cutting and perhaps a tendency to defocus at the limits of the raster. You should check that the tube is the correct replacement and not the type with the stepped flare where the neck joins the bell.

However, if the trouble is simply that the raster cannot be made to fill the screen, yet varies with picture modulation, you may find the h.t., although apparently in order, is not properly smoothed. The Ultra models are notoriously sensitive in this respect.

The boost voltage should be about half as much again as full h.t., and if this is low you may suspect the 2·2MΩ focus control, across the boost line. This component has a habit of draining boost volts.

QUERIES COUPON

This coupon is available until MAY 24th, 1968, and must accompany all Queries sent in accordance with the notice on page 379.

PRACTICAL TELEVISION, MAY, 1968

TEST CASE -66

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

? *The receiver, a 405-line-only Cossor of some years back, exhibited very poor field lock. Sometimes the field sync would tend to disappear altogether, leaving the timebase free-running, while at other times a fair lock could be achieved but it was noticed that this could be varied by altering the position of the coaxial aerial downlead at the rear of the set.*

The best locking point was within the range of the vertical hold control at all times, and even when the sync disappeared there was no significant drift in oscillator frequency.

All the components around the sync separator stage, including the valve itself, and those between the sync separator and the field generator were carefully checked and found to be in order. Thinking that perhaps something was amiss in the video output stage this valve and the associated components were checked and, again, all found to be well up to standard.

What else should have been looked at, and did the effect of moving the downlead at the rear have any significance on the fault? See next month's Practical Television *for the solution to this problem and for a further item in the Test Case series.*

SOLUTION TO TEST CASE 65
Page 332 (last month)

Many switched tuners, as distinct from the turret variety, contain an aerial coil which is untuned and consequently of fairly wide band since it is heavily loaded by the aerial feeder. To restrict response to v.h.f. only an extra rejector circuit is included. This may take the form of a simple choke or it may be a properly tuned circuit, depending on the nature of the tuner. Whatever form it takes, however, its purpose is to by-pass medium frequency signals to chassis and thus prevent the interference effects mentioned last month

Medium wave breakthrough will occur should a dry joint or fracture develop in this circuit, and this was the cause of last month's symptoms.

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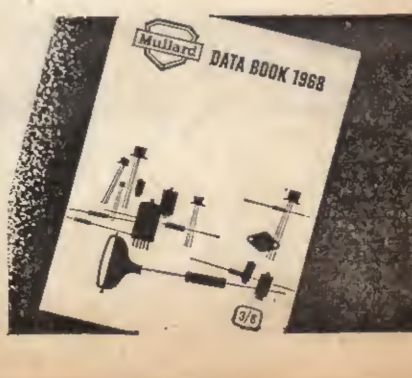

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