PRACTICAL
TELEVISION
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AUGUST
1970

using LINEAR INTEGRATED CIRCUITS

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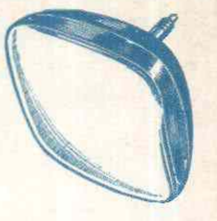
UHF SET-TOP AERIALS

SERVICING THE STC-ITT VC51-53 CHASSIS

LAWSON BRAND NEW TELEVISION TUBES



SPECIFICATION: *The Lawson range of new television tubes are designed to give superb performance, coupled with maximum reliability and very long life. All tubes are the products of Britain's major C.R.T. manufacturers, and each tube is an exact replacement. Tubes are produced to the original specifications but incorporate the very latest design improvements such as: High Brightness Maximum Contrast Silver Activated Screens, Micro-Fine Aluminising, Precision Aligned Gun Jigging, together with Ultra Hard R.F. High Vacuum Techniques.*

DIRECT REPLACEMENTS FOR MULLARD-MAZDA BRIMAR GEC, ETC.

A47-11W (P)	MW53/20 (M)	C21/AA	CME2104	7504A
A47/13W (T)	MW53/80 (M)	C21/AF	CME2301	7601A
A47-14W (M)	AW47-97 (M)	C21/KM	CME2302	7701A
A47-17W (P)	AW53-80 (M)	C21/SM	CME2303	CRM121
A47/18W (P)	AW53-88 (M)	C23/7A	CME2305 (P)	MW31-74
A59-11W (P)	AW53-89 (M)	C23/10A	CME2306 (T)	
A59-12W (P)	AW59-90 (M)	C23/AK	CME2308	
A59-13W (T)	AW59-91 (M)	C23/AKT (T)	CRM173	
A59-14W (T)	C17/1A (M)	CME1402	CRM212	
A59-15W	C17/5A (M)	CME1702	CRM211	
A59-16W (T)	C17/7A (M)	CME1703	23SP4	
AW36-80 (M)	C17/AA (M)	CME1705	171K	
AW43/80 (M)	C17/AF (M)	CME1706	172K	
AW43-88 (M)	C17/FM (M)	CME1901	173K	
AW43-89 (M)	C17/SM	CME1902	212K	
AW47-90 (M)	MW/53-80	CME1903	7205A	
AW47-91 (M)	C19/10AP (T)	CME1905	7405A	
MW43-69 (M)	C19/AK	CME1906 (T)	7406A	
MW43-64 (M)	C21/1A	CME1908	7502A	
MW43-80 (M)	C21/7A	CME2101	7503A	

LAWSON RED LABEL CRTS are particularly useful where cost is a vital factor, such as in older sets or rental use. Lawson "Red Label" CRTS are completely rebuilt from selected glass, are direct replacements and guaranteed for two years.

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16–17" ,,	**£5.19.0**	**£4.12.6**	**12/6**
19" ,,	**£6.19.0**	**£4.17.6**	,,
21" ,,	**£7.19.0**	**£6.10.0**	,,
23" ,,	**£9.10.0**	**£6.12.6**	**15/–**
19" Panorama	**£8.10.0**		**15/–**
23" Panorama	**£11.10.0**		,,
19" Twin Panel	**£9.17.6**		,,
23" Twin Panel	**£13.10.0**		,,
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18 CHURCHDOWN ROAD,
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2 YEARS' GUARANTEE FULL TUBE FITTING INSTRUCTIONS

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17in.	**£5. 5.0**	19in. Twin Panel	**£7.10.0**

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- ★ Each tube is rebuilt with a completely new gun assembly **and** the correct voltage heater.
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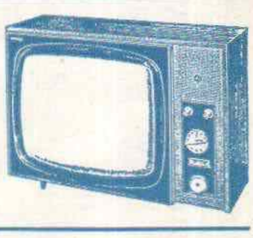

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Open type controls with mounting lugs to suit printed circuit boards.
Vertical Mounting .. .. **2/6 each**
K Ohms 5, 10, 25, 100, 150, 250, 500, 680.
M Ohms. 1, 2, 2·5.
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Satisfaction or money refunded.

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AZ31	9/6	EF184	11/3	PL81	10/3	6AT6	9/9
DAF91	8/3	EH90	10/3	PL81A	12/6	6U6A	15/6
DpF96	8/3	EL34	9/9	PL82	7/3	6AV6	6/6
DF91	9/–	EL41	10/–	PL83	10/3	6BA6	9/6
DF96	9/–	EL81	9/6	PL84	8/3	6BE6	12/–
DK91	11/6	EL84	7/9	PL500	16/6	6BR7	15/–
DK96	11/6	EM81	11/6	PL504	17/–	6BR8	19/–
DL92	7/6	EM84/7	12/9	PL505	29/–	6BW6	16/6
DL94	7/6	EY51	7/6	PL508	20/–	6BW7	13/9
DL96	9/3	EY86/7	7/9	PL509	30/9	6CD6G	28/–
DY86/7	8/–	EZ40/1	7/6	PL802	17/3	6V6G	8/–
DY802	8/6	EZ80	6/6	PL805	17/3	6X4	7/6
EABC80	10/6	EZ81	5/9	PY32	10/–	6X5	9/6
EBC33	11/–	GY501	14/6	PY33	10/9	12AU6	15/–
EBC41	9/6	GZ30	9/6	PY81	8/3	12BA6	9/6
EBC81	6/6	GZ32/4	11/9	PY800	8/3	12BE6	12/–
EBC90	9/6	GZ33/7	16/3	PY801	8/3	12BH7	14/–
EBF80	8/–	KT66	25/6	PY82	7/–	35W4	9/6
EBF83	8/–	KT88	32/6	PY83	10/–	50C5	12/6
EBF89	8/–	N37	15/6	PY88	8/3	50CD6G	28/–
EB91	5/3	N339	25/6	PY500	20/–	6F23	15/6
ECC81	8/–	PC86/8	10/3	PZ30	16/–	6F24/5	12/6
ECC82/3	8/6	PC900	10/3	R19	13/–	6F26	8/3
ECC84/5	8/6	PC95	7/3	R20	15/–	6F28	11/6
ECC88	11/–	PC97	8/3	UABC80	10/6	6/30L2	15/6
E88CC	12/6	PCC84	9/3	UBF89	8/–	10F1	15/–
ECF80/2	9/6	PCC85	8/6	UBC41	9/9	10F18	10/–
ECF86	11/–	PCC88	14/–	UCC85	9/3	10P13	16/–
ECH35	13/6	PCC89	12/3	UCH42	13/9	10P14	19/–
ECH42	13/3	PCC189	12/3	UCH81	10/9	20P4	20/–
ECH81	10/3	PCF80	10/3	UCL82	10/3	30C1	10/3
ECH83	8/–	PCF82	10/6	UCL83	12/3	30C15	13/9
ECH84	9/6	PCF84	9/6	UF41/2	11/–	30C17	15/9
ECLL800	20/–	PCF86	12/3	UF80/5	7/6	30C18	13/6
ECL80	8/–	PCF200/1	16/3	UF89	8/3	30F5	16/6
ECL82	9/9	PCF801	12/3	UL41	11/6	30FL1	12/9
ECL83	11/6	PCF802	12/3	UL84	11/–	30FL12	17/6
ECL86	9/9	PCF805	13/–	UM80/4	9/–	30FL14	13/6
EF39	10/6	PCF806	12/3	UY41	8/–	30L1	9/3
EF80	8/–	PCF808	13/6	UY85	6/9	30L15	15/3
EF83	10/–	PCH200	11/6	U25	15/–	30L17	14/6
EF85	8/3	PCL82	10/3	U26	15/–	30P12	15/6
EF86	13/3	PCL83	12/3	U191	14/6	30PL1	12/9
EF89	8/–	PCL84	10/3	U193	8/3	30P4MR	20/–
EF91	8/6	PCL85	10/6	U301	17/–	30P19	12/9
EF92	10/–	PCL86	10/3	W729	11/–	30PL13	18/6
EF93	9/6	PD500	30/6	Z759	24/6	30PL14	18/6
EF94	15/6	PFL200	14/9	5Y3	8/6	30PL15	18/6
EF95	12/6	PL36	12/9	5Z4	9/6		
EF183	11/3	PL38	18/–	6U4	15/–		

90% B.V.A. BOXED (NORMAL GUARANTEE) OR OWN VALVES SUPPLIED, 1 YEAR'S GUARANTEE. ADD 6d. PER VALVE ON ORDERS UNDER 6, OTHERWISE FREE POST & PACKING.

SEMICONDUCTORS

AC117	12/–	BC115	6/6	BF225	6/–	2N1305	4/10
AC126	4/4	BC117	7/9	BF257	9/6	2N1306	6/2
AC127	4/9	BC118	7/9	BF22A	9/6	2N3055	15/–
AC128	4/6	BC134	11/6	NKT125	5/9	2N3392	5/–
AC176	7/4	BC147	5/8	NKT281	4/–	2N3702	5/6
ACY17	6/–	BC148	4/4	NUT401	17/6	2N3705	4/6
ACY20	6/–	BC152	5/6	OC25	9/6	2N3711	4/9
AD149	11/8	BC175	5/6	OC44	5/6	2N3819	9/–
AD161	6/9	BC187	5/8	OC45	5/4	2N3826	6/–
AD162	6/9	BC213L	5/4	OC71	4/4	2N4062	4/6
AF114	4/8	BDY20	30/6	OC72	5/4	2N4289	4/6
AF115	4/8	BFY50	5/–	OC77	5/6		
AF116	4/9	BFX84	7/–	OC78	5/–		
AF117	4/6	BFX29	7/6	OC81	4/–	**RECTIFIERS**	
AF118	12/–	BF115	5/6	OC81D	4/–	BY126	4/4
AF126	4/8	BF117	9/6	(GET113)		BY127	5/–
AF127	4/8	BF163	7/–	OC84	5/–		
AF139	8/8	BF167	6/–	OC169	4/8		
AF178	9/–	BF173	7/–	OC171	6/–		
AF179	9/–	BF178	7/–	OC200	6/6	**DIODES**	
AF180	12/4	BF180	8/–	OC202	9/6	AA119	2/–
AF181	9/4	BF181	8/–	OC203	6/6	OA47	1/9
AF186	13/4	BF182	8/–	OCP71	12/6	OA79	1/10
AF239	8/6	BF184	5/–	P346A	4/6	OA81	1/10
BC107A	5/–	BF194	5/–	2N456A	17/6	OA91	2/–
BC108B	4/6	BF197	6/4	2N697	5/10	OA202	2/–
BC109C	5/–	BF200	7/4	2N698	10/6	BZY88	
BC113	5/6	BF224	6/–	2N1132	11/6	(SERIES)	6/6

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	CME2303		
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PRACTICAL TELEVISION

VOL 20 No 11
ISSUE 239

AUGUST 1970

QUERY SERVICE CHARGE

THE average monthly tally of readers using the query service to solve servicing problems runs to around 500. To provide the best practical answers to such queries, we rely on a panel of specialists who are fully conversant with repairing this equipment professionally.

However, familiarity with servicing does not necessarily ensure rapid and accurate diagnoses for all these queries. Many are written by readers obviously not too well versed in the subject, and this means that the professionals often have to sort out (a) unclear explanations, (b) irrelevant information and other red herrings, (c) lack of key clues, (d) mazes of confusing and illogical testing procedures, etc. Lack of the necessary test equipment often precludes details of all-important tests and, quite often, the reader cannot even supply the model number of the faulty receiver!

Yet despite these tribulations our panel has battled on. We have seen queries spread over page after page of confused and unconnected data in largely illegible handwriting, when an orderly presentation of the important facts could have taken ten lines or so.

But to maintain this service takes time. And in these days of rising overheads the cost is becoming prohibitive. Fees to consultants, clerical work, typing, stationery, postage, etc. are putting the service in danger. To abandon it, or to charge a realistic consultancy fee, would be alien to our aims, but something has to be done.

It is, therefore, with reluctance that we have decided that from the next issue a nominal covering charge of two shillings will be made to offset some of the running costs of maintaining the query service. This *does not* apply to queries concerning constructional or other articles which have appeared in the magazine, nor to general enquiries, but applies only to the time-consuming and costly processing of TV receiver servicing problems.

W. N. STEVENS, *Editor*

CORRECTION: 625-LINE RECEIVER

An error occurred in Fig. 12, the underchassis wiring diagram, in the June issue. The earth end of C17 should be connected to the adjacent earthed tag not the h.t. tag.

THIS MONTH

THE NEXT ISSUE DATED SEPTEMBER WILL BE PUBLISHED AUGUST 21

TELETOPICS

WIDE LIGHT-RANGE CAMERA TUBE

RCA are developing a television camera tube that will provide pictures in light conditions ranging from almost total darkness to bright sunlight. The silicon intensifier tube (S.I.T.) as it is called consists of a vidicon-type scanning gun and an image intensifier section separated from each other by a silicon target which consists of more than 600,000 pn junction diodes. The intensifier provides the gain which gives the ultra-sensitive performance of the tube at low light levels. Tubes are at present available only on a development basis, and only in the US—at 15,000 dollars each! The tube is a development of RCA's silicon target vidicon which was first demonstrated in 1969. At low light levels useful pictures can be obtained from a scene illuminated with a light level equivalent to that provided by a 100W bulb two miles away. At the other end of the light range the silicon target enables the tube to be exposed to the sun direct without damage. Development to the point where the tube is a commercial proposition is expected to take about three years.

VIDEOTAPE DEVELOPMENTS

Philips expect to have available late next year a video-cassette system able to record and playback colour and monochrome television programmes. The recorder will use $\frac{1}{2}$in. magnetic tape in a pocket-book size cassette providing an hour's playing time. The tape can be erased and recorded on immediately afterwards. Simplicity of operation and reasonable size are claimed with easy connection to a television receiver. Playback is via the receiver's aerial socket and a built-in tuner will be available to enable recordings to be made off-air direct. The flexible system will feature a number of machines ranging from monochrome players at about £125 and colour players at about £145 to a complete video-cassette recorder with tuner for recording and r.f. playback at about £230.

Agreement has been reached between the leading Japanese manufacturers of cassette-type colour television videotape recorders and five US and European counterparts on the standardisation of the structures and operating principles of their colour v.t.r.s. As a result it is expected that size of cassette pack, width of tape, speed, manner of revolution, frequency and other parameters will soon be closely matched.

Four major new items have been introduced by Ampex, a third-generation video recorder type AVR-1, broadcast colour camera type BC-230, high-speed colour/monochrome tape duplicator type ADR-150 and broadcast-quality video-cassette recorder-player type ACR-25. A technical note on the high-speed tape duplicator was given on page 442 last month.

VIDICON EQUIVALENTS CHART

An equivalents chart for vidicon camera tubes is available from the Electron Tube Division of EMI Electronics Ltd., Hayes, Middlesex. EMI vidicons suitable for replacing over 100 other types of vidicon are listed. The chart is free of charge and provides a certain amount of useful data.

SECOND MULLARD TV TUBE FACTORY

Mullard are building a £7 million factory at Belmont near Durham for the production of ColourScreen picture tubes. This is in addition to the £1·5 million expansion at their main tube manufacturing centre at Simonstone, Lancs. Production at the new plant is scheduled to begin during the second half of 1971.

NEW CCTV COMPANY

A new company, Beulah Electronics (1970) Ltd. has been formed by Photo-Scan (London) Ltd. and Closed Circuit Television/Electronics following an arrangement with the founder directors of Beulah Electronics Ltd. Maintenance and service of Beulah and other CCTV equipment will be available at Closed Circuit Television/Electronics, 56 Barnwell Road, London SW2 (Tel. 01-733 8509) while marketing and administration will be at Photo-Scan (London) Ltd., 24 Upper Halliford Road, Shepperton. Tel. Sunbury-on-Thames 87633.

COLOUR VIDEOPHONE

Toshiba of Japan have developed a colour TV-phone system which is claimed to be the world's first. The colour telephone is based on the colour system used in the Toshiba super-mini colour TV camera. The console has a 12in. colour receiver tube in its lower centre portion, a camera lens in the upper centre part with 3in. monochrome monitor to the top right.

NEW TRANSISTORS FOR TV

SGS (U.K.) Ltd. (Planar House, Walton Street, Aylesbury, Bucks) have introduced four new transistors for TV receivers, two for u.h.f. tuner use and two for use in the i.f. stages. All are encapsulated in TO-72 packs. The two u.h.f. transistors, the BF272 and BF316, are pnp silicon types. A typical noise figure of 3·5dB at 800MHz is quoted, with very low reverse transfer capacitance (0·09pF maximum), giving a power gain of 13dB at 800MHz with adequate stability. The i.f. types are the BF270 for use with a.g.c. and the "straight" BF271. The gain of these is quoted as 28dB at 36MHz with a control range of 60dB for the former type. The base and emitter connections of these two transistors have been reversed to reduce the feedback capacitance and thus improve the stage gain.

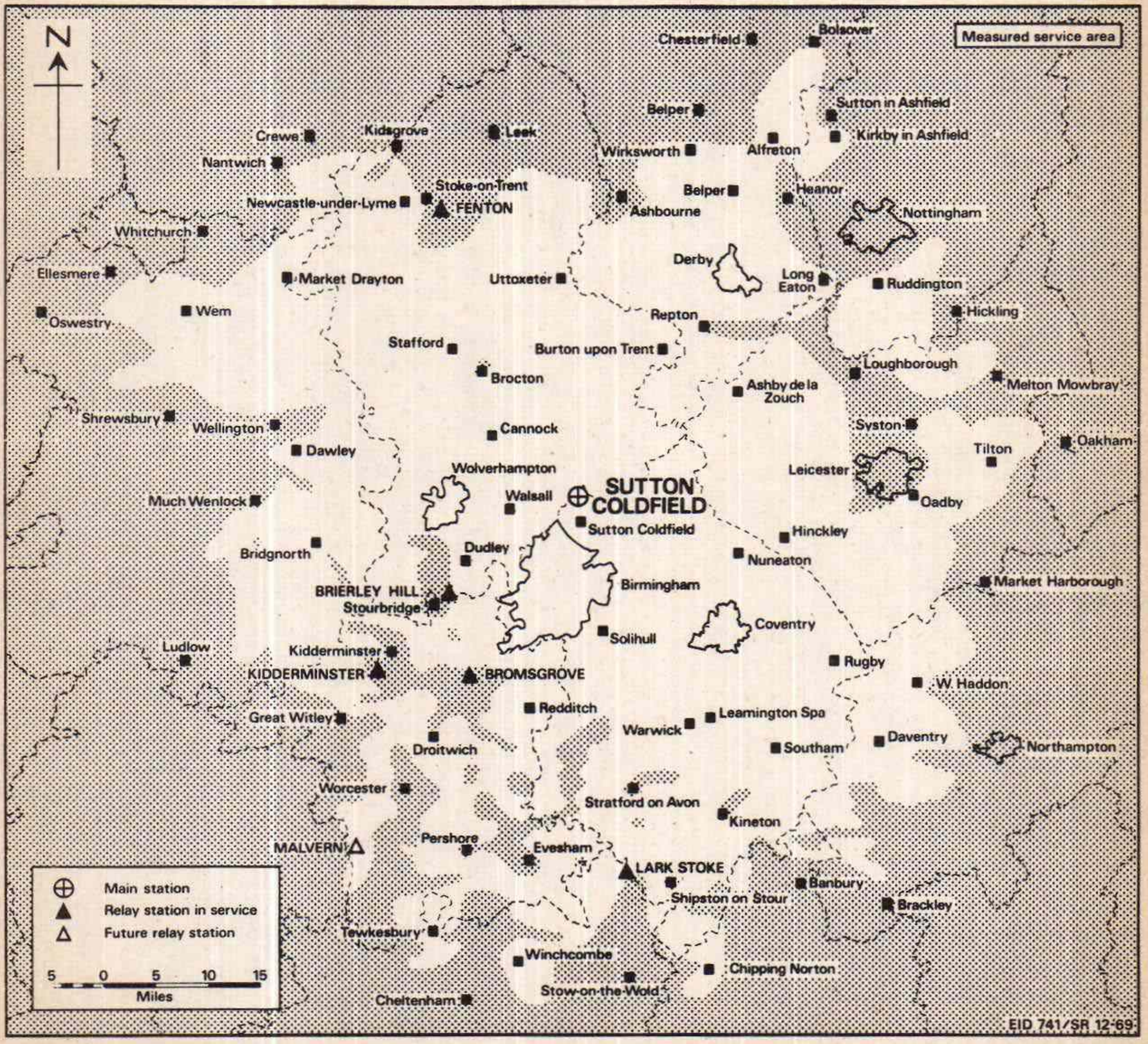
LATEST TRANSMITTERS

The BBC-1 colour u.h.f. service from **Mendip** has now started on channel 58 with horizontal polarisation (group C aerial). The **Oxford** u.h.f. transmitter is now transmitting BBC-1 on channel 57 and ATV on channel 60: a horizontally mounted group C aerial is required. BBC-1 colour u.h.f. from **Pontop Pike** is on channel 58 (group C aerial, horizontal polarisation) and from the **Darwen** (Lancs) relay station on channel 39 (group B aerial, vertical polarisation).

The ITA has announced that there will be a delay in the opening of the following u.h.f. relay stations: Reigate, Brierley Hill, Pendle Forest, Sheffield, Wharfedale, Fenton, Chesterfield, Tunbridge Wells, Kilvey Hill, Bromsgrove, Guildford and Hemel Hempstead. The delay is due to technical difficulties experienced by the manufacturers of some of the equipment to be installed. A revised programme will be announced as soon as acceptance tests of the equipment for the first station, Reigate, have been satisfactorily completed.

SUTTON COLDFIELD UHF TV SERVICES

Horizontal polarisation
Group B receiving aerial



The above BBC map shows the approximate service area of the Sutton Coldfield transmitter (maximum e.r.p. 1000 kW). Small pockets of poor reception too small to be shown in this map may be experienced. Channels: BBC-1 46, ITV 43, BBC-2 40.

TIME-DELAY techniques

I. R. SINCLAIR

TIME-DELAY circuits have been used in electronics from the early days, but only recently has one type of delay become common in domestic equipment in the form of the one line delay necessary in the PAL colour television system. The function of a time-delay circuit is, as its name suggests, to give an output at a specified (or adjustable) time after an input is presented to it. The time may be short (10μsec) or long (50msec), the input and output may appear at the same terminals or at different ones, and the output may be a faithful replica of the input (as it must be if a TV waveform is being delayed) or bear no resemblance to it other than providing some prominent pulse after a given time delay (as is usually the case in pulse delays).

For the purposes of classification we can separate all the known time-delay circuits into four groups. There are first electrical transmission-line delays which delay a waveform by making it travel along a path which is electrically long. This may also be physically long, as when the delay consists of several yards of coaxial cable, or short, as when an artificial delay line is made by using series inductances and parallel capacitors as in Fig. 1. Such lines delay the signal by only a small amount—

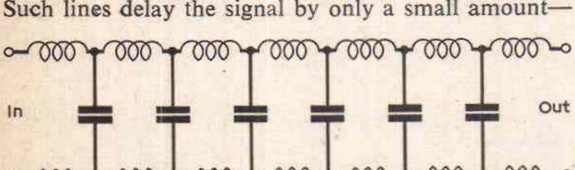


Fig. 1: Artificial delay line for balanced twin cable.

75Ω coaxial cable causes a delay of only 0·16μsec for a length of 100ft., artificial lines providing up to 2μsec for a much shorter length—and have a bandwidth depending on their construction and matching impedance. Generally artificial lines made from inductors and capacitors have a narrower bandwidth (though this may be of the order of 20MHz) than cables. Both types of electrical delays may be used as pulse generators.

The second group of delay devices record the waveform and reproduce it later. This type of delay uses tape or wire recorders with multiple heads and has its most intensive use in the generation of sound effects, artificial echoes and synthetic music.

The third group, similar in effect to the second but of much greater importance, uses mechanical vibrations in a variety of substances to delay the waveform. In this group of delay devices, which includes those used for the important PAL colour TV application, electrical waveforms are turned into mechanical vibrations by a transducer which may be a piezoelectric crystal or the more familiar moving-coil device similar to a loudspeaker. These vibrations travel in a solid which may be a glass or quartz block, a stretched wire or spiral spring and are delayed by the time taken for the waves to travel along the solid. This time is determined by the path length and by the speed of waves in the material which in turn depends on the elasticity and density of a solid bar or on the tension, mass and length of a wire.

The fourth group of time-delay techniques is also of considerable importance but unlike the three previous types does not transmit a waveform unchanged. These are pulse delay systems which are triggered into action by a pulse and will deliver another pulse some time later at the output. Of all the delay arrangements we have mentioned, this group is most easily constructed and offers the widest range of delay times ranging from nanoseconds to seconds.

In this article we shall not deal with the second type of delay because of its specialised nature, but we shall look closely at the last group with a glance at the other two.

Transmission-line Delays

A length of transmission line, whether coaxial cable or twin 300Ω transmitter feeder, is a path for electromagnetic waves and as such will act as a delay according to its length and the speed of the waves. The speed of electrical waves in space is 3×10^{10} (3 followed by 10 zeros) centimetres per second (about 18,600 miles per second) but the speed is less in cables just as the (identical) speed of light is less when it is travelling through glass. The time taken for waves to travel from one end of a line to the other depends on the construction of the line and is given by $T=RC/10^6$ where R is the impedance of the line (in ohms) and C is the capacitance in pF per foot. This gives T in microseconds per foot and since RC is divided by 10^6 (one million) the value is small.

Such a line can be used within an amplifier provided it is fed by and feeds into resistors of the same value as its characteristic impedance (R). Failure to do so (mismatching) causes the waves to be reflected at the mismatch, and such waves can travel up and down the line causing an echo to be added to the waveform. Artificial transmission lines can be made to give a greater range of impedances and total capacitance but the calculations necessary are extremely complex. Fig. 2 shows how reflections travel in lines and how this may be used in pulse generators where very short pulses have to be

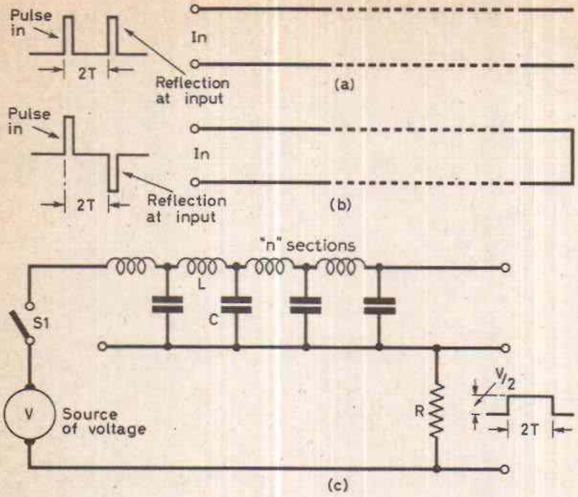


Fig. 2: Reflections in lines. (a) Line open-circuit at far end. Pulse is reflected with same polarity at time 2T later. For a made up line using inductors value L and capacitors value C, $T=2n\sqrt{(LC)}$ where n is the number of sections. For a coaxial or turns line $T=l\sqrt{(LC)}$ where l is the length and L and C the calculated characteristic inductance and capacitance. (b) Line short-circuited at the far end. Pulse is reflected with opposite polarity at time 2T later. (c) Pulse generator. When the switch is closed a step of voltage travels down the line and current flows in R. At the end of the line the pulse is reflected and current continues to flow. When the pulse returns all the capacitors have charged and no more current flows. The "switch" may be a switching transistor.

generated. This is a most useful technique now that suitable switching transistors can be obtained.

Mechanical-Vibration Delays

The simplest form of mechanical-vibration delay consists of a room containing a loudspeaker and a microphone. Signals converted into sound by the loudspeaker travel across the room and are picked up by the microphone at a time later which depends on the size of the room (and to some extent on the temperature of the air in the room). This is a poor method of delay because of the distortion, due to echoes as well as to the characteristics of the loudspeaker and microphone, and practical delay systems of this type avoid the use of air by making the mechanical waves travel in solids (sometimes also in liquids such as mercury). As sound and ultrasonic waves travel very much faster in solids and liquids than they do in air however a large effective length of material may be needed. The devices used to convert the electrical waveform into vibrations usually limit the bandwidth obtainable, but in any case the bandwidth is eventually limited by the speed at which the atoms of the material are capable of vibrating.

For audio frequencies coiled wire can be used as the delay, waves being driven by a converted earphone which has the wire soldered to the diaphragm. The pickup at the other end can be a similar earphone, a microphone or a crystal cartridge (gramophone type). Bandwidth is severely limited by the driver but this matters little when the delay is used for its usual task of providing artificial echo.

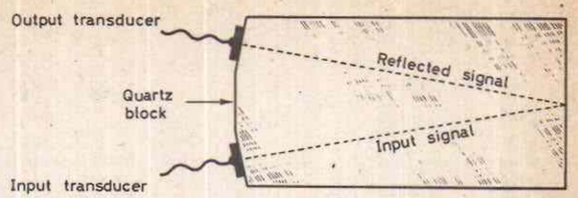


Fig. 3: One scanning line duration quartz delay line for use in a PAL-D decoder. The signal in the quartz block is ultrasonic, i.e. the transducers convert an electrical signal into a pressure one and back again.

Better quality, but a smaller range of delay, can be obtained by using a crystal cartridge at each end of a glass rod, one as driver and the other as pickup. The length of rod for a delay of 1msec is about 400cm. (about 13ft. 4in.) but this can be reduced by doubling the rod back, assuming some means of softening the glass by heat is available.

The delay lines for the PAL colour TV system use quartz (which is fused sand and expands very little as temperature changes). The Mullard delay line uses the ingenious idea of forming a quartz block so that waves are driven at a small angle to one end (which is ground flat), reflected and received at the first end again. By using a shape similar to that shown in Fig. 3 only waves which have travelled along the block and back are received at the output transducer, and this arrangement also has the great advantage of enabling the effective delay to be adjusted by grinding the reflecting end instead of having to remove one of the transducers to grind either the transmission or reception end. Furthermore the delay can be adjusted even while the line is working. In this type of line, where the frequency of operation is high and the bandwidth wide, the contact between the transducers and the line is of great importance.

In all the "acoustic" lines we have described the losses are very high so that signals applied to the

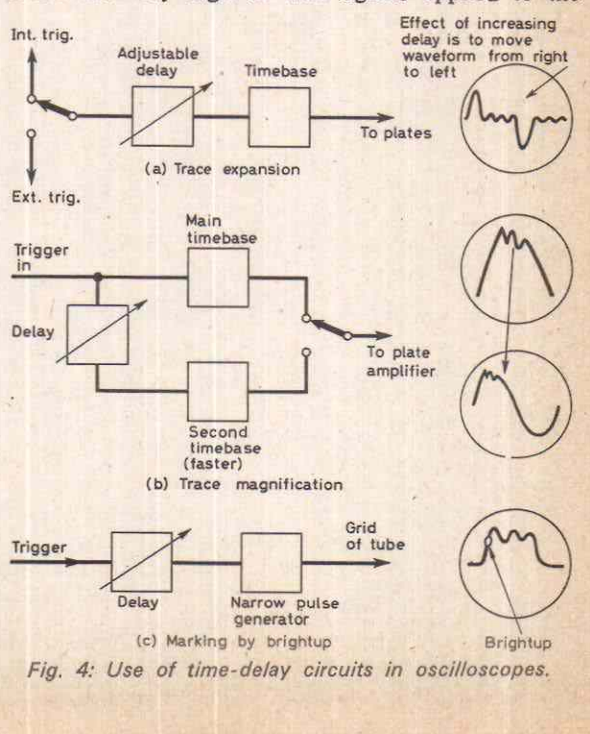


Fig. 4: Use of time-delay circuits in oscilloscopes.

lines should have as high a signal-to-noise ratio as possible to allow for the considerable amplification which will be necessary after the signal has passed through the line.

Pulse Delays

Unlike the delay techniques so far described pulse delay systems are easily made from standard components by anyone capable of reading a circuit diagram while the delay times are easily adjustable by the turn of a potentiometer. Pulse delay circuits are found in oscilloscopes, where the start of the timebase sweep may be delayed until some time after the arrival of the trigger pulse. The effect of this is that as the delay is varied one part after another of the waveform is brought into view. A delay circuit may also be used to trigger a second timebase so that a portion of a waveform under examination can be seen "magnified", or the delay may control the position of a bright-up pulse so that a portion of the waveform can be marked. Fig. 4 shows block diagrams for some oscilloscope applications. Apart from specialised uses in radar and TV, pulse delay circuits also have considerable use in electronic equipment such as a photographic automatic exposure control and watch calibrators.

Flip-flop Circuit

Figure 5 shows a time-delay circuit using a flip-flop (monostable multivibrator). When not in action Tr2 is biased on and the current flowing in its emitter circuit results in a voltage across the common emitter resistor R2. This voltage biases Tr1 off so that its collector voltage is high. If a positive-going trigger pulse is now applied to the base of Tr1 this transistor switches *on* (a negative-going pulse would be required if Tr1 was a pnp type) and there will be a negative-going pulse at Tr1 collector which will switch Tr2 *off* due to the coupling through C1 and R3. Tr2 remains off with Tr1 on until the voltage at the base of Tr2 is high enough to switch Tr2 on again, cutting off Tr1 as before because of the voltage developed across R2. The time taken for Tr2 to switch on again is determined by the time-constant of C1, R3 and the voltages used, and the resultant waveform at the collector of Tr2 is a squarewave whose second side is *delayed* compared to the time of arrival of the original trigger pulse.

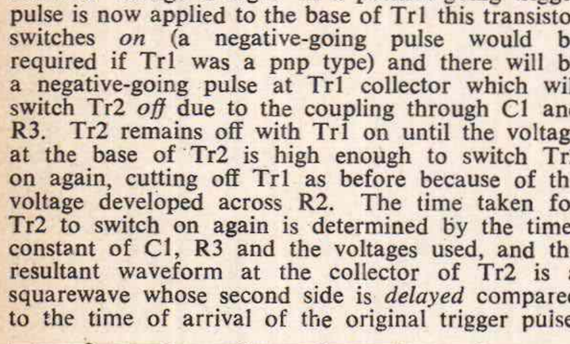


Fig. 5: Flip-flop (monostable) time-delay circuit. The values of C1 and R3 set the delay time. Typical values are given for these two components (giving a time delay of 30µsec). Time in µsec is approximately equal to 0·7 × R3 × C1. Tr1 and Tr2 may be any small-signal npn transistor (reverse polarity of supply if pnp types are used).

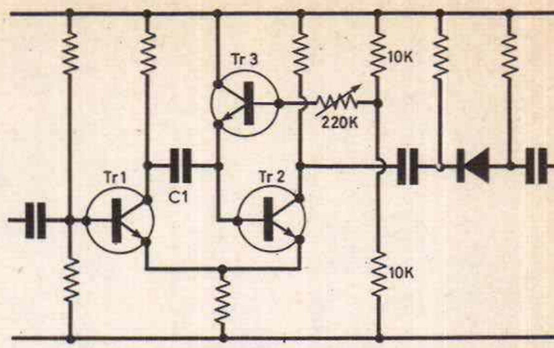


Fig. 6: Using a transistor (Tr3) as the source of charging current for C1. Tr3 must be a low-leakage silicon planar transistor. Other values of components are typically as in Fig. 5.

This squarewave output can be converted to a pulse output by differentiation (C3, R7), the time-constant of C3 and R7 being short compared to the delay time.

The time delay of such a circuit may be varied by making R3 variable. This has the effect of changing the time-constant so that the squarewave at the collector of Tr2 changes in width. If the required time delay is small germanium transistors may be used but for delays greater than about 1msec silicon transistors should be employed. When *precise* time delay is essential silicon planar transistors should be used because of their low leakage between base and collector.

This basic flip-flop delay can be elaborated by replacing the resistor of the time-constant network by a transistor so that the charging current is constant. This makes the waveform at the base of the second switching transistor Tr2 a switch so that the moment of switchover is more precise due to the great change of voltage with time. Fig. 6 shows an example of this technique.

Precision Time-delay Circuits

A more elaborate approach to time delay must be used when precise delays are required with the

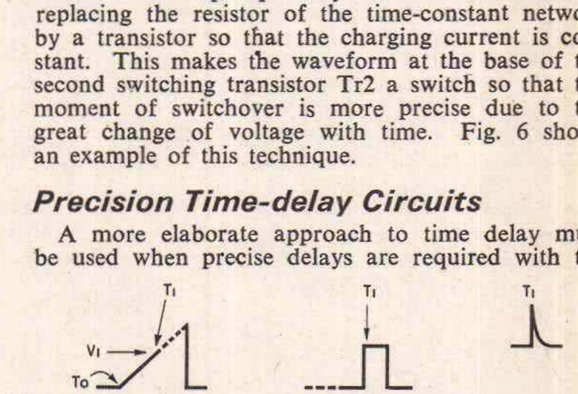


Fig. 7: Outline of a precision delay system. The voltage coincidence circuit can be set to operate at any point along the linear voltage sweep applied to it to give a range of delay times.

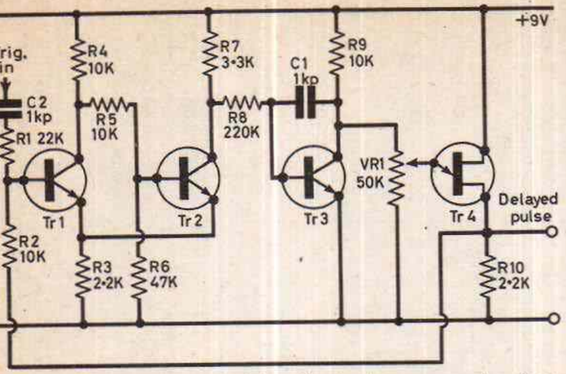


Fig. 8: Timebase type of delay. Typical component values given (they may have to be adjusted to suit particular purposes). Tr1, Tr2 and Tr3 are silicon small-signal transistors and Tr4 a unijunction transistor which fires at any point between 2V and 4V (value of R3 may have to be adjusted to suit—raise for a higher voltage type of unijunction transistor). The values of R8 and C1 (which set the maximum delay time) quoted give a maximum delay of about 200μsec. VR1 adjusts the delay time.

minimum of jitter (variation in time from one operation to another) and wide variation of time. This class of time-delay circuits uses a trigger pulse to start a linear sweep (see article in P.TV. Dec. 1969 and Jan. 1970 on "Linear Timebases") which in turn operates a triggering circuit at some set voltage as in the block diagram of Fig. 7. The linear sweep circuit may be a transistor charging a capacitor, a bootstrap or a Miller integrator, and the voltage-sensitive circuit (voltage coincidence) may be a tunnel diode, a unijunction transistor or any transistor arrangement such as the Schmitt-trigger circuit which gives a rapid switchover at a specified voltage. Fig. 8 shows a typical arrangement of a bistable circuit (Tr1 and Tr2) which when triggered permits the Miller sweep circuit (C1 discharging) to start. The sweep is stopped when the voltage at Tr3 collector is sufficient to fire the unijunction transistor Tr4 which then turns off the bistable circuit restoring the whole arrangement to its original condition.

Such circuits can be much more economically arranged using valves. Fig. 9 shows an arrangement known as the cathode-coupled phantastron which pro-

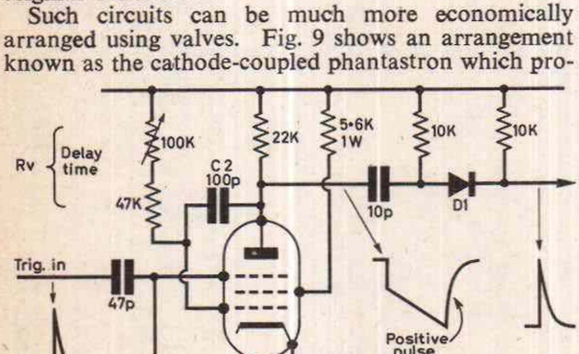


Fig. 9: Cathode-coupled phantastron time-delay circuit. Values of RV and C2 give delays of about 10μsec. V1 can be any pentode with a short suppressor grid base (the old 6F33 was useful) or a mixer heptode such as the EH90.

vides a wide range of time delays using only one valve. In the waiting state (prior to the arrival of a trigger pulse) the cathode voltage is above the suppressor grid voltage so that the cathode current flows in the screen grid circuit, the anode remaining at line voltage. A positive trigger pulse at the suppressor grid causes some of the cathode current to be diverted to the anode, starting the Miller run down. In this state the control grid is biased back by the anode-grid capacitor C2 and the screen grid takes less current because of the lack of negative suppressor grid bias so that the cathode voltage drops, maintaining the triggered condition after the trigger pulse has passed. The sweep takes place, its time controlled by the time-constant of C2,RV, until the voltage at the grid is high enough to provide enough cathode voltage to shut off the suppressor grid again, the circuit then reverting to the waiting condition. At the changeover there is a positive pulse at the anode which is delayed by about 2·2*RC* seconds (where *R* is in MΩ and *C* in μF) from the trigger fed in at the suppressor grid.

Long Time Delays

For really long time delays of the order of 30 seconds and more devices such as thermal switches, relays and clocks must be used, but quite long delays can be achieved with electronic circuitry and an example combining transistor circuitry with a relay is shown in Fig. 10. Applying power

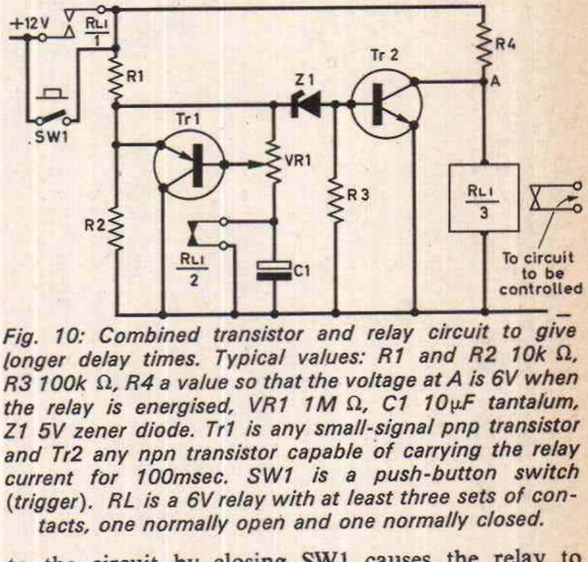


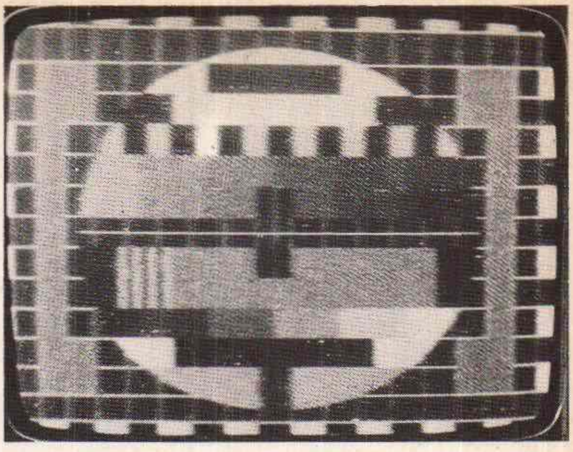
Fig. 10: Combined transistor and relay circuit to give longer delay times. Typical values: R1 and R2 10k Ω, R3 100k Ω, R4 a value so that the voltage at A is 6V when the relay is energised, VR1 1M Ω, C1 10μF tantalum, Z1 5V zener diode. Tr1 is any small-signal pnp transistor and Tr2 any npn transistor capable of carrying the relay current for 100msec. SW1 is a push-button switch (trigger). RL is a 6V relay with at least three sets of contacts, one normally open and one normally closed.

to the circuit by closing SW1 causes the relay to latch on (contacts RL1/1 close while contacts RL1/2 open) and feeds power to the transistor Tr1 which passes a current depending on the setting of the bias control VR1. As the capacitor C1 charges Tr1 is biased back, the change in Tr1 current and emitter voltage being extremely slow. When Tr1 emitter voltage is high enough for current to pass through the zener diode Z1 Tr2 is biased on and shorts out the relay, switching off the power and shorting out the capacitor (contacts RL1/1 open and contacts RL1/2 close). Very large values of capacitor can be used, provided the leakage current is not excessive, and time delays of 10 seconds to 5 minutes are obtainable. ■

DX-TV

A MONTHLY FEATURE FOR DX ENTHUSIASTS

CHARLES RAFAREL



Test card received by Seppo. J. Pirhonen, Lahti 6, Finland on ch. E2 on May 16th at 0904 g.m.t.

MAY 1970 has been a very queer month for both SpE and tropospheric DX reception. I promised last month that we would get some good SpE openings once May was with us and was congratulating myself on my prediction when on the 1st SpE/DX came in extremely well. This was at least a fortnight earlier than the main May openings of previous years—usually about the 14th of the month.

This happy state of affairs however did not last. DX was good up to the 6th with very strong long duration signals from many sources, then things went somewhat erratic. On the 7th and 8th signals were there but of poorer strength and shorter duration. Signals were good again on the 9th, receded again from the 10th to the 13th, were excellent on 15th to 17th, then they dropped right off until the end of the month.

The Trops were rather more rewarding with a very good opening here on the 18th when 15 French stations were received. But some measure of how the new local BBC1-ITV u.h.f. stations have affected me can be judged from the fact that no Dutch or West German u.h.f. signals could be received. The second reasonable Trop day was the 23rd. It was not quite so good but I suspect that DXers in East Anglia had a "party".

F2 reception of the USSR Forward Scatter Network was still about on the 16th but it is no longer as active as it was earlier in the year.

In all May 1970 tended to "fizzle out" but had its interesting moments as noted below. Here is my SpE log for the period 1st-31st May:

1/5/70 USSR R1, Poland R1, Hungary R1, West Germany E2 and Spain E2.
2/5/70 USSR R1, Poland R1, Czechoslovakia R1, West Germany E2 and Spain E2.
3/5/70 Poland R1 and R2, Czechoslovakia R1, West Germany E2 and Sweden E2.
4/5/70 USSR R1, Poland R1, Czechoslovakia R1, "new" electronic test card R1 (see below), West Germany E2, Sweden E2, Norway E2 and Spain E2.
5/5/70 USSR R1, Czechoslovakia R1, Sweden E2, West Germany E2, Switzerland E2, also "new" electronic test card on R1/E2a.
6/5/70 USSR R1, Poland R1, Czechoslovakia R1, West Germany E2, Sweden E2 and "new" electronic test card on R1/E2a.
7/5/70 Poland R1, Czechoslovakia R1, West Germany E2.
8/5/70 Poland R1, Sweden E2 and "new" electronic test card on R1/E2a.
9/5/70 USSR R1, Poland R1 and R2, Czechoslovakia R1, West Germany E2, Italy IA and IB.
10/5/70 USSR R1, Poland R1 and Sweden E2.
11/5/70 Poland R1, Czechoslovakia R1, West Germany E2, Norway E2, Spain E2 and Portugal E2.
12/5/70 Poland R1, West Germany E2 and Sweden E2.
13/5/70 Czechoslovakia R1, West Germany E2, Sweden E2 and Spain E2.
14/5/70 USSR R1, Poland R1, Czechoslovakia R1, Norway E2 and West Germany E2.
15/5/70 Sweden E2, Spain E2 and E3.
16/5/70 USSR R1, Poland R1, Czechoslovakia R1, Sweden E2, Italy IA and IB.
17/5/70 USSR R1, Czechoslovakia R1, Sweden E2 and E4.
18/5/70 Czechoslovakia R1, Sweden E2 and E4.
19/5/70 USSR R1, Poland R1, West Germany E2, Sweden E2, Finland E2.
20/5/70 USSR R1 and Sweden E4.
21/5/70 Poland R1, Czechoslovakia R1, West Germany E2, Sweden E2.
22/5/70 Czechoslovakia R1 and Sweden E2.
23/5/70 Poland R1 and Czechoslovakia R1.
24/5/70 USSR R1, Poland R1, Italy IA and IB, Yugoslavia E4, Spain E2, E3 and E4 and a *second* "new" type of electronic test card on R1.
25/5/70 Czechoslovakia R1, Poland R1 and the first type of "new" electronic test card on R1/E2a.
26/5/70 Czechoslovakia R1 and the first type of "new" electronic test card again on R1/E2a.
27/5/70 West Germany E2.
28/5/70 Poland R1 and Sweden E2.
29/5/70 Poland R1, Czechoslovakia R1, Hungary R1, Sweden E2 and West Germany E2.
30/5/70 West Germany E2.
31/5/70 Czechoslovakia R1.

I was most interested to note the SpE reception of Switzerland E2 on the 5th and Finland on the 19th both extremely strong signals on test cards.

—*continued on page 502*

USING LINEAR I.C.s

Martin L. Michaelis, M.A.

Two broad classes of applications for silicon integrated circuits interest readers of this journal. The first aims to save space and production costs by integrating sections of television receiver circuitry which could in principle be constructed equally satisfactorily with discrete components. For the general experimenter on the other hand very attractive possibilities are offered by the second category of integrated circuits which provide circuit functions not conveniently realisable with straightforward conventional assemblies. The reason why the equivalent conventional circuit fails to work is because it depends on closely-matched semiconductor junctions, often a dozen or more such junctions being required with almost identical electrical and thermal characteristics. This is technically realisable only by simultaneous formation of the junctions on a common microchip—the technique used in silicon integrated circuit fabrication.

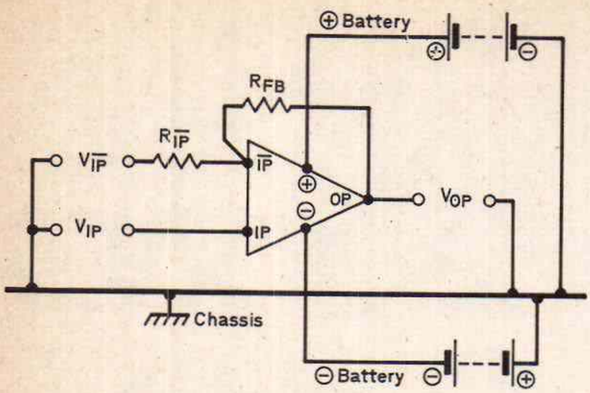
It is very difficult to design high-gain d.c. amplifiers having good temperature stability and low drift using conventional circuitry. The price of several types of silicon integrated circuit operational amplifiers has now however fallen below the price of the individual components that would be required in the nominally equivalent circuit using conventional components. Silicon i.c. operational amplifiers give a quite unparalleled performance as d.c. amplifiers. Thus the time is ripe to delve into this subject. The uses for efficient d.c. amplifiers are many in television. New possibilities arise for example for black-level transfer, a.g.c. amplification, control-loop amplification for colour circuits and for all manner of measuring circuits.

We will not go into details of particular applications in television circuits because these will become self-evident once the basic principles of d.c. amplifier circuit design and performance with integrated operational amplifiers are clearly understood. The reader will then be able to make use of these devices for his own purposes as and when required. We shall however discuss a particular example, the Motorola MC1709CG operational amplifier, and will later illustrate the practical applications by giving full constructional details for an i.c. millivoltmeter with outstanding drift stability and 1MΩ/V input impedance on all ranges. This instrument provides an unusually sensitive lowest range of 50mV f.s.d. with 50kΩ input resistance. With the increasing use of transistorised television equipment circuit voltages have become smaller yet circuit resistance has not reduced but in many cases increased. There exists a definite need for electronic voltmeters with very low ranges (in addition to the normal ones) and extremely high input resistance.

Operational Amplifiers

There is no fundamental difference between any ordinary signal amplifier and an operational amplifier. The latter term is used for signal amplifiers with superior performance in gain, linearity and stability as distinct from merely developing power for a loudspeaker or drive for a cathode-ray tube. This superior performance is desirable for measuring equipment, but the need for it was first felt most acutely in the design of analogue computers. Critical mathematical operations are here performed on the signal waveforms and drifts or linearity errors of a few per cent, which are readily tolerable in simple audio amplifiers or video output stages, would be fatal in a computer called upon to calculate orbit corrections for spacecraft or to predict exactly the landing point of a lunar vehicle. The operational amplifier was named after these computer applications.

The type of operation carried out on the input signal waveforms (addition, subtraction, multiplication, division, integration, differentiation, forming a logarithm, etc.) is not an inherent feature of the operational amplifier itself but is the result of the type of external negative feedback connected from the amplifier output back to its input. For complex operations this negative feedback system may contain further operational amplifiers with their own subsidiary negative feedback loops. An operational amplifier is not designed to carry out any particular operation: it is simply a straightforward amplifier. Its voltage gain without any negative feedback applied via externally connected components is called the *open-loop gain*. Practical operational amplifiers must possess very high open-loop gains, at least an order of magnitude greater than the highest operating gain factor used in a practical circuit with a negative feedback loop. This condition ensures that the operating gain factor is determined virtually entirely by the component values used in the negative feedback circuit and no longer to any significant extent by the characteristics of the actual amplifier. This is a general law of negative feedback circuits: if a fraction $1/n$ of the output voltage of any amplifier is returned as negative feedback to the input of the amplifier whose open-loop gain N is very much greater than n, the actual gain with negative feedback is extremely close to n irrespective of N.



IDEAL DC CHARACTERISTICS
(signs to be understood in algebraic sense)

(1) $V_{OP} = A(V_{IP} - V_{\overline{IP}})$ in general

(2) $V_{OP} = A\,V_{IP}$ if $V_{\overline{IP}}$ = zero

(3) $V_{OP} = -A\,V_{\overline{IP}}$ if V_{IP} = zero

(4) V_{OP} = zero if both V_{IP} and $V_{\overline{IP}}$ are zero

(5) V_{OP} = still zero if $V_{IP} = V_{\overline{IP}}$ = any potential arbitrarily between limits ⊕ battery and ⊖ battery

(6) $A = \text{gain factor} = \frac{R_{FB}}{R_{\overline{IP}}}$

(7) Input impedance for $V_{\overline{IP}}$ = $R_{\overline{IP}}$ (generally low)

(8) Input impedance for V_{IP} = open loop input impedance generally high (250–400kΩ) irrespective of R_{IP} or R_{FB}

(9) Output source impedance of V_{OP} = low, typically 150Ω, so that considerable current can be drawn if required

1 to 9 are very closely approached by MC1709CG

Abbreviations:

V	Voltage
IP	Input, non-inverting
$\overline{IP}$	Input, inverting
OP	Output
FB	Feedback

Fig. 1: Integrated circuit operational amplifier used as a differential d.c. amplifier.

Thus practical circuits seldom if ever use an open-loop operational amplifier. Many operational amplifiers are not even stable in open loop. Heavy negative feedback is normally used. For accurate amplification (the operation of multiplying a waveform by a numerical constant factor) or first-order arithmetical operations (addition and subtraction of two signal voltages) the negative feedback circuit is a simple network of pure resistors. We are concerned only with such simple operations in this article.

Frequency Response

Any high-fidelity conventional a.c. amplifier can perform these simple functions to operational amplifier standards for a wide range of applications, but not down to virtual d.c. (almost zero frequency). This pinpoints the real difference between a common high-fidelity amplifier and a true operational amplifier (they otherwise have much in common). The operational amplifier must be able to handle correctly slowly changing d.c. input signals. Above all, a quite steady d.c. input signal must be held indefinitely and correctly translated to the output, the output potential not changing until the input potential commences to change again.

Offset

If the input potential is zero the output potential must be exactly zero too. Any discrepancy is called an *offset voltage*. This condition is difficult to satisfy in a drift-free manner with conventional circuits. Modern i.c. operational amplifiers however adopt a completely revolutionary circuit approach to ensure stable offset cancellation in spite of their very high open-loop gains and d.c. coupling throughout. We shall examine these methods in more detail later.

Differential Drive

Most i.c. operational amplifiers possess two separate inputs arranged for accurate differential drive. Both inputs possess the same open-loop gain factor with respect to the single output but with the input IP there is no polarity inversion (a positive-going change of input voltage produces a positive-going change of output voltage and vice versa) whilst with the input $\overline{IP}$ there is a polarity inversion. Fig. 1 shows the conventional circuit symbol for an operational amplifier, with inputs IP and $\overline{IP}$ as well as the output OP. If the amplifier is to work with a single input it must be to the $\overline{IP}$ one because resistive feedback is negative only if taken to an $\overline{IP}$ input. It would be positive feedback (regeneration) causing sustained oscillation if taken to an IP input. Thus an ordinary high-fidelity amplifier can serve as a makeshift a.c. operational amplifier only if it possesses an odd number of phase-inverting stages.

Now an important feature of the two inputs IP and $\overline{IP}$ of an operational amplifier is that the output potential at OP is not only zero when the input potentials are both zero (zero offset condition) but that it *remains zero* if any other potential is applied to IP and $\overline{IP}$ *simultaneously* (input bootstrap condition). The zero offset condition and the input bootstrap condition must be accurately satisfied *even for pure d.c. inputs.* The output voltage at OP is affected only by a *difference* between the voltages applied to IP and $\overline{IP}$. Even if these applied input voltages are several volts each and the difference is only a few millivolts, the output voltage must change by exactly the same amount as it would change in response to the same few millivolts applied to one input with zero voltage applied to the other input. This is the vital *differential drive condition.*

The simple offset condition is difficult enough to satisfy with conventional circuits, the input bootstrap condition even more difficult whilst the differential drive condition imposes extraordinarily exacting demands on drive linearity. Nevertheless the integrated circuit operational amplifier type MC1709CG (to be featured in subsequent projects) satisfies these conditions to a high degree of perfection and for a price less than the separate components of the nominally equivalent 13-transistor circuit (see Fig. 3).

DC Characteristics

The d.c. input/output characteristics of the ideal operational amplifier with differential input are listed (1) to (9) in Fig. 1. The practical applications of the device are self-evident once these characteristics have been clearly understood and appreciated. The characteristics (1) to (5) are already clear from the above description. The operating gain factor which is the reciprocal of the negative feedback voltage fraction is specified by (6). The voltage source $V_{\overline{IP}}$ is assumed to have zero internal resistance; if it possesses finite resistance this must be added to $R_{\overline{IP}}$ in the expression for the operating gain factor A, i.e. the $R_{\overline{IP}}$ value used in the expression must always be the total effective input circuit resistance because this total resistance is the bottom section of the negative feedback voltage divider constituted with R_{FB}.

These d.c. characteristics are equally valid for a.c. signals up to the cut-off frequency determined by the negative feedback system. The MC1709CG can be operated with a cut-off frequency approaching 1MHz at low operating gain factors, or much less at maximum operating gain factor. Operational amplifiers with bandwidths covering from d.c. to the full video range at maximum operating gain factor are still extremely expensive, but this situation is likely to change in the next few years. In the present article we are primarily concerned with the d.c. performance which most clearly distinguishes these amplifiers from straightforward conventional types.

Input and Output Impedances

Still referring to Fig. 1 we see that $R_{\overline{IP}}$ is the amplifier input impedance as seen by $V_{\overline{IP}}$. This is because the ordinary rules of negative feedback circuits place a voltage node directly at $\overline{IP}$. A voltage node is a virtual short-circuit to chassis, i.e. a point maintaining essentially zero potential to chassis under all normal conditions. In other words the input impedance at $\overline{IP}$ is effectively zero so that $R_{\overline{IP}}$ is the only input impedance left over with respect to $V_{\overline{IP}}$. This behaviour is based on the general rule that voltage negative feedback reduces the input impedance of an amplifier. The reduction is essentially to zero if the voltage negative feedback is so heavy that the residual gain is a small fraction of the open-loop gain, as is always the case in a practical operational amplifier circuit.

Thus we can effect continuous gain control by using a potentiometer wired as a variable resistor for either $R_{\overline{IP}}$ or R_{FB}, but the proper position is R_{FB} if the continuous gain control is required with constant input impedance.

The input impedance seen by V_{IP} is much higher and equal to the value which IP would assume too in the open-loop condition. This value is typically several hundred kΩ, determined by leakage and the required input bias current for the first amplifier stage. The negative feedback taken to $\overline{IP}$ equally reduces the gain for IP, but not the input impedance at IP. Thus if we require a large input impedance we must apply the input signal to IP. To be able to inject the negative feedback we also require $\overline{IP}$. The differential input is thus necessary even if we are not primarily intent on amplifying small differences between two input voltages but are concerned solely with a single input voltage which can be connected only to a high-resistance circuit if falsification by shunting is to be avoided. It is not generally practicable to obtain high input impedances directly for $V_{\overline{IP}}$ by using a large value of $R_{\overline{IP}}$ because this would call for an unmanageably large value of R_{FB} to give the required operating gain factor. Leakage and stability considerations impose early limits on the maximum usable value for R_{FB} so that $R_{\overline{IP}}$ generally has to be quite small for large gain arrangements.

The output impedance is always very small because the final stage of the amplifier is an emitter-follower arrangement. Thus reasonable loads can be driven directly. This is important because the offset and input bootstrap conditions at least would be upset through the imperfections of any external power output stage if such were necessary. The same consideration holds true for boosting the input impedance with an external emitter-follower or Darlington arrangement. This would be quite futile because such conventional circuits possess large offsets and certainly will not bootstrap accurately. If a still higher input impedance is required series resistance must be used at the non-inverting input IP and R_{FB} or $R_{\overline{IP}}$ readjusted to give a correspondingly higher operating gain factor. For extreme cases requiring multimegohm input impedances i.c.s are on the market with *integrated* Darlington or field-effect transistor input stages. This is fully satisfactory because integration of these stages at the same time matches all junctions accurately to the main amplifier. But the price is at present quite prohibitive for general experimenting.

Typical Nominal Data

Table 1 lists important data for the MC1709CG. The total permissible power supply voltage between the positive and negative pins of the device is 36V but not more than 18V may be placed between either supply pin and the common return of the input and output signal voltages (see Fig. 1). Otherwise it is quite uncritical which particular supply voltage values are adopted. This tolerance factor is expressed by the supply voltage drift sensitivity which is typically 25μV/V, that is if either the positive or the negative supply voltage is changed by 1V, keeping the other constant, the effect is the same as if a difference signal of 25μV had been applied between IP and $\overline{IP}$. This is quite negligible for most simple applications so that power supply stabilisation is not necessary and the device is eminently suitable for battery operation, the gradual drop of battery voltage having no significant effect. The device will operate satisfactorily with any supply voltage well above the semiconductor junction saturation potentials, i.e. a few volts at each supply pin suffice.

The common-mode swing expresses the bootstrapping tolerance of the differential input. The swing to ± supply voltage implies that millivolt *difference* voltages between IP and $\overline{IP}$ are amplified equally correctly for any absolute values of the potentials at IP and $\overline{IP}$ right through the range from near the positive to near the negative supply voltage pin. The common-mode rejection ratio expresses the residual (unwanted) sensitivity to

Table 1: Manufacturer's nominal data for the MC1709CG

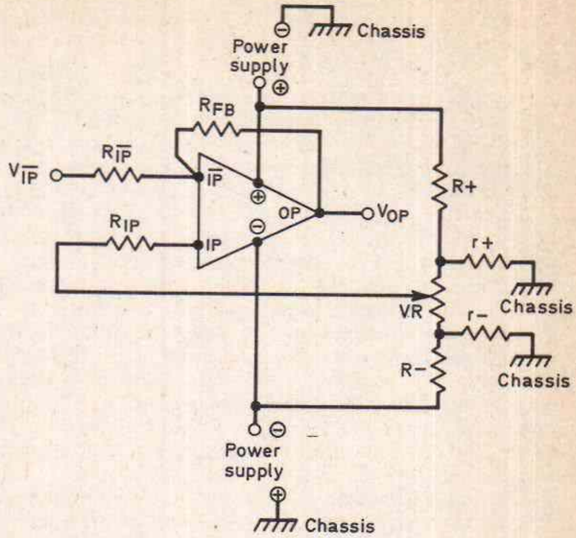
Power supply voltage:	+ 18V/ − 18V (36V) maximum
Common-mode swing:	Permissible to ± supply voltage
Maximum differential signal at input:	± 5V
Maximum output load current:	10mA
Operating ambient temperature range:	0 to + 75°C
Typical open-loop voltage gain:	45,000 (93dB)
Typical output impedance:	150Ω
Typical open-loop input impedance:	250kΩ
Typical input bias current (25°C):	0·3μA
Typical input offset current:	0·1 μA
Typical input offset voltage:	2mV
Temperature coefficient of input offset voltage:	3μV/°C average
Supply voltage drift sensitivity:	25μV/V typical
Common-mode rejection ratio:	90dB typical

changes of these absolute input voltages. The typical value of 90dB (about 30 thousand) implies that a change of 1V of the common absolute input potential produces an (unwanted and ideally zero) output voltage change of only $(A/30{,}000)$V where A is the operating gain factor. This change is clearly negligible because it lies in the microvolt range.

The maximum differential signal at the input is restricted to ±5V for this device. This means that the potentials at IP and $\overline{\text{IP}}$ must not differ by more than 5V if the amplifier is to perform correctly. At large operating gain settings this restriction is trivial anyway because much smaller differential input voltages then already saturate the output (drive the output potential at OP to one of the supply pin potentials). The restriction may however become important at low operating gain, i.e. if the device is used essentially to effect d.c. impedance step-down without incurring offset as otherwise inherent in a simple emitter-follower or Darlington stage.

Suppose for example we use a positive and a negative supply voltage each of 10V and make R_{FB} equal to $R_{\overline{IP}}$ (Fig. 1) so that the operating gain is unity. We are now unable to obtain the full output swing of ±10V allowed by the power supply because the maximum permissible differential input swing of ±5V produces an output swing of only ±5V at unity gain factor. In general, if a power supply voltage of $\pm P$ volts is used the full output swing of $\pm P$ volts can be exploited only if the operating gain factor is at least $P/5$. This is the ultimate implication of the differential input signal restriction to ±5V. Excursions beyond this limit do not necessarily lead to damage but certainly to saturation, non-linearity, offset or other departures from the proper operational behaviour.

The input bias current is the drive and leakage current required by the amplifier input stage as for any ordinary transistor. The input offset current is the inputs bias current asymmetry. The input offset



Condition for offset current balance:

$R_{\overline{IP}} = R_{IP}$

Offset voltage balance:

V_{OP} = zero exactly when $V_{\overline{IP}}$ = zero
adjust VR for this condition

General conditions:

r+ = r− (typically 50–100Ω)
R+ = R− (typically 10 – 20kΩ)
$R_{IP} \gg VR \gg r\pm$
typically 5–100kΩ; typically 500Ω–1kΩ; typically 50–100Ω

Fig. 2: Operational amplifier off set balance arrangement.

voltage is the differential input voltage required to make the output voltage exactly zero. Its value is of course ideally zero. The remaining parameters listed in Table 1 have already been mentioned or are self-explanatory.

Offset Balance

Any practical circuit employing the operational amplifier must provide for external offset compensasation. Fig. 2 shows the standard arrangement. We saw in Fig. 1 that $R_{\overline{IP}}$ is required to establish the operating gain factor and to give finite input impedance for the inverting input. The bias current produces a small voltage drop across $R_{\overline{IP}}$ and this appears as a spurious differential signal unless an equal value resistor $R_{\overline{IP}}$ is inserted in series with IP. We saw that $R_{\overline{IP}}$ is necessarily quite small but as the input impedance at IP is always large R_{IP} produces negligible loss of gain.

It is usually more important to compensate the offset voltage, which is the residual error of the internal d.c. levels • translation process and may possess either polarity for different samples of the device. Fig. 2 shows the standard potential divider arrangement around the alignment control *VR* used for offset compensation. Note that *r*+ and *r*− are essential to hold the balance point within the track range of *VR*. The resistors *R*+ and *R*− alone will not give stable offset compensation with *VR* because the slightest mismatch of their values or relative change of the e.m.f. of the two batteries would then be sufficient to shift the track potentials

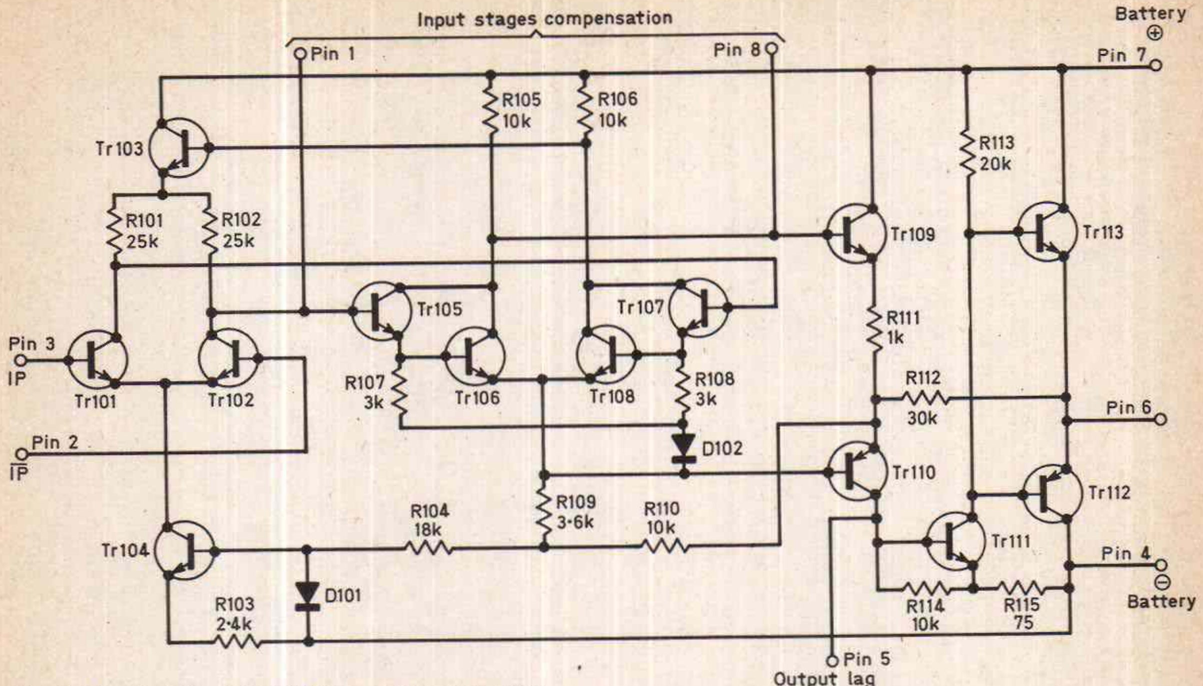


Fig. 3: Circuit of the MC1709CG operational amplifier.

on *VR* through a multiple of the offset millivolt range.

It is basically immaterial whether the offset voltage correction is applied to IP or to $\overline{\text{IP}}$. If IP is required for the high-impedance input and one pole of this signal source must be tied to chassis the offset voltage correction must be applied to $\overline{\text{IP}}$. Note that this dictates the value of $R_{\overline{\text{IP}}}$ which must now be made equal to the source impedance of the signal fed to IP to satisfy the offset current balance condition (in as far as one does not decide to relax this condition as we have done for the i.c. millivoltmeter design). This has also unambiguously fixed the value of R_{FB} for a given operating gain factor.

Circuit Description, MC1709CG Operational Amplifier

So far we have considered the operational amplifier as a "black box" viewed from its input and output terminals. Now let us look at the contents of this black box. The types of circuitry used for different devices are very varied, but the MC1709CG circuit shown in Fig. 3 illustrates a number of general features. A description in very general terms is sufficient because this circuit will not work if copied with individual components. The correct operational performance is dependent on very close matching of the integrated components. Present-day techniques for manufacturing integrated circuits readily produce closely matched component values on a single chip because all similar components are formed simultaneously by common processing steps.

All component numbers in Fig. 3 are greater than 100 to avoid confusion with the i.c. millivoltmeter circuit to be given in a later article. Tr101 and Tr102 operate as a differential amplifier with a constant-current source transistor Tr104 used in place of a common emitter resistor. This has the same effect as an *extremely large* common emitter resistor (without requiring a high power supply voltage or incurring the expense of large-value i.c. resistors). Any voltage change across R101 as a result of Tr101 conducting say more heavily because of a change in the drive applied to it will result in a change in the emitter potentials of Tr101 and Tr102 which will lead to an exact replica antiphase voltage change across R102. There will on the other hand be a high rejection factor for common-mode inputs (i.e. in-phase signals at IP and $\overline{\text{IP}}$.) The loop from Tr101 collector via Tr107, Tr108 to Tr103 emitter bootstraps R101 so that Tr101 collector potential is held essentially constant (thus also the collector potential of Tr102 in the equal inputs state) irrespective of the absolute value of the input voltage.

In effect Tr109 and Tr110 sense the collector potentials of Tr102 and Tr101 so that the potential difference across R111 can change only if a potential *difference* appears between the collectors of Tr101 and Tr102. This is possible only in response to a *differential* signal between IP and $\overline{\text{IP}}$. The resulting change of potential across R111 implies a corresponding change of current through Tr109, Tr110 to the base of Tr111. Thus Tr111 collector current through R113 changes so that its collector voltage changes and this change is translated through the complementary-symmetry emitter-follower Tr112, Tr113 as a corresponding change of output at OP (pin 6).

The arrangement of Tr109-Tr113 is one of the many variants of a totem-pole output stage commonly used in integrated operational amplifiers. On its own the series path of Tr113 and Tr112 is unable to conduct because with the bases and emitters commoned there is a crossover gap—equal to the sum threshold voltage—in which neither transistor can conduct, and beyond this range only one or the other can conduct. Thus depending on the actual potential demanded at OP for proper operational

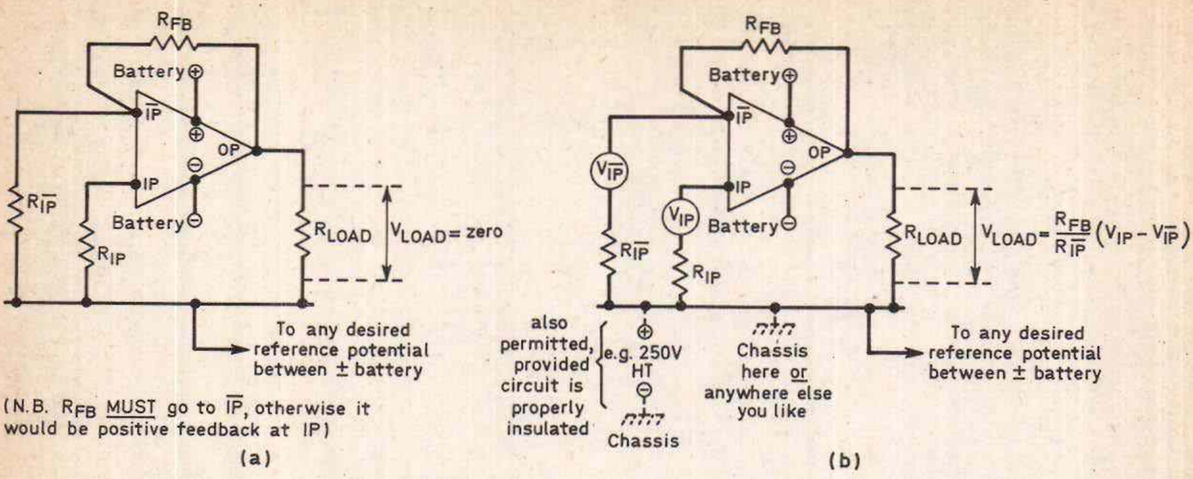


Fig. 4: Reference potential and earthing.

action either Tr113 or Tr112 will function alone as emitter-follower to drive current through the output load connected to OP whilst the other transistor is cut off. R112 provides pull-up to cancel the crossover gap.

The use of one or more differential amplifier stages derived from the basic long-tailed pair and a totem-pole output stage (named after the "stacking" of its functional sections) represents typical practice in i.c. operational amplifiers. Major differences between one device and another are mainly found in the manner in which the bootstrap and offset conditions are satisfied with intricately intermeshed feedback loops.

Operating Point

There is nothing to relate the input and output potentials of this circuit as it stands with its inputs and output open-circuit, so that no definite steady-state operating point can be taken up before we establish external connections between the inputs and the output. If the inputs and output are left disconnected slight asymmetries generally produce an immediate latch-up of OP to either the positive or negative battery potential. The amplifier is blocked in this state but will not suffer damage unless OP is short-circuited causing excessive current to flow through Tr113 or Tr112.

The correct operating point is established by returning IP, $\overline{\text{IP}}$ and OP *externally via their respective load resistors* to a common reference potential related to the positive or negative battery potentials by being tied to a voltage divider between these points.

OP must not be left open-circuit. The smallest permissible value for *R*load (Fig. 4) is dictated by the maximum output current rating of 10mA. At the other extreme *R*load must remain much smaller than the input impedance at IP as otherwise the input bootstrap condition cannot be satisfied. If it is necessary to drive a very high-impedance circuit from OP, shunt its input terminals with a suitable low-value *R*load.

For practical applications these conditions boil down to the simple rule that the external circuits connected to IP and $\overline{\text{IP}}$ must be returned to whatever common reference potential we desire OP to take up in the absence of input voltage sources or in the presence of some arbitrary equal input voltage sources in series with the IP and $\overline{\text{IP}}$ circuits.

These conditions are illustrated in a quite general manner in Fig. 4. If plain resistors or other passive components are used in series with the IP and $\overline{\text{IP}}$ inputs it is quite immaterial whether the respective input voltage sources are inserted at the "hot" end of these resistors—as shown in Fig. 4(b)—at the zero reference line end of the resistors or simply produced as a voltage drop across these resistors by injecting current from some external source—as will be the case in our i.c. millivoltmeter.

Earthing

We are still free to earth the circuit at any desired point. The conditions discussed above for establishing an operating point with a common reference line do not demand that this reference line, any other particular point, or any point at all of the circuit should be earthed.

We can earth any point of the circuit which is convenient for the purpose from other considerations of the composite equipment we are designing. The ± battery limits are not imposed here so that we can place any smaller or larger d.c. potential of either polarity between the freely chooseable grounding point of the operational amplifier circuit network and actual chassis potential—provided proper attention is given to insulation of the operational amplifier circuit network to avoid short-circuits where high float voltages are used. These considerations are important in applications such as a.g.c. or other control amplifiers in television equipment where the entire d.c. amplification process for the small control voltages (e.g. at the grids of i.f. amplifier stages) may have to take place at a large float voltage (the mean grid potential) with respect to chassis.

Single Power Supply

The reference line and earthing conditions permit operation with a single power supply as illustrated in Fig. 5 instead of with two power supplies of opposite polarity. The particular arrangement which will be

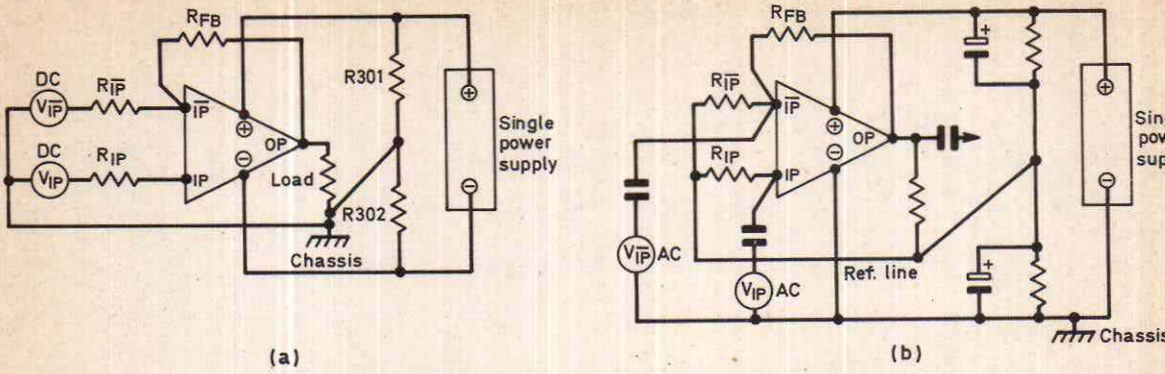


Fig. 5: Practical arrangements with a single power supply.

adopted in practice is largely determined by subsidiary considerations. For battery operation it is always preferable to use a pair of batteries since this dispenses with the bleeder establishing a reference line potential and thus greatly reduces the battery current drain. We have seen that it is not necessary to stabilise the power supply so there is no stabiliser shunt current drain involved in a battery circuit and the resulting economy with a twin battery circuit is most attractive. In a single power supply arrangement the bleeder—e.g. R301, R302 in Fig. 5(a)—must draw at least the same shunt current as the maximum circuit load current so that the battery current is twice that for twin batteries yet the voltage of the single battery must be twice that of each one of a pair. The single battery arrangement more than doubles the overall battery costs for a given circuit.

For mains operation a single power supply may be more convenient and doubled current drain amounting to only a few milliamps extra is normally no problem. There is however little difficulty in providing two equal supplies of opposite polarity with a mains power pack (they need not be exactly equal). For a single winding on the mains transformer simply earth one end and connect two rectifier diodes to the other end, the anode of one and the cathode of the other. This amounts to full-wave loading so that there is no d.c. in the transformer secondary and even small transformers will not overheat. Even if a bridge rectifier is used on a single winding, remember that a centre-tap on this winding, if available, gives the mid-point d.c. voltage. It serves directly as the reference line potential and the + and − d.c. terminals of the bridge rectifier then give the two antipolar supplies.

A situation which may make the single supply bleeder arrangement of Fig. 5 imperative is where the circuit is to be operated from the existing h.t. supplies in a television receiver. Here use a large series dropping resistor to send sufficient current through R301 and R302 of Fig. 5(a)—making sure that the total voltage drop across these two resistors does not exceed the maximum ratings for the operational amplifier—and use the earthing point as in Fig. 5(b).

AC Amplification

It is not intended to go into details of a.c. amplification with operational amplifiers in the present article but a few simple remarks may be useful. Fig. 5(b) also shows the basic arrangement for a.c. amplification. The two a.c. input voltage sources are connected via blocking capacitors to the respective inputs which are returned through independent input leak resistors to the essential reference line. This of course means that the output leak resistor must also be returned to the same reference line which will not be resting at chassis potential if one side of the single power supply is connected to chassis (it is not advisable to take the reference line too close to one power supply pole in a practical circuit; the centre point is always best). Nevertheless the amplified a.c. output signal can be taken off with respect to chassis via a blocking capacitor connected to OP.

The circuit arrangement depicted in Fig. 5(b) will deliver an amplified output waveform which is the point-for-point subtraction of the two input waveforms. If two or more waveforms are to be added point for point, connect them all to $\overline{IP}$ if the resultant is to be phase-inverted or to IP if not. Insert a series resistor with each input waveform source. The addition of the waveforms then takes place weighted in inverse proportion to the values of the resistors, since each resistor determines the individual operating gain for each waveform in relation to the common R_{FB}. Groups of waveforms may be added at IP and $\overline{IP}$ respectively in this manner so that the output is the point-for-point weighted group sums difference.

There are virtually unlimited applications for this type of circuit in shaping waveforms by part synthesis, in assembling electronic television test patterns and for similar purposes. There still exists a price barrier for devices with full video bandwidth performance, but applications in scan synchronising circuits or amateur slow-scan video systems are already possible with cheap devices. Needless to say if the a.c. signal sources are directly coupled the d.c. potentials will be transferred correctly too. The d.c. and a.c. gains can be made different by shunting the input coupling capacitors with suitable resistors or resistor networks.

The amateur circuit designer will find that the i.c. operational amplifier with differential input becomes one of his most useful "stock devices" once he has mastered the relatively simple set of rules for its use. At least for all situations demanding accurate d.c. amplification or d.c. impedance transformation these devices now available to the constructor at competitive prices represent a major breakthrough. We hope

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STROBOSCOPIC FLASH LIGHTING

BAYNHAM HONRI

In 1889 the German engineer Raders designed and constructed a "Photo-Automat" camera which used a magnesium flash in conjunction with a quickly processed ferrotype photographic reversal system. It was a brave effort, long before its time, to overcome the ordeal of sitting and posing for a portrait photograph.

Photographic emulsions were so insensitive then that in the glasshouse portrait studios used, with daylight the only illuminant, lengthy time exposures had to be made and the customer's head rested (or was clamped into position) to avoid movement during the exposure. When the weather was dull artificial light had to be added with acetylene gas flames, gas mantles or magnesium flares. No wonder those early society "cabinet" photographs gave the impression that the victim was stuffed!

Magnesium flashes have been used by newspaper, portrait and still photographers for about eighty years. They started with the igniting of the original slow-burning magnesium ribbon (sometimes fed slowly by a clockwork mechanism) and later progressed with magnesium flash powder lit with touch-paper or by a mechanically released flint device. The powder was improved and the result was a brighter flash-brilliancy of somewhat shorter duration but having explosive characteristics followed by intense smoke and an acrid smell which were most discouraging—even frightening. As might be expected this method (being potentially lethal) was responsible for the apprehension and horror often reflected on the faces of the people in press photographs of the period.

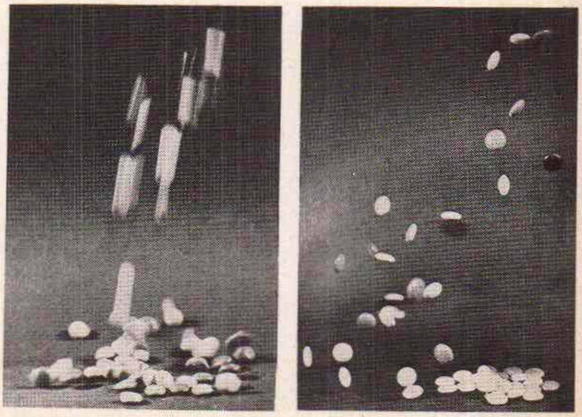
Photoflash Developments

It was not until about 1925 that the *Photoflash* and *Sashalite* systems became practicable, with magnesium-foil electrically ignited within oxygen-filled glass bulbs. This solved the magnesia smoke nuisance. As before the camera lens had to be uncapped (or the shutter opened) to be ready for the flash to give the required exposure. It was soon realised that the flash could be synchronised precisely with the opening of the camera shutter to enable cameras to be hand-held instead of mounted on a tripod. This in turn led to the development of sophisticated electronic flash-tube equipment with rather complicated but (thanks to transistor circuitry) light-weight portable control gear.

After each flash the internal capacitor has to recharge before the next flash can be made. It used to take several seconds for the energy required to strike the flash again to build up. This did not matter very much for press photography as the flash itself was of very short duration (about ten micro-seconds) and "froze" even fairly rapid movements of the people being snapped. (The word "snapshot" has been loosely and inaccurately used for years to describe amateur hand-held cameras with shutter settings as slow as 1/25th second.) But the modern snappy electronic-aided flash duration has been speeded up to 100,000th of a second and this has opened new fields of photography which are now being explored. The main and fundamental objective is to illuminate the proposed picture at the exact moment when the shutter is open—not to waste light when it is closed.

Stroboscopic Photography

Stroboflashes have progressed from weak flashes (usually for visual observation of moving machinery) to bright flashes for photography. Stroboscopic photography can be used for analysing motion on a single frame of film or glass-plate negative with the camera shutter remaining open for several exposure flashes. The velocity of a falling moving body is measured in strobe photography as a variable length, directly proportional to the variable velocity. The procedure is to open the camera shutter for the full duration of the event to be analysed and to illuminate the body with the strobe light flashes at carefully regulated speed. It is not always practical to slow down or stop machinery so stroboscopic photography



Shots from a filmed television commercial for Smarties, left using normal lighting and right stroboscopic flash lighting. ***Photos: Samuelsons.***

enables the quality and accuracy of mechanical operations to be recorded and checked.

Television Commercials

The electronic photoflash has made much progress in the last few months and is now capable of radiating fifty, sixty or more *intense* flashes a second. It is now regularly used for analysing photographically the motion of intricate machinery, projectiles—and people. The latest developments enable flashes to be synchronised accurately with the open sectors of rotating shutters of motion-picture cameras at 25 flashes per second—the number of film frames per second preferred for television use. Twenty-five flashes per second is however very flickery to the human eye and extremely uncomfortable to work under. An alternative is to provide fifty flashes a second, which are, in any case, essential when used with motion-picture cameras with reflex mirror shutters.

One of the new flash systems already offers an interlace mode in which an intermediate flash is introduced between the main "take" flashes, not only essential for reflex camera operation but to reduce the flicker effect. In this respect they can assist the optical illusions made possible by the persistence of human vision. Some of these have already been highly successful in filmed TV commercials, particularly with special effects which attract the viewers' attention to the product being presented.

Colour Balance

There are now several companies making stroboscopic flash systems suitable for synchronising with motion-picture and television cameras. All have an internal oscillator for controlling the flashing rate, or triggered off by external make-and-break contacts on a film camera or a genlock pulse from a television camera control unit. The outputs from the control consoles can usually feed one to four xenon light sources incorporating integral reflectors and front diffusers (or filters) mounted in small fully-insulated plastic housings or luminaires. The design of this housing provides an even illumination similar to daylight at about 5,400° Kelvin, with such colour balancing gelatine filters as may be necessary for the requirements of Eastman, Gevaert or Ferrania colour negative (or reversal) film stock or different three- or four-tube colour television cameras.

Two stroboscopic systems already offer a flash outfit suitable for film or TV use and capable of controlling ten xenon flash lamps (of smaller type), while another claims that it is developing a system which can supply facilities for controlling up to 32 xenon strobe lamps. These lamps are assessed on a joule rating (power on a time scale) of from 3 to 12 joules per lamp and with a current consumption of 150 Watts from the mains a.c. supply. At present the lamps make a noise, especially at slow operating speeds such as 25 f.p.s.

The economy of power for flash lighting is a factor which may in due course help the reinforcement of lighting on exteriors as well as interiors, especially when large xenon light sources become available. At the time of writing use has been confined to a lighting area of about 8ft. by 8ft. but the author has been astonished at the versatility of this new instrument for film and television purposes. Strobe lighting has the additional advantage of transmitting no heat along the light beam—unlike the heat generated by tungsten lamps or the soot, smoke, heat and noises radiated by the H.I. arc lamp.

Uses

Already strobe flash lighting has been used for pictorial action studies such as the swing of a golf club or tennis racquet, ice skating, dance routines, machinery etc. and in advertising—particularly for television commercials. It is a new field with a few pitfalls yet to be explored and avoided. But it also has a potential for increasing efficiency. The original objective for use in films or television was to ensure that the light output of every flash was fully utilised. This was a useful aim, for increased productivity, to reduce power consumption and to reinforce existing lighting techniques. Going a step further, weird effects can be contrived when three or four flashes of exposure are introduced on each frame at 25 f.p.s. Remarkable (and sometimes ghostly) multi-faced portraiture can be achieved with a moving human profile or figure.

The advertising boys are always quick off the mark in making instant use of new techniques and when some of the more irresponsible avant garde TV producers and directors get to know about i it will probably soon become yet another over-used cliché.

Systems and Suppliers

Synchronised flash systems for film and television usage are now available from the following sources:

Systems	Suppliers
Ernest Turner	John Hadland Ltd. (Hemel Hempstead)
Dawe Instruments	Samuelson Film Service (Cricklewood)
Strobe Automation	Gordon Cameras Ltd. (London)
Bron System	Rank Audio Visual (London)
Unilux	Unilux Corporation (New York)

USING LINEAR I.C.s

—continued from page 497

that this article has helped to dispel some of the fears in using these unconventional devices and will be illustrating the fine performance that can be achieved with them by giving full constructional details for an i.c. millivoltmeter using the MC1709CG. Among the features of the millivoltmeter are:

Ranges: 50, 100, 500mV, 1, 5, 10, 50, 100V f.s.d. plus 1kV f.s.d. with probe.

Resistance: 1MΩ/V on all ranges.

Overload tolerance: F.S.D. voltage for highest range (100V) tolerated permanently on any range, even in wrong polarity.

Zero setting control: From zero to f.s.d. in either polarity, continuous. Can thus be set to centre zero for aligning f.m. detector circuits etc. Indication of exhausted battery is when f.s.d. can no longer be reached with zero setting control.

Zero drift: Invisible over a period of a few hours; about ±1% f.s.d. over 24 hours' continuous operation.

Battery life: 80-100 hours non-stop, 100-150 hours intermittent.

UHF SET-TOP AERIALS

K. E. G. PITT, B.Sc.

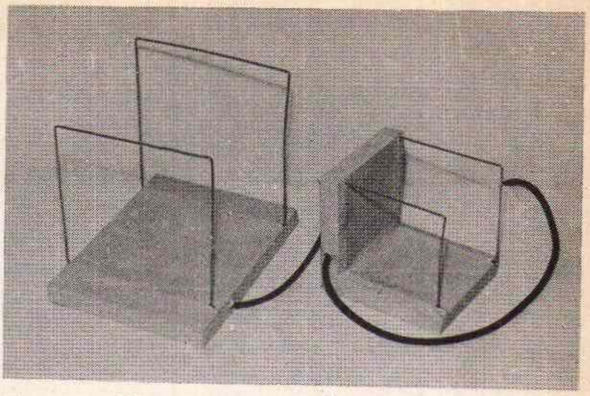
THIS is the first of two articles on set-top aerials for u.h.f. television reception. It describes the construction of three versions of the popular double-square and an easy to construct Yagi. A following article will describe a log-periodic room aerial.

A large number of people use set-top aerials for BBC-1 and ITV on v.h.f. and get quite satisfactory results although the picture quality sometimes varies with the movements of the occupants of the room due to capacitance effects. V.H.F. waves are not seriously attenuated by building materials—except steel structures—and adequate results are obtained even at distances of 15-20 miles from a main transmitter. In general it is unwise to try to repeat the use of room aerials at u.h.f. due to the significant absorption of u.h.f. signals by buildings. The attenuation is particularly noticeable on the higher channels. Wherever possible it is desirable to use an outside aerial of the correct channel group accurately positioned for the transmitter. A loft aerial may be more satisfactory than one in the room with the set because of the elimination of capacitance effects due to the occupants. However the signal in the roof space may be inadequate due to attenuation even where outside mounting under the eaves gives first rate results.

Flat dwellers may however have a restriction on the use of individual outside aerials and in the absence of a communal distribution system may be forced to attempt to get a picture with a set-top aerial if they wish to view the programmes on the u.h.f. channels.

Bisquare Aerials

The basic bisquare aerial was described in the May 1969 issue of PRACTICAL TELEVISION (page 372). Two of the versions described here are capable of being mounted either vertically or horizontally while the third is for horizontal mounting (for main transmitters) only. Dimensions are given for the three main channel groups but one of the aerials is designed to fit into a specific box which restricts it to group C only. The electrical dimensions are based on the mid-frequency of channel groups A, B, and C. For stations using D and E (wide channel spacing) the aerial may lose efficiency on the extreme channels if these figures are used. Some improvement may be made by using measurements based on the mid-frequency of the particular set of channels used. If it is impossible to obtain adequate bandwidth in this way bias the dimensions towards the high frequency end which is usually the more difficult to receive satisfactorily.



Prototype bisquare aerials, left horizontal type, right universal type for vertical or horizontal polarisation.

The dimensions of the elements for the bisquare aerials are given in Table 1 and Fig. 1 shows their construction. They are made of tinned copper wire straightened and stiffened by stretching. Stretched copper wire becomes quite stiff and is a convenient element material. For group A it is desirable to use 14 s.w.g. wire for added rigidity, but for the others 16 s.w.g. is adequate. The use of the thicker wire makes soldering a little more difficult, requiring a relatively large iron to overcome heat losses. For an even stronger alternative, $\frac{1}{16}$in. round or square brass rod may be used. The dipole and reflector are made in the same way for all three types of bisquare aerial construction to be described. The 1in. spurs on the dipole are trimmed to a convenient length before soldering. Make the reflector so that there is an overlap for soldering in the middle of the bottom face to complete the square.

Fully-sealed Version

The first version is a fully sealed and electrically isolated model using a plastic food box, approximately 4×4×2in., obtainable from Woolworths. It is only applicable to group C channels due to the physical size although it may be possible to find the larger boxes necessary for the lower channels. The optimum element spacing of a double square is $\frac{1}{4}\lambda$ but there is very little loss of signal if this is reduced to $\frac{1}{8}\lambda$ and this spacing is used here. 1·8in. is conveniently close to the inside depth of the box.

The reflector is fixed to the inside of the lid using p.v.c. tape while the dipole, with its cable soldered on first, is taped to the inside of the base. A small hole is made in the corner of the box to take the cable. It is then possible to use this model for either horizontal or vertical polarisation. If the lid is sealed on and a sealant also put round the cable entry hole it is quite practicable to mount it outside a window to avoid possible capacitance and attenuation effects. The double square is quite directional and it is worthwhile experimenting to find the best location and direction.

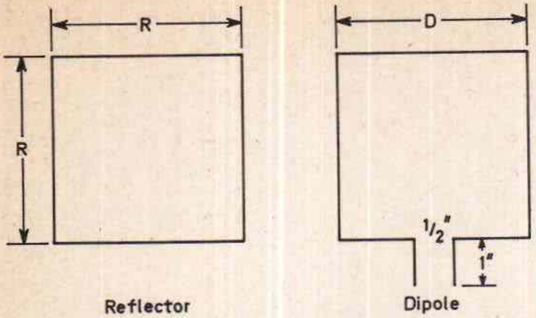


Fig. 1: Bisquare aerial elements.

Horizontal and Universal Versions

The other two versions of the bisquare are electrically identical and are suitable for the three main channel groups and for groups D and E with the reservations stated earlier. The elements are supported on a chip board block hollowed out to take the cable connections and isolating capacitors. It is necessary to use isolating capacitors for safety reasons as the metal elements are exposed giving rise to a risk of live parts being present if the aerial socket in the set is inadequately isolated. The version for horizontal polarisation uses one block only but the universal one has a second block mounted at right angles to the first to act as support when receiving vertical transmissions. In both cases the aerial is completed by covering the blocks with adhesive vinyl sheeting as supplied for covering shelves. This can be chosen to match the decor of the room if desired and gives a neat finish.

First, then, the horizontal-polarisation version.

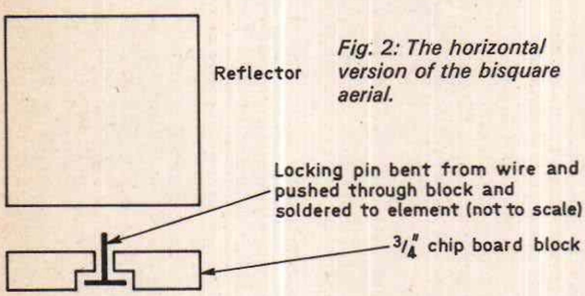
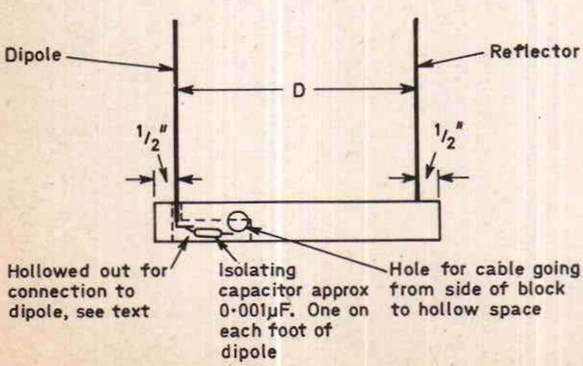


Fig. 2: The horizontal version of the bisquare aerial.

(a) Cross-section through reflector



(b) Side view of aerial block

Table 1: Element dimensions for bisquare u.h.f. set-top aerials

Element	*Channel Groups* A	B	C
D	5.5in.	4·3in.	3·6in.
R	6in.	4·5in.	3·75in.

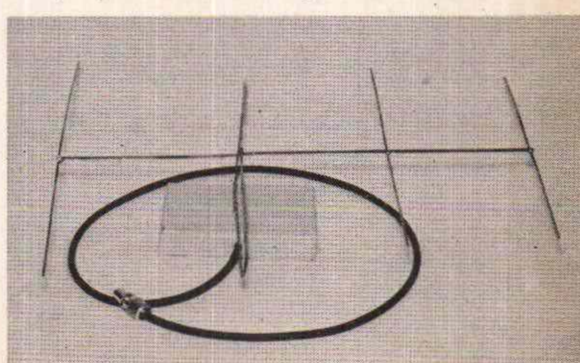
The mounting block is made from ¾in. chip board cut to a size depending on the channel group needed. The length is $(D+1)$in. and width Rin., where D and R are as given in Table 1. The reflector is held in place on the block by a pin of the same material and this is soldered to it. The pin itself is held captive in the block as shown in Fig. 2. Two holes ½in. apart, just large enough to force the wire through, take the dipole connecting feet. The area under these holes, approximately two inches square, is hollowed out to about half an inch deep to take the cable connections and isolating capacitors. The dipole is locked in place before soldering by bending the feet over. The cable may be brought in either at the end or side of the block. It is shown in Fig. 2 at the side. When building is finished the block is completely covered by vinyl sheeting, covering also the bottom sides of the squares which rest on it. This makes the assembly quite sturdy.

For the horizontal/vertical version a second block at right angles to the first is added to enable the aerial to be turned through ninety degrees for vertically polarised transmissions. The elements are locked to the second block by soldered pins as above, making a very rigid assembly. The completed structure is then covered as before. Assuming that the chipboard is ¾in. the length of the second piece is the same as before but its other dimension is ¾in. greater.

A double square aerial may also be used for Band III. In this case the square sides are between 13in. for channel 13 and 15½in. for channel 6. The spacing ($\frac{1}{8}\lambda$) ranges from 6½in. to 7¾in. It may in practice be worth finding experimentally the best distance before making a rigid assembly.

Four-element Yagi

The four-element Yagi array is for set-top use with horizontally polarised transmissions. To avoid a large and obtrusive structure, gain and directivity have been sacrificed for size. If the gain and directivity are insufficient it is possible that a version of



The prototype four-element Yagi array for use with horizontally-polarised transmissions.

the log-periodic aerial to be described in a following article may provide a more efficient alternative.

A convenient and simple room aerial may be made by constructing a conventional Yagi from thin rectangular brass rod. The elements may be either soft or hard soldered together. In the prototype (see accompanying photo) $\frac{1}{16}$in. square material was used throughout although greater rigidity would be obtained using $\frac{1}{8}$in. square rod. The aerial is supported by its folded dipole connections on a chipboard base. Fig. 3(a) shows a cross-section through the dipole. The coaxial cable passes through a hole in the side of the block into a hollowed out space below the dipole feet. Electrical connection from the cable is via isolating capacitors of approximately 1000pF, one to each side of the dipole as shown. To give a presentable finish the completed block is covered with an adhesive vinyl sheeting.

Table 2 gives the element dimensions and spacing for the group C channels, 51-68. The dimensions for group A (21-34) and B (39-51) may be obtained by multiplying the figures in the table by 1·5 and 1·2 respectively. If the completed aerial is too flexible, leading to flashing on the screen if it is knocked, an alternative dipole construction using $\frac{1}{8}$in. rod may be used as shown in Fig. 3(b). The $\frac{1}{16}$in. rod was used originally because of the ease with which it can be bent. The $\frac{1}{8}$in. material is much more difficult to form in this way and as shown the folded dipole

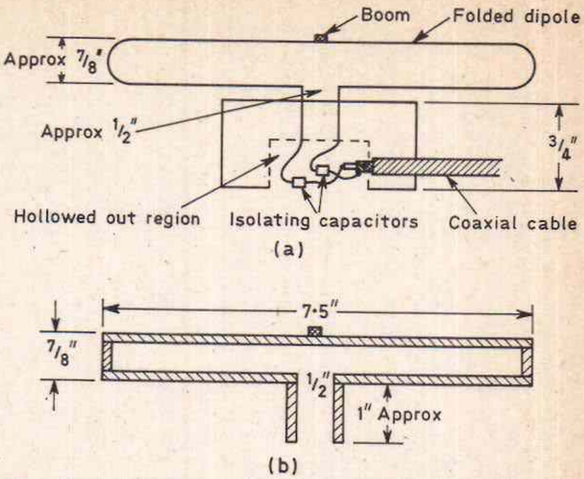


Fig. 3: (a) Cross-section through folded dipole using $\frac{1}{16}$ in. brass. The dipole feet are $1\frac{1}{2}$ in. long and bent over inside the block to lock them in place, then cut to a convenient length before soldering the capacitors and cable. (b) Dipole using $\frac{1}{8}$ in. brass. The six pieces are hard soldered together before insertion into the block and the electrical connections made by soft soldering using a fairly powerful iron.

is fabricated from six pieces hard soldered together. The aerial is effective in areas of high signal strength but like all room aerials its results are liable to fluctuate with movement of people in its vicinity.

Table 2: Four-element Yagi u.h.f. aerial dimensions

Element	*Length*	*Spacing*
Reflector	*7·5in.*	
		3·5in.
Dipole	*7·2in.*	
		3·0in.
Director 1	*6·7in.*	
		2·9in.
Director 2	*6·2in.*	

Safety Note

Isolating capacitors must be used in order to avoid any risk of exposed metal parts becoming live due to insulation failure in the aerial connections of the set. They must have a working voltage of at least 250V, preferably higher.

DX-TV

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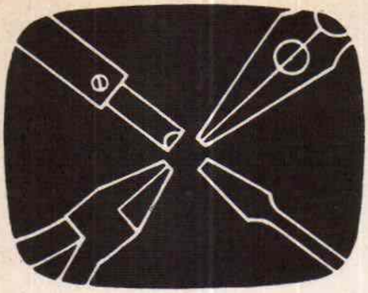
These are usually late season stations which confirm that SpE/DX is somewhat unusual at present.

At least two "new" electronic test cards are about but in the absence of good signals and some photographic record for the second one I can only describe them as best I can. Type "A" electronic card on R1/E2a is vaguely reminiscent of the Marconi Resolution Chart No. 1 as used by Yugoslavia and Eire and shown in our data panel No. 18. A noticeable similarity is the white rectangle with inner black rectangle inside the centre circle at the top. The bandwidth graduations are similar to data panel No. 18 but with a distinctive black horizontal band centrally across the centre circle with a narrow white line running through it.

We have a report and photo via R. Bunney from a DXer in Finland of his reception of this card late in 1969. Both R. Bunney and myself have seen it, my dates of reception being given above. The best reception was of fairly long duration on the 4th but it was not very strong. The later dates were for short duration reception. We have noted that it "floats" with the Czech card so the station using it is probably in the same direction generally and at about the same distance.

As yet we have no positive identification but I have done a little detective work. The following are my conclusions. It cannot be Czechoslovakia or Poland which still use the old Retma Polish/Hungarian type card followed immediately by the opening caption. It is not of USSR origin and seems unlikely to be Bulgaria, seen earlier this year on test card G. This leaves us with Hungary or Austria as the only possibles. My own recent Hungarian reception has been identified from clocks and opening captions some time after reception of the usual Polish/Hungarian Retma card. I still feel that this card is being used by Budapest—with the consequent confusion with Poland. Therefore my suggestion is that this "new" card is of Austrian origin. I am pretty sure that this is correct. Apart from this possible card Austria has been missing so far this year although Czechoslovakia has been around quite a lot.

Type "B" card as received here on the 24th May —on R1/E2a again—was a weak short duration signal consisting of an irregular pattern of black, white and grey squares and rectangles within a centre circle. There are apparently no corner circles. I have no idea as to its origin except to note from the aerial direction that it lies to the East and would welcome any reports from other DX friends who have seen it.



SERVICING television receivers

L. LAWRY-JOHNS

ITT-STC VC51 CHASSIS

THIS chassis is a development of the VC4 and in fact some of the large number of KB and RGD models in which it is used were fitted with the VC4 in early production runs. The KV015 and the RV215 are examples but in the main most of these and all later models are fitted the VC51. Some chassis carry the number VC51/1 or VC51/2. The former denotes that the heater chain is modified to include indicator lights whilst the latter means that the chassis mounting is altered to suit a particular cabinet presentation, e.g. models KV025 and RV225. The subsequent VC52 and VC53 chassis are basically similar, see notes later.

Hand-Wired Chassis

All these and preceding chassis are hand wired and therefore the problems which are often encountered in servicing printed panels do not arise. Accessibility is good and fault tracing presents few problems. The u.h.f. tuner is transistorised but all other stages including the v.h.f. tuner use valves.

Circuit Notes and Common Faults

The mains supply is taken direct to the on-off switch, thence neutral goes to chassis and live to the mains dropper with no intermediate fuse. Three sections of the dropper are at a.c. potential and two are at d.c. It is important to study the circuit in order to appreciate the following notes. The live mains is taken to the junction of R169 and R170. The heater circuit is through R170 and R171, over to the front right side R166 and thence through the heater chain commencing with the PY801. The VC51/1 is a little different to cater for the indicator lamps: R166 is reduced in wattage rating and in value and is in series with a thermistor also on the front right side; there is also an indicator lamp shunt thermistor next to the dropper. As R166 often becomes open-circuit (resulting in the set being inoperative with none of the valve heaters working) it is as well to remember its value—135Ω 15W (the value is 50Ω in the VC51/1). The two heater sections on the dropper are R170 (78Ω) and R171 (100Ω). The voltage selector must not be altered in order to short out a defective section. More basically good sets are ruined by this irresponsible action than by any other. If a section is open-circuit replace it with a resistor of the correct value (or at least very near) or replace the complete dropper.

In brief therefore the first common fault is that although the mains supply is applied to the set the valves do not light up due to R166 (usually) being open-circuit. At this point the reader may well ask what happens when C142 (mains filter capacitor) shorts as there is no protective fuse. The answer is that it depends upon the value of the first fuse in the circuit at the supply point. Ideally this should be a 2A cartridge in the supply plug or adaptor in which case it will merely fail with no harm done. If the fuse rating is much higher the on-off switch may be damaged necessitating the replacement of this as well as the capacitor.

The HT Supply

The a.c. supply at R169 (7Ω) is taken to the 1A h.t. fuse and thence through R165 (13Ω) to the BY 100 h.t. rectifier. The d.c. output of this is taken to the smoothing circuit consisting of the reservoir capacitor (C145) and the resistors R167 and R168 on the mains dropper. Smoothing is effected by C143 and C141.

If therefore the valve heaters are glowing but there is no other sign of life first check both tags of R169 (using a neon or a.c. voltmeter) then the 1A fuse and R165. If all is well go back to the dropper sections R167 and R168 remembering that the voltage is now d.c. R165 is the likely culprit. If on fitting a replacement an h.t. short is obvious (resistance test with the receiver off or the fuse blows when switched on) further tests will have to be made to locate the source of this. Check the condition of the video stage resistors and that of R32 (roughly in line with V11 valve base) which is the supply resistor to the tuner unit.

HT Shorts

The causes of h.t. burn outs are not always what one might expect. A charred resistor usually leads one to suspect a capacitor short to chassis. This is sometimes the case and the remedy is obvious. However, consider the following case: "We were watching ITV on 405 lines but when we switched over to BBC-2 there was a smell of burning and no picture. We switched back but there was nothing on 405 either." Upon investigating the source of the burning it was found that R32 was charred. The supply to the u.h.f. tuner is taken from a socket on the side of the v.h.f. tuner. The cover of the v.h.f. tuner—which has to be removed for turret cleaning—is secured by clips at either side (sometimes, but

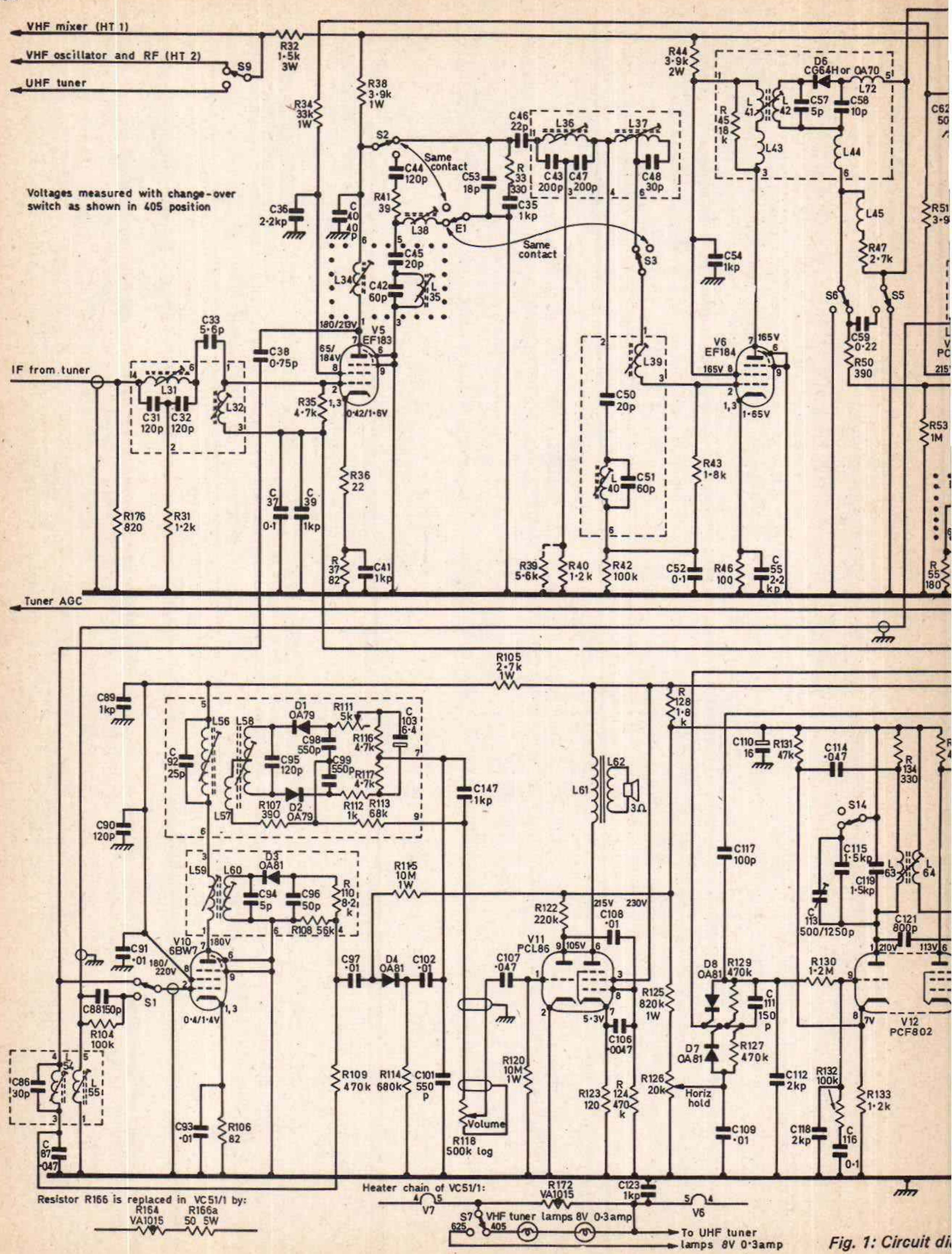
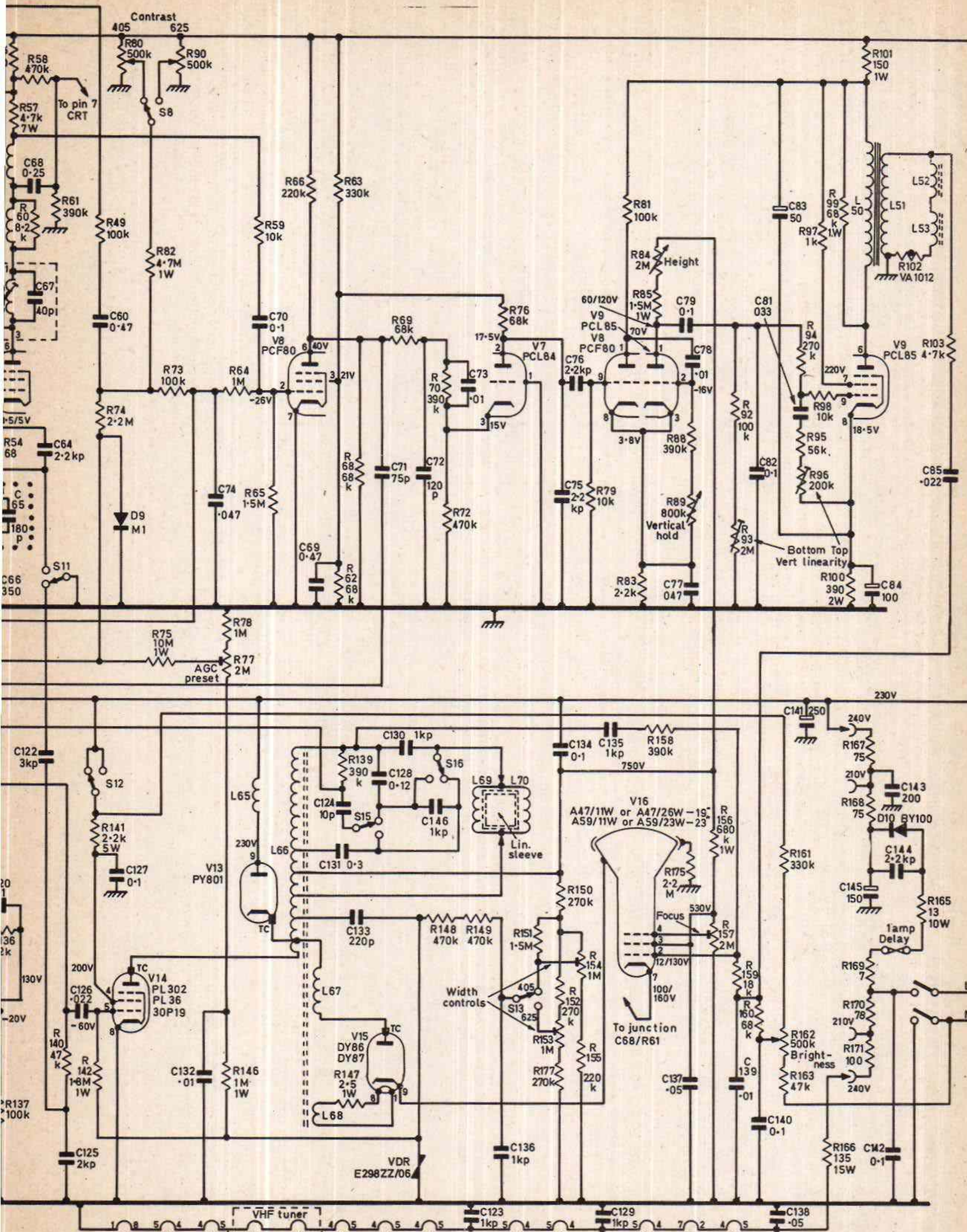


Fig. 1: Circuit di



...am of the STC-ITT VC51 chassis. *C143 should be shown as an electrolytic.*

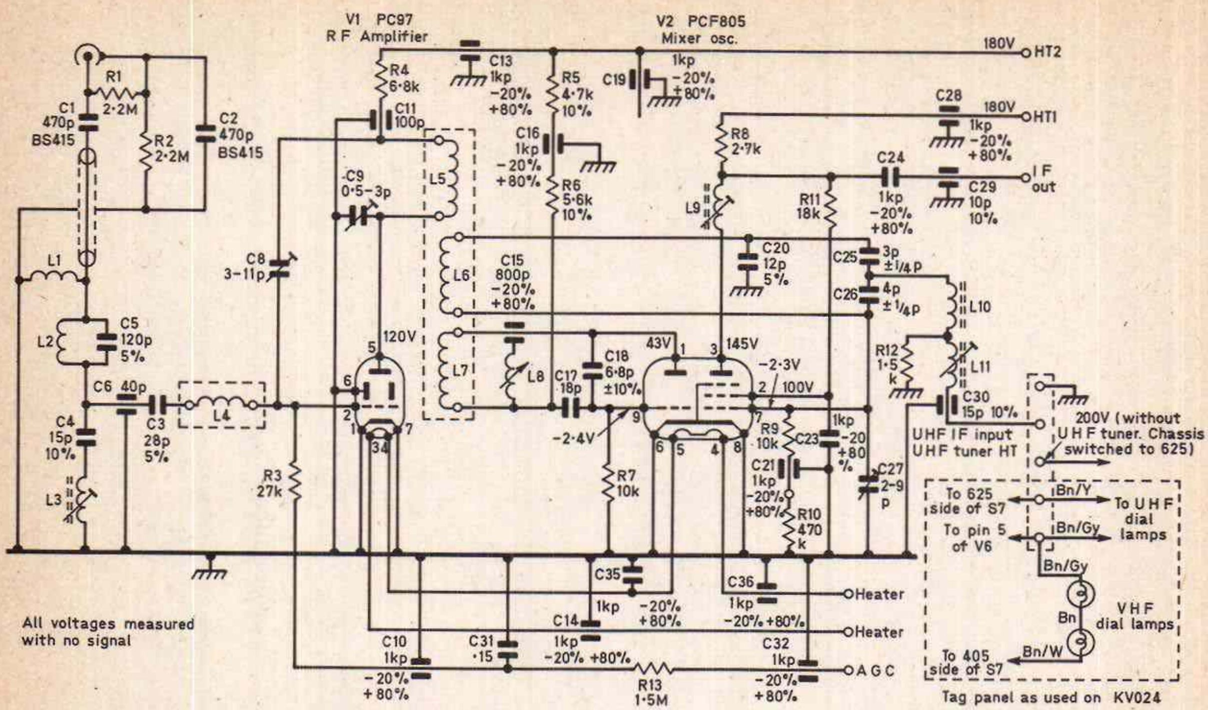


Fig. 2: Circuit diagram of the rotary v.h.f. tuner unit.

not always, also by screws). On more than one occasion the cover has been found unclipped and touching the h.t. supply socket to the u.h.f. tuner. It is reasonable to assume that the cover had been removed at some time and had not been securely replaced. The action of switching from one 405 channel to another had loosened it so that it touched the supply point and when the receiver was switched to 625 R32 was shorted to chassis.

The Video Stage

The PCL84 video circuit is a happy hunting ground for damaged resistors. The usual sequence is for the PCL84 to develop an internal short, either screen to cathode or screen to control grid. Whilst the effects are similar in the latter case it is most likely that the detector diode (D6) is also damaged if the set was operating on 405.

The interesting thing about the former condition (screen to cathode short) is that the set may still be operating, albeit with a very poor picture. This is achieved with something like 20V on both screen (pin 9) and cathode (pin 7) with R51 and R55 in an advanced state of decomposition although R56 and R54 seem to escape damage.

In either case the drill is to check all associated resistors, change the PCL84 and check the back-to-front resistance of the OA70 (OA90, CG64H or whichever is fitted in the D6 position). There is no need to remove the diode in order to check it. With an ohmmeter connected with the negative probe to chassis and the positive to pin 8 of the PCL84 a very low reading will be obtained due to the diode conducting. When the leads are reversed however the diode should not conduct and a reading of 3kΩ should be read through R50 and R47. If the reading is low both ways the diode is shorted. If it is 3kΩ both ways the diode is not functioning at all. These readings will be obtained with the system switch in the 405 position only due to the presence of C59 when 625 is selected.

Field Timebase

The field circuit consists of a PCL85 valve working in conjunction with the triode section of a PCF80. The latter gives very little trouble. It is a pity that the same cannot be said for the PCL85. The later PCL805 seems to fare little better. Therefore this is the first suspect whenever trouble is experienced with the vertical size of the picture or the hold. A faulty valve in this position will often damage its cathode bias resistor causing it to go high or low. If it goes high the top of the picture will be compressed. If it goes low, the bottom will be affected and the new valve will have a short life. We can summarise the expected faults and their symptoms as follows:

Bottom Compression: If this is severe check the valve, the bias electrolytic (C84) and the h.t. electrolytic C83. The valve and C83 can also cause an undulating picture where there is regular waving up and down, i.e. the space between the lines is constantly varying, leading the viewer to complain of sea sickness. This should not be confused with poor h.t. smoothing which also affects the line timebase, giving vertical objects a regular varying wave as well.

Overall Lack of Height: In earlier STC (ITT) models (WV05 etc.) the boost line supply to the height control was taken via a resistor and decoupled by an 0·1μF capacitor from the control to an h.t. point. This capacitor had a habit of shorting, causing the feed resistor to overheat and the height of the

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ICONOS

UNDERNEATH THE DIPOLE

ABOUT four years ago sufficient progress had been made with 8mm. colour film emulsions for this gauge to begin to have a potential for full professional status in television. Better utilisation of the photographic area and a rearrangement of perforations (with an alternative space for a sound track) led to the Super-8 format, which provides a 52% greater picture area per frame than the long-established "standard" 8mm. This difference alone gives a great improvement in photographic resolution and has encouraged television engineers to consider it for television use—particularly for local news items. Until about six months ago the best results approaching professional requirements were on Ektachrome commercial type 7255 film stock for original camera film with Eastman colour type 7170 internegative for the print process and Eastman colour print film type 7385 for the final release print for projection or for telecine play-off. This was followed by further slight improvements in the internegative film emulsion, giving better colour rendering and a sharper result. Progress then halted a while so far as quality was concerned, but advances of another kind took place in the print film, enabling that process to be carried out three times as fast and without loss of quality. Finally has come a new Ektachrome commercial film, type 7252, which gives more latitude for the cameraman together with better colour balance and sharpness.

This has led to modifications to the colour processing baths, which are now more or less along the same lines as the popular ME4 developing process used by many 16mm. Ektachrome films by the BBC and ITV companies, for complete colour documentaries as well as inserted exterior sequences in videotaped productions.

TV NEWS ON SUPER-8?

I have written down these Kodak emulsion numbers with caution. It is probable that other manufacturers of colour film will reveal similar advances in photographic quality. I have seen splendid Gevacolour results on Southern Television under the name Gevachrome using 16mm. colour reversal film.

These points are of special importance to the regional TV stations, both BBC and ITV, whose film stock and processing costs have rocketed up to four or five times with the advent of colour. The use of 35mm. colour negative has been practically abandoned by the BBC for shooting exteriors. The colour balance between videotaped interiors and 16mm. filmed exteriors has proved entirely satisfactory. The new stocks and processing system have yet to be seen by viewers.

Marvellously improved film stock is not the only factor: what about the Super-8 film cameras, projectors and telecine machines? And what about synchronous sound; how will it be recorded? It must be admitted that Super-8 film cameras are at present mainly in the amateur holiday-snap class, more or less mass-produced with film-transport claws like miniature stiletto heels, film gates which don't always hold the film in the right position and cassettes which aren't 100% reliable. There are however a few rather expensive instruments in the Super-8 category. At the time of writing, the Beaulieu (French-made) seems to be the only camera in this class with a mirror reflex shutter and a high magnification reflex viewfinder.

REGIONAL NEWS

Away from the big cities in the USA local TV news in colour has become very popular, particularly since high-quality Super-8 film and equipment became available. Will our provincial and regional stations be able to do the same? The trend during the past two or three years has been the exact opposite. Local news at most regional stations is in black-and-white. Southern has made good progress with 16mm. reversal colour but the present cost of colour film dismays the programme controllers of the smaller stations of both ITV and BBC.

The BBC has restricted the activities of its smaller regions to cut down costs. Super-8 filming, using colour-reversal film processing in the station's film department (not requiring film printing), then editing and putting the film straight on to colour telecine might be one answer. Another way would be to use Super-8 film in negative form on telecine, electronically phase-reversing the picture to convert it into a properly colour-balanced positive picture for transmission. In both cases really professional Super-8 projectors would have to be multiplexed on telecine so that a choice of 16mm., Super-8 and slide-transparencies could be displayed to one colour TV camera.

DIRT—8mm SNAGS

The gauge of the film may be reduced in width to save money but the magnitude of dust and dirt remains the same, becoming relatively more objectionable on the smaller gauges. Every time a film is projected or run on telecine and rewound friction is applied to the film and this develops a charge of static electricity. This attracts dust like a magnet attracts iron filings, especially when the air is very dry. One way of neutralising static charges on a non-conductive material is by ionizing the air around it. The dust then becomes loosened and can be blown away. The Meech system does this electrically with a device which can be fitted to a motorised rewinder or on to an actual telecine machine. This is a dry-cleaning type of treatment, in a way like a vacuum cleaner.

Then there is a kind of washing-machine process using a special quick-dry liquid that is activated by a supersonic transducer and bombards the film with

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EVR AND ALL THAT

PAUL SILVERHAY

A REVOLUTION in home entertainment has come over the horizon and is fast approaching our front doors. Soon it may be possible to watch *Steptoe and Son* every night of the week or to see again that "marvellous play". This revolution is the result of the simultaneous development of a number of systems for replaying recorded television programmes from a machine into the ordinary domestic television receiver.

That so many manufacturers should be interested in this field is significant. The possible markets for variants of instant television replays are large. Education and industry must be the basic meat but the market attraction is the home. At the right price a replay system could possibly be sold to anyone with a television receiver—given time. The systems offered or proposed fall into two distinct types—those based on the use of film and of tape. The present systems have been developed by EVR, Philips, Sony and RCA.

THE EVR SYSTEM

The EVR (Electronic Video Recording) Partnership was set up to exploit the invention of Dr. Peter Goldmark—who also produced the first successful long-playing record—outside the US and Canada. The Partnership was formed by CBS, ICI and CIBA, making an extremely powerful group. The EVR system uses a microfilm with two half-tracks of recorded information. The film strip width is 8.75mm. and is loaded into a self-sealing cartridge. To achieve reasonable definition with such a small area (frame image size is 0.10in. by 0.13in.) the grain size of the film is critical. A large amount of successful work has been done on this aspect by Ilford.

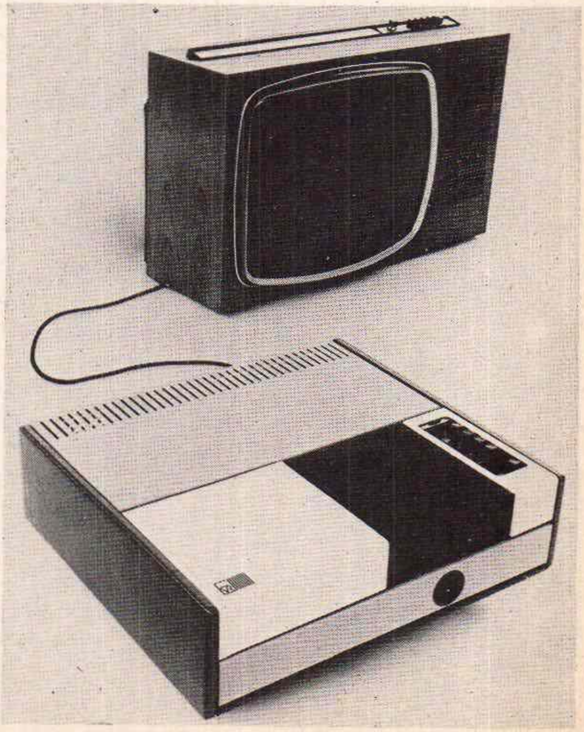
To eliminate the loss of definition inevitable with normal photographic exposure and development an EVR master film is made using an Electron-Beam Recorder (EBR). In this a stream of electrons bombards the special master film which is mounted in a vacuum. The cartridge films are then made from this master film by a multiple copying process. Each half-track of the film has its own magnetic sound track. With a monochrome cartridge there can be two half-hour programmes with appropriate sound and with colour cartridges (when the second track carries the chroma information) one half-hour programme is accommodated and the two sound tracks can carry stereo information or possibly a two-language version.

Playback of the EVR film for television display could be by using either a camera or flying-spot system but because of its advantages a flying-spot system has been adopted. The "Teleplayer" as it has become known contains this equipment and takes the EVR cartridge. Automatic threading is employed so that the film is never touched by the operator. This together with the cartridge sealing and the fact that the film has no sprockets ensures a long life. To synchronise the frame rate of the teleplayer a series of electronic sprocket holes is recorded down the centre of the film. From this is produced sync pulses. The output from the player is either video plus audio or a modulated r.f. signal which can be fed directly to the aerial socket of a television receiver.

The system design inevitably means that the programme viewer cannot record his own material—he will be limited in his choice to the films made by the EVR Partnership at their Basildon Plant. Already however the catalogue suggests a very large choice. It is expected that the first teleplayers sold in this country (manufactured by Rank-Bush-Murphy under license from EVR) will be available in the early part of 1971. They will be monochrome machines but adaptable for colour by the insertion of four or five printed-circuit cards. The price is expected to be around £300.

VIDEOTAPE CASSETTES

Conventional ½in. videotape is used in the cassette videotape recorder recently demonstrated by Philips. In an attempt to standardise such machines, Philips and Sony have liaised and this will lead to the production of machines capable of playing back and



Prototype EVR teleplayer connected to a standard domestic television receiver.

recording on 60-minute cassettes in monochrome and colour. The machines from Sony are expected to be available in Asia towards the end of this year but no firm date has been announced for supplies to Britain. It is expected that unrecorded tape cassettes will be available as well as a programme library of prerecorded material.

Philips of course also market (through Pye TVT in this country) a number of VTR machines not using cassettes. The latest and lowest priced of these is the Pye "Teacher" (see *Teletopics*, March 1970). Sony too have their EV210CE and CV2100ACE machines which will continue. These machines will still attract a market slightly different to those that cassette machines are aimed at.

RCA HOLOGRAM SYSTEM

RCA also intend to enter the cassette market. Their system is ambitious in the extreme and if it becomes commercially viable could render all the other systems completely redundant. The product to the user will be a videotape cassette with the tape made of vinyl—the material used for packing foodstuffs. The tapes will be produced in massive numbers by a holographic process in which a beam of light is split into two parts, one part going to the optically sensitive surface and the other after processing to the object being recorded. The interference pattern produced by the two beams is the hologram.

The production of the holograms requires a light source which can be accurately controlled both in terms of intensity and beam width. High colour purity is also essential. The light source that fills these requirements is the laser—famous for its James Bond role of cutting through 2in. steel plate but less renowned in its more constructive roles such as welding the retina in the human eye.

The RCA system has been demonstrated in public but those who saw it considered the results very disappointing. It would however be wrong to dismiss it. Even if it is five years before the system is commercially available at an acceptable quality it may still be said to be years ahead of its time.

PROSPECTS

All the systems described are either colour capable as a design feature or as a later conversion. In each system the cassettes are bound to be the area of maximum competition between manufacturers. EVR cartridges are expected to cost "under £20" and ½-hour cassettes of videotape should cost about £8.

Each announcement of another system jars to those who have been striving towards some sign of compatibility in these matters. And the field is certainly not yet closed—a number of Japanese manufacturers have already indicated that their research is leading towards the production of further machines. Perhaps too the cards are on the table for the development of an all-British videotape recorder for this kind of market. We know certainly that one large manufacturer in this country is keeping the area under constant discussion and surveillance.

The systems so far developed are in competition in so far as replay facilities are concerned and in the sense that the VTR chains (except RCA) allow recording of any material whereas EVR only allows the use of catalogued material. Thus VTR must be considered more flexible. A videotape however is unlikely to allow more than 100 or so satisfactory passes whereas EVR film gives every indication of allowing over 300 passes without degradation of quality.

Even though the marketing of EVR has been delayed until the New Year (so as to provide a teleplayer simply convertible for colour) it has a head start unlikely to be overtaken. The market at the moment is theirs and it is expected that both teleplayers and cartridges will become available to educational and industrial training users by March 1971. It is possible that the domestic user will begin to see EVR offered for sale by the summer of 1971.

EVR is interesting not only as a domestic entertainment system but also as an electronic process. A much fuller description of the system will be given in next month's PRACTICAL TELEVISION.

Note: The E in our heading is a scale drawing of blank EVR film stock.

SERVICING TV RECEIVERS

—continued from page 506

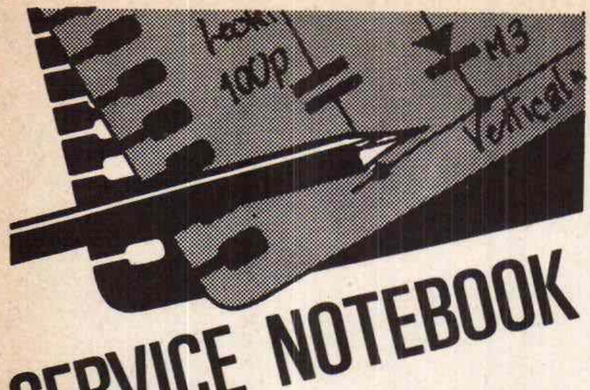
picture to be considerably reduced. The circuit has been modified in these later models so that the height control connects direct to the boost line and a 1·5MΩ resistor is wired from the control to pin 1 of the PCL85 valve base. This is the resistor (R85) to check if the height is reduced and the valve is in order. Check C79 if the resistor is found to be in order. The check should be of leakage as well as capacitance; merely shunting a similar capacitor across the suspect is no test.

Top Non-Linearity: Most readers seem to be able to cope with non-linearity defects which affect the bottom of the picture but are less certain when the top is affected. We have already mentioned that the value of the cathode bias resistor of the output valve is critical, the top of the raster being affected when the resistor is too high. Quite obviously the top linearity control and therefore C81 are suspect and should be checked, but an item often ignored is the damping device across the primary of the field output transformer. In these receivers this is a resistor (R99 68kΩ 1W) and while this does not often change value it can. If it drops sufficiently in value it can severely cramp the top of the raster.

The oscillator stage components are often only checked in the event of hold problems and it is not often appreciated that the duration of the retrace period (shape of the oscillator sawtooth waveform "down slope") affects the top of the picture: the "pulse and bar" inserted off the top of the BBC-1 transmissions for example are sometimes seen superimposed on the top of the picture. The first suspects in this event should be the cathode components of the oscillator, R83 and C77. R83 is 2·2kΩ and the effect of it increasing in value is to slow down the retrace period. This is not likely but it can happen.

Before leaving the subject of height and linearity we should mention that a faulty PCL85 can often damage its screen feed resistor, R97 (1kΩ). Check this if the vertical scanning is not up to standard when a new valve has had to be fitted.

CONTINUED NEXT MONTH



SERVICE NOTEBOOK

G. R. WILDING

"Peaking" Contrast Control

CONTRAST controls should normally gradually increase the gain from minimum to maximum at each end of their travel without any suggestion of a midway peaking point.

In valved receivers—except those employing high-level control—the gain is varied by backing off the negative a.g.c. potential with a slight positive voltage tapped from the contrast control which consists of a potentiometer connected between h.t. and chassis. A clamp diode is usually included to prevent the a.g.c. rail going positive. Its action is to conduct and hold the rail at chassis potential when the positive potential tapped from the control exceeds the negative a.g.c. potential. Thus in normal circumstances with the contrast control set at minimum gain there will be no off-setting positive potential but as the control is advanced this positive voltage will gradually be applied to the a.g.c. rail until the point is reached when the clamp diode conducts. There should therefore be no midway peaking point for maximum gain.

However on occasions it will be found that the contrast control does give peak output at some point short of its full travel. The cause is almost always a slightly soft gain-controlled valve which draws grid current unless the applied a.g.c. is kept above a certain minimum level.

We came across a Philips 17in. model recently in which maximum gain was obtained well before full control rotation and which when fully warmed up gave maximum gain at minimum control setting and vice versa. In this rather elderly model both the EF80 vision i.f. amplifier and the PCF80 mixer were distinctly soft and once really warm would pass appreciable grid current unless adequate bias was applied. As the positive off-setting voltage was increased with control rotation the valve grid current would progressively increase to greatly reduce amplification. We were thus presented with a greater gain at minimum control settings when the a.g.c. potential prevented grid current than at high contrast settings when the a.g.c. potential was cancelled out. Replacing both valves completely cured this apparent reversal of control action.

This contrast peaking before maximum control setting must not be confused with the limitations imposed by a low-emission video pentode or c.r.t. when to secure best results the contrast must be reduced well below the most desirable level. This effect is caused by the signal being more than sufficient to drive the video pentode and/or c.r.t. to saturation resulting in highlight clipping on 405 when peak signal amplitude equals peak white. Thus if a c.r.t. normally requires a 60V reduction in cathode-grid potential to drive it from the correct no-signal brilliance level to full beam current, and one with low emission requires only 40V to do this, all signal excursions in excess of this value will be reproduced at the same brightness level. In such cases the drive must be reduced or the tube given a heater current boost to at least temporarily increase cathode emission and thereby raise the saturation point.

The video pentode is a hard-driven valve and when servicing a receiver in which it appears to be old or if there is any suggestion of inhibited contrast range always try a new one.

HT Short-Circuit

THE owner of a Bush Model TV135R said that on switching on one day there was a loud bang and no results. On removing the back the first thing we noticed was that the long thin spring for earthing the c.r.t. Aquadag coating was loose and draped across the lower chassis. We clipped it back in position and as nothing appeared to have been damaged and there were no shorts across the h.t. and chassis or across the heater circuit we replaced the fuse, plugged in and switched on.

Again the result was a loud bang accompanied by a vivid flash from the fuse, obviously caused by an extremely heavy overload current. On retesting we found no h.t. short and the heater circuit was complete and continuous. We checked the latter by connecting our ohmmeter across the mains plug pins (right way round since the heater current is rectified in this model) and on obtaining a reading found it reduced to zero when the c.r.t. base connector was removed.

As the c.r.t. is almost universally last in the heater chain if removing its base connector fails to reduce meter indication to zero a partial short-circuit must exist from a point in the chain to chassis. This will be caused by a heater-cathode short-circuit in a valve or the boost rectifier, and while it is true that most receivers have several heater circuit decoupling capacitors from various points in the chain to chassis I have yet to come across one short-circuited.

This Bush circuit is unusual in that the two BY101 rectifiers are series connected (see Fig. 1) with their junction feeding the heater chain and with a single 0·01μF capacitor spanning the pair. We again checked these diodes and the capacitor and as all were in order then removed the PL36 valve which being first in the heater chain left only the h.t. supply system in circuit.

Once again switching on resulted in a loud bang and instantaneous fuse blowing but this time we knew the cause must be associated with the h.t. circuit. Because of the dual BY101 arrangement used even if a sparkover had occurred in either rectifier it would not result in a.c. being applied to the smoothing electrolytics and anyway it is our experience that these and similar types of silicon rectifier are either perfect—even after massive over-loads—or on occasion completely shorted.

The main possibility would therefore seem to have been the 300μF reservoir electrolytic linked to the h.t. rectifier by only a 16Ω surge limiter section on the mains dropper resistor. Again modern electrolytics give little trouble—loss of capacitance being their main defect. A dead shorted h.t. electrolytic is a very rare bird indeed and the chances of one shorting across only on h.t. application seemed even more remote; but the fact remained that somewhere close to the h.t. rectifier we had a component that acted as a short-circuit to high voltage but measured all right on an ohmmeter.

We therefore began to disconnect the h.t. feed from a multi-point tag strip leading to the reservoir capacitor and as we did so noticed that the tag strip was blackened on the reverse side, almost certainly due to the Aquadag earthing spring having momentarily linked the tags to chassis. We immediately disconnected all h.t. carrying feeds from the tag strip but left them joined together suspended in air.

On switching on again no further fuse blowing was experienced and after replacing the tag strip the repair was completed. We have known electrical leaks between adjacent pins on small multi-pin connectors but this was the first occasion on which so heavy a current was caused by h.t. application with no ohmmeter indication of a short. More than likely some Aquadag particles picked up by the earthing spring had become "fired" on the bakelite to provide a spark-gap path across which high voltage could jump.

Alba T655: Faulty Electrolytics

THE picture on this 17in. set would intermittently break up into wildly varying lines accompanied by loudspeaker crackles, somewhat similar to the effect caused by extremely heavy local interference or an intermittent spark-over from the line output transformer. Inspection of the latter during the brief periods when the fault was present failed to show any sparking but it was noticed that there were small coincident sparks inside the PL81. We immediately replaced this valve but the symptoms later reappeared. We then changed the PY81 as this rectifier is subject to extremely high pulse voltages, checked inside the mains plug and made sure that the receiver's voltage selector was OK.

Hum level was objectionably high in this set so while waiting for the main fault to reappear we decided to shunt a wire-ended electrolytic across each section of the multiple reservoir-smoothing capacitor unit. Just as we were about to shunt the first suspect however the fault reappeared and we noticed that miniature sparks appeared around the common negative soldering tag. They were just under the end cap, but even if the sparking had been between rivet and tag on the surface it would have been impossible to solder across as the former is aluminium.

The unit fitted was a 60-250-40μF type in a small-diameter can. We had a 60-250μF unit which was

SERVICE ACTION: WEAK PICTURE CONTRAST

(Conventional valved receivers)

With grain and possibly plus sound hiss. (Signal strength insufficient to swamp mixer noise.)

(a) Check aerial connections. Try results when using inner coaxial conductor only. Improved results indicate aerial defect, i.e. element disconnection or shorting lead.

(b) Replace r.f. amplifier. (First action if grain worse on Band III.)

(c) Check adjustment of sensitivity presets.

Without grain. (Indicating post mixer stage fault.)

(a) Try new video, mixer and i.f. valves.

(b) Test vision detector diode by measuring forward/reverse resistance ratio. In most sets this can be done 'in situ' on 405 by testing from the video amplifier grid to chassis. Highest (reverse) resistance will be mainly that of the load resistor. Lowest resistance will be total of forward diode resistance plus resistance of i.f. and filter coils.

(c) If the tube is old and if the contrast peaks before maximum setting to produce a flat picture thereafter, check for a possible grid-cathode leak.

(d) In most sets the brilliance is controlled by holding the c.r.t. cathode voltage constant and varying the grid voltage. Check that increasing the latter by advancing brilliance level does not tend to raise the former: if it does a leak exists.

(e) Check voltages and look for signs of discolouration in current-carrying resistors, particularly in the video stage.

(f) Shunt replacements across the i.f. and video circuit decouplers. Check feed capacitors when a.c. coupling is used.

Note that open-circuit series-connected compensating coils result in severe loss of gain especially at low frequencies. Open-circuit parallel-connected compensators impair h.f. definition.

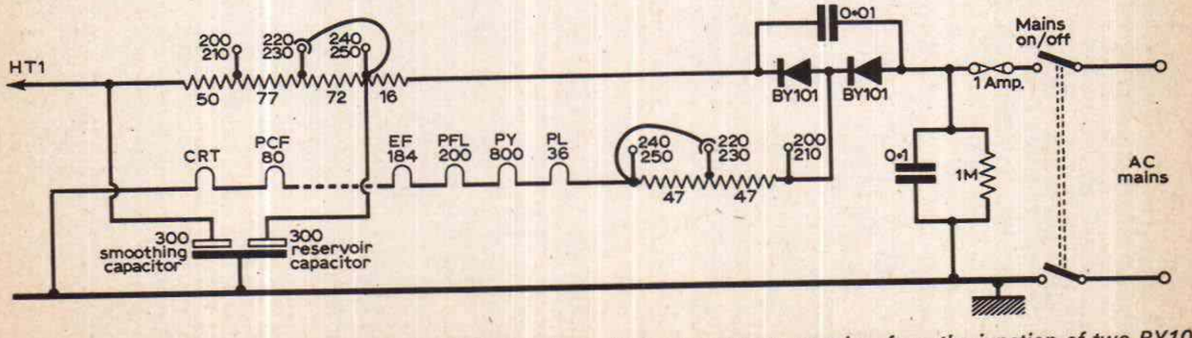


Fig. 1: Power supply circuits of the Bush TV135R series, with the heater current taken from the junction of two BY101 rectifiers—if either goes short-circuit the electrolytics are still protected from a.c.

physically the same size so this was fitted with an additional 50μF on the chassis. If an exact replacement is not to hand it is often necessary to use two separate components in this manner, but it must be added that although smoothing capacitor replacements may be of slightly larger value than the originals the reservoir capacitor value must be strictly adhered to as the value is dictated by the rectifier type, the output current demand and the surge limiter value. Fitting an excessive value reservoir capacitor can only impose extra strain on the rectifier.

On fitting the replacements both the intermittent severe line fault and crackle plus the constant high hum level were removed. It is worthwhile bearing this possibility in mind when tracing similar faults as the sparks were so small they would hardly have been noticed unless they were directly looked for at the capacitor end cap.

Also as a general rule curved end caps usually indicate some loss of capacitance due to chemical change in the electrolyte.

Valve Failures

THERE were no results on a KB 23in. model. Inspection showed that the 1A h.t. fuse had blown and as the BY100 was conveniently placed nearby we checked that it didn't have a short by connecting an ohmmeter across it in both directions. BY100s seldom break down but the possibility must always be considered and on this occasion the BY100 again proved to be in order.

We then checked for an h.t. short-circuit by testing from the 150μF reservoir capacitor tag to chassis and obtained a fair meter deflection. We reversed the meter leads and obtained a negligible fixed reading after the initial charging current. Obviously the first reading was via the BY100 and the series heater chain. We mention this point again because it is so easy to assume that an h.t. short-circuit exists when in fact there is none. It is often best to break the heater chain by removing a valve or disconnecting the c.r.t. base.

With no apparent reason for the fuse blowing the only thing to do was to replace it, plug in and switch on. After a normal warming-up period we obtained good sound and vision but after a few more minutes we heard slight crackles and noticed small white spots on the screen. We then saw that slight sparking was occurring between the electrodes of the EF184 vision i.f. amplifier. This had almost certainly caused the fuse to blow so we rapidly switched off and replaced the valve.

This resulted in improved picture contrast at first but it then reduced and we noticed that the new EF184 was beginning to glow almost red hot. It now seemed likely that a defect in this stage was over-running this valve and had caused the internal sparking in the original one.

Not having a.g.c. and therefore being free from the possibility of a positive grid voltage being applied due to failure of the clamp diode, we began to consider that the cathode resistor might be short-circuited by its decoupling capacitor—as it was transformer fed from the preceding i.f. stage there was little chance of a positive leak on the valve grid. On removing the valve we found that the resistance of the valveholder's cathode pins (1 and 3) to chassis was almost exactly 100Ω as specified.

We then decided to try another EF184—just in case our replacement was also faulty—and obtained normal results. The incidence of faults in new valves is not high but the possibility must be borne in mind, for on more than one occasion when tracing weak sync after valve replacements failed to effect a cure we have found after subsequent voltage and component checking that one replacement was defective. We particularly mention sync faults because valve defects in signal or timebase amplifying stages usually clearly display their presence by reduced contrast, volume, width or height together with abnormal temperature.

Frame-grid valves similar to the type found to be faulty possibly have a greater risk of failure due to the reduced electrode spacing. Even so they are very reliable valves.

Low 405 Contrast

THE customer's phoned complaint was weak line lock on an Ekco Model T433. However inspection showed that the basic and main fault was simply insufficient gain as the brilliance had to be grossly over advanced to produce a viewable picture. The picture was free of grain so obviously the poor contrast was not due to inadequate aerial input or a low-emission r.f. amplifier.

Low-emission video pentodes with in addition a reduced-value cathode resistor always severely reduce picture contrast—especially on 405—and as the owner said the fault had progressively developed we checked the cathode resistor value and as that was normal tried a new PCL84. There was a distinct improvement, but the picture was still woefully short of gain and we felt there was probably a component rather than a valve failure.

Before getting involved with meter tests etc. it always pays to check all valve possibles however. The tuner mixer in this unconverted model was a 30C17 and looked original. We replaced this first and were immediately rewarded with nothing less than a transformation, for we obtained a superb black-and-white picture, overdriving the video stage on Band III, and we had to reduce the chassis-mounted preset contrast control. These valves are not as widely used as other types of mixer, but in future whenever we come across one in any receiver with low gain it will be our number one replacement.

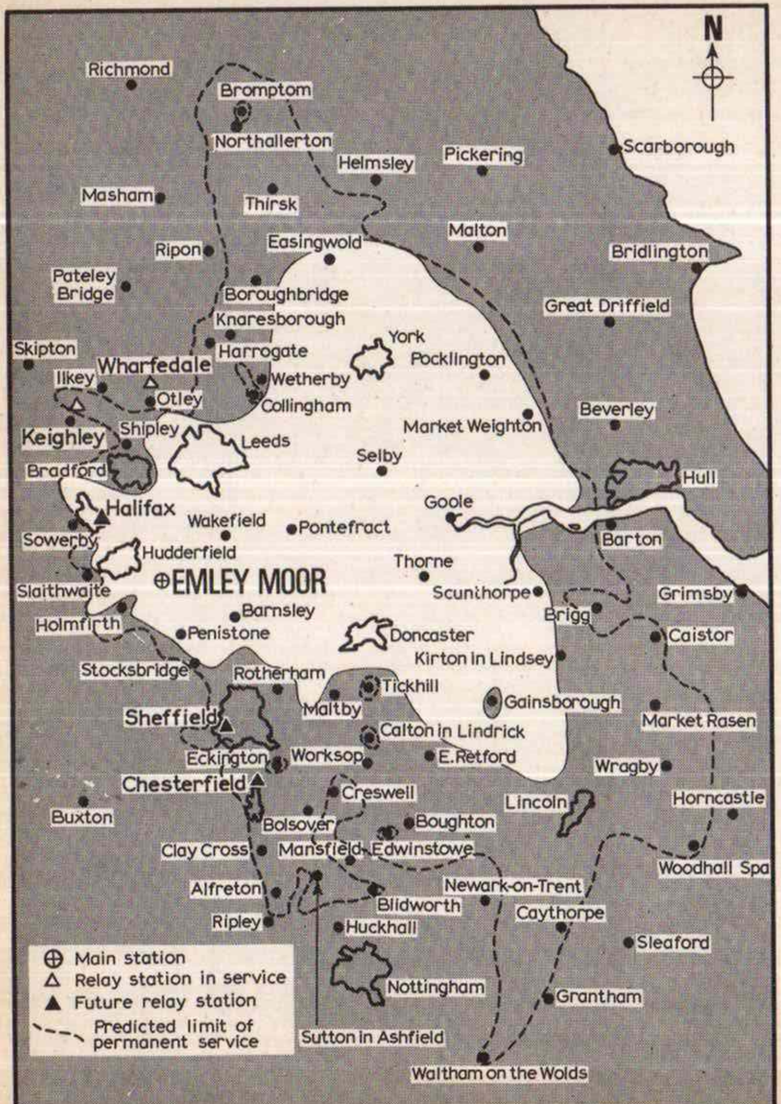
Incidentally, do you know why a reduced-value video amplifier cathode resistor will markedly reduce 405 contrast and why shorting the cathode to chassis will almost totally remove the picture whereas shorting the cathode of any other amplifying valve will still permit it to operate? The reason is that on 405 with d.c. coupling the signal is purely positive-going and with the cathode shorted the video pentode is completely unbiased. The signal input can thus only run the grid positive, attract electrons, and fail to increase significantly the anode current from the zero bias saturation level. Were the signal a.c. coupled the negative-going excursions would markedly reduce the anode current and change the anode voltage.

When the video bias is below normal the working range of the valve is reduced and the peak positive-going swings are limited by running the valve into grid current.

TO BE CONTINUED

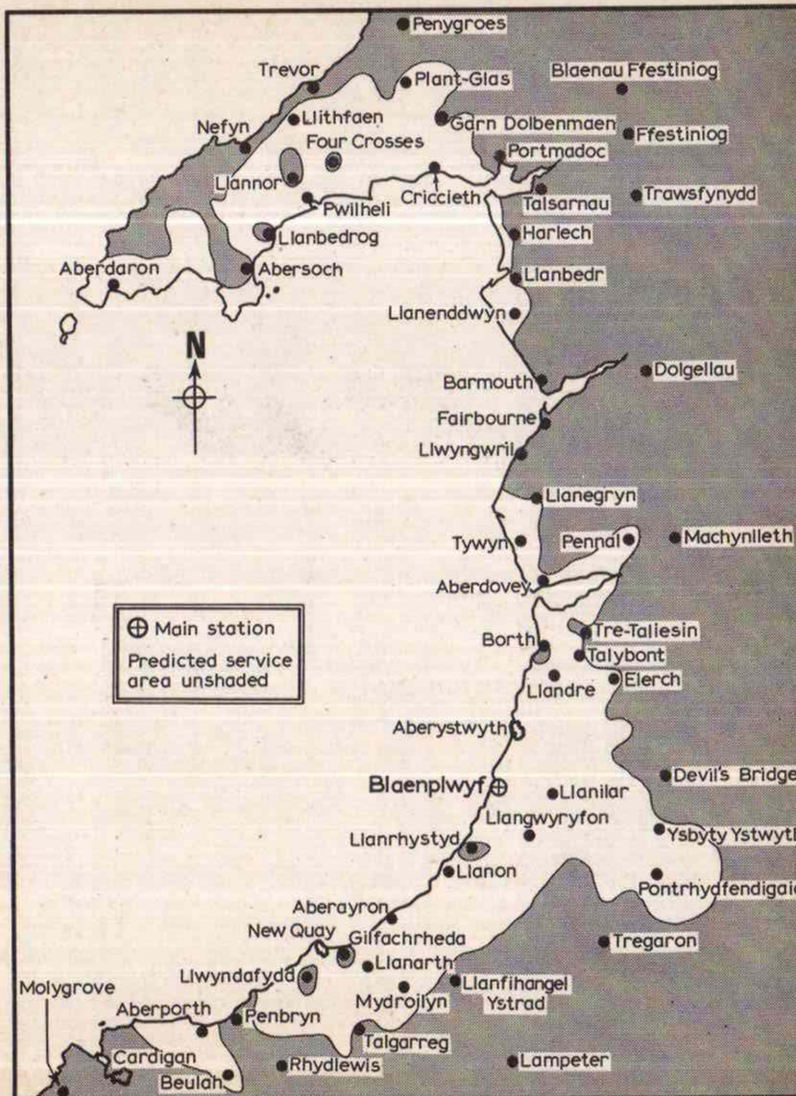
EMLEY MOOR

Horizontal polarisation. Group B receiving aerials. Channels: BBC-1 44, ITV 47, BBC-2 51.



BLAENPLWYF

Horizontal polarisation. Group A receiving aerials. Channels: BBC Wales 21, ITV 24, BBC-2 27.



The above maps show the expected service areas of the Emley Moor (interim service) and Blaenplwyf u.h.f. transmitters (625-line colour service).

TRANSISTORS IN TIMEBASES

PART 8 FIELD OUTPUT STAGES

H. W. HELLYER

IN Part 7 we saw how the field oscillator stage acts as a switch shorting the charging capacitor(s) across which the sawtooth timebase waveform is developed once each field to give the flyback portion of the sawtooth waveform. In this Part we shall take a look at the output side of the field timebase. A simple basic transistor field output stage of Mullard design is shown in Fig. 1 and consists of an AC128 emitter-follower driver stage direct-coupled to the OC28 output transistor which is loaded with a 600mH choke across which a voltage-dependent resistor is connected to limit the flyback pulse which occurs at the end of the scan period. The deflection coil impedance is fairly low: it is desirable to get the impedance of the coils as low as possible to reduce dissipation but some compromise is necessary.

The negative-going sawtooth timebase waveform is generated by the charging of the two electrolytics in the base circuit of the driver stage. As these charge Tr1 is driven on and by emitter-follower action Tr2 is also driven on progressively. The charging electrolytics are discharged once each field cycle when the oscillator stage conducts briefly to in effect short them to chassis. This action also shorts Tr1 base to chassis and consequently both Tr1 and Tr2 are cut off during the flyback period. The resulting collapse in the field around the output choke serves to produce the necessary current reversal in the output stage to move the spot back to the top of the picture ready for the start of the next field.

A parabolic waveform is added to the basic sawtooth by the linearity feedback from the emitter of the output transistor to the junction of the two charging electrolytics. The feedback linearity control affects mainly the top of the picture, i.e., the initial part of the scan. Height is adjusted by altering the rate of charge of the electrolytics, this of course affecting the peak deflection current at the end of the scan.

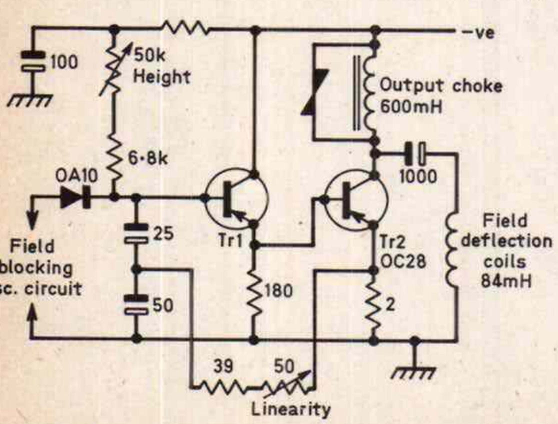


Fig. 1: Field timebase driver and output stages of Mullard design. Tr1 is type AC128.

SONY PORTABLE CIRCUIT

The field output stage circuit used in the current Sony Model TV9-90UB 9in. transistor portable model is shown in Fig. 2 and shows some variations in detail within the same basic overall pattern. A pnp driver stage drives an npn output transistor and as the two are again brought into conduction simultaneously the output transistor is this time driven from the collector of the driver stage. The charging capacitor C1 again provides a negative-going sawtooth waveform which is coupled via C2 and the height control to the base of the driver stage, bringing it progressively into increased conduction. The height control operates in conjunction with C2 in the same manner that the height control in the previous example operated with the charging capacitors. The voltage at Tr1 collector will be positive-going during the scan period so that Tr2 is also driven into conduction to drive current through the deflection coils which are returned to Tr1 emitter circuit. To assist in linearising the scan two feedback loops are incorporated, one from the collector to the base of the driver stage and the other from the collector of the output transistor to the junction of C2 and the height control. A simple linearity shaping network shunts the input to Tr1.

TRANSFORMERLESS OUTPUT STAGE

A somewhat different circuit, by Mullard again, is shown in simplified form in Fig. 3 and has—with modifications to take into account the need for variable d.c. in the coils for d.c. shift and the necessary convergence circuitry—been used in several colour chassis including the latest Bush-Murphy single-standard one which, incidentally, also uses the silicon controlled switch field oscillator circuit described in Part 7. In the circuit shown in Fig. 3 a transistor Tr3 replaces the output choke used in the previous examples and the combination Tr2 and Tr3 will be recognised as a version of the single-ended push-pull configuration. In this version the "top" transistor Tr3 is driven by the lower one

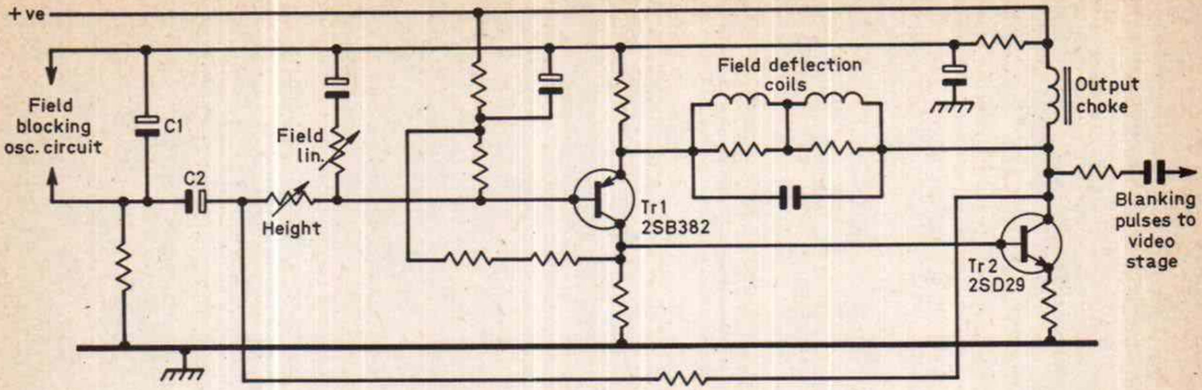


Fig. 2. The field driver and output stages of the Sony Model TV9-90UB 9 in. portable dual-standard receiver. A 2SB383 transistor is used in the oscillator stage.

Tr2, but to check through the operation of the circuit let us as before go back to the basic charging capacitors C.

These charge positively at the base of the driver stage during the forward scan period. Tr1 is thus driven towards cut-off and the voltage at its emitter rises. This rise drives the lower output transistor Tr2 progressively on. Unlike our previous examples therefore the driver and driven output transistor here operate in the non-simultaneous mode, i.e., as the driver moves towards cut-off the transistor it drives is progressively driven into greater conduction. Conversely during the flyback period Tr1 base is effectively at chassis potential due to the action of the oscillator circuit so that it is fully conducting, its emitter being returned to the h.t.+line, while as Tr2 base is also at chassis potential it is cut off—Tr1 being a pnp type and Tr2 an npn type. This arrangement gives low dissipation in the driver transistor, firmly clamps the base of Tr2 to chassis potential each cycle, while any change in the driver stage base bias with temperature opposes that of the output circuit providing stability of the working point with temperature. The type of linearity circuit used in our first example is also employed in this circuit.

The values of Tr3 base bias network are selected so that with Tr2 cut off—during the flyback period—Tr3 is conducting. Bootstrap drive is applied to Tr3 via C2. As Tr2 is driven progressively on during the forward scan period the voltage across R6 increases and as this is effectively connected between the base and emitter of Tr3, Tr3 is driven towards cut off. Thus as the scan progresses the current in Tr3 decreases while that in Tr2 increases.

FLYBACK PERIOD

When the output stage employs a choke or transformer the complete reversal of the deflection coil current required to move the spot back to the top of the picture is easily obtained by making use of the energy stored in the choke or transformer during the scanning stroke. In a transformerless or chokeless circuit such as the present one however it is necessary to use the inductance of the deflection coils as the main current reversal source and flyback is therefore more difficult to achieve. The flyback period is thus particularly important and it is essential to use the energy stored in the coils as efficiently as possible, keeping dissipation in components or devices that contribute nothing to flyback to the minimum.

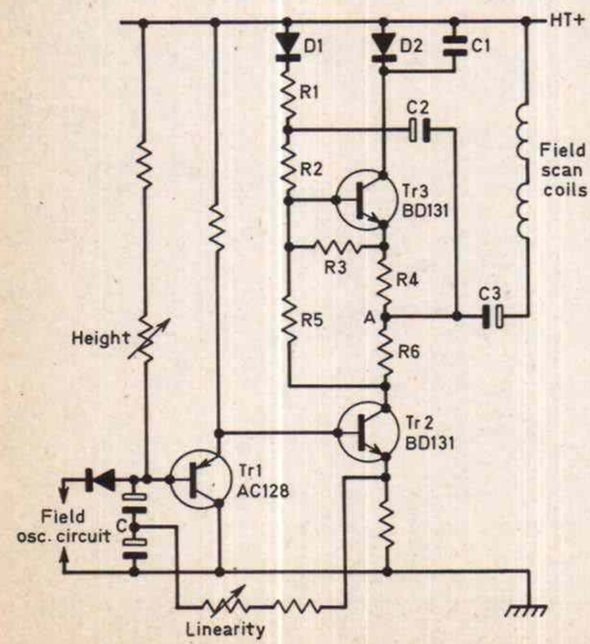


Fig. 3: This later Mullard field timebase circuit uses a single-ended push-pull output stage.

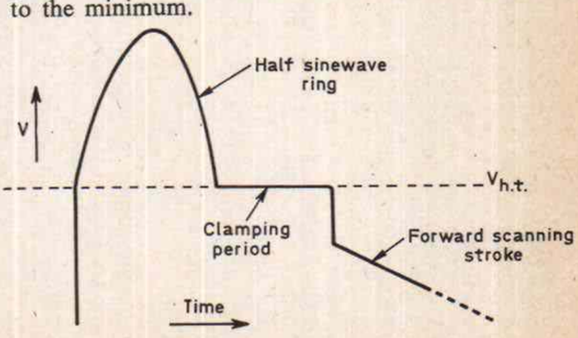


Fig. 4: The collector voltage waveform of Tr2 (Fig. 3) during the flyback period.

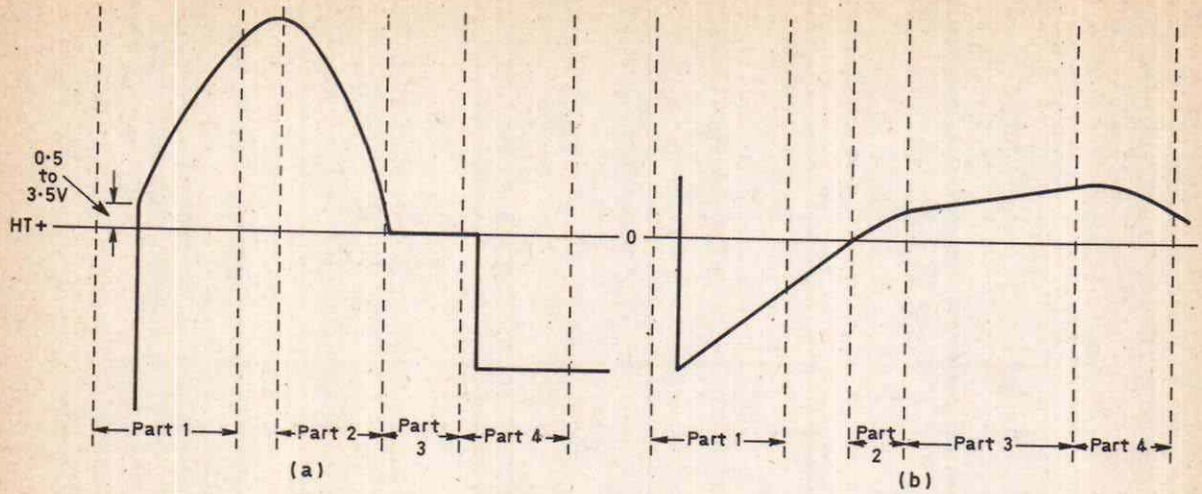


Fig. 5: Tr2 (Fig. 3) collector voltage (a) and Tr3 collector current (b) during the flyback period.

During flyback Tr2 is as we have seen cut off and Tr3 on. The field around the coils then collapses and the voltage across them rises positively. As a result of the bootstrap connection via C2 Tr3 base and emitter are also taken positive. This is where the diodes D1 and D2 play a part. Since their anodes are taken to h.t.+ they are normally conducting. When however Tr3 base and emitter are taken sufficiently positive D1 and D2 cut off and the voltage across the deflection coils is free to rise to a high value. This it does in the form of a half-cycle ring since the coils in conjunction with C1 form a resonant circuit. The waveform at the collector of Tr2 during the flyback period is shown in Fig. 4. As soon as the voltage falls to h.t. again D2 conducts to provide a clamping period until the coil current has been fully reversed. Although the current stored in the coils is the main current reversal source this energy is not quite adequate because of resistive losses in the coils and external circuit. During the clamping period the voltage across C3 is connected across the coils and this provides the necessary compensation.

The operation of the output circuit during the flyback period is quite complex. Fig. 5 shows at (a) Tr2 collector voltage and at (b) Tr3 collector current during the period (though not to the same time scale). It is convenient as indicated to split the action into four parts.

ANALYSIS OF FLYBACK PERIOD

Starting at the beginning of the flyback period when Tr1 is saturated and Tr2 cut off, the voltage at point A (Fig. 3) goes rapidly positive because of the collapse as we have seen of the field around the scan coils. There is rapid current reversal, as (b) shows, and being of large value (250μF) C2 acts as a battery. During this time Tr3 operates in the reverse current mode with most of its base current supplied by R2.

In Part 2 the voltage at point A reverses. From the point where Tr3 current crosses the zero line it operates in the normal manner. Its collector current increases but as the voltage across R4 also increases its base current decreases. The clamping period, Part 3, follows. The clamping voltage across the 14Ω scan coils will be about 18V and the aiming current 18/14A or 1.3A over a period determined by the *LR* time-constant of the circuit. With Tr3 base current falling however there will come a time when its collector current begins to fall. Tr3 then becomes—Part 4—a constant-current generator, i.e. its base current remains constant irrespective of its collector-emitter voltage, C2 providing an effective "battery" condition between its base and emitter. Tr3 collector current drops to about 0.45A and the voltage across the coils suddenly drops to a value determined by this current, i.e. 0.45×14 or 6.3V.

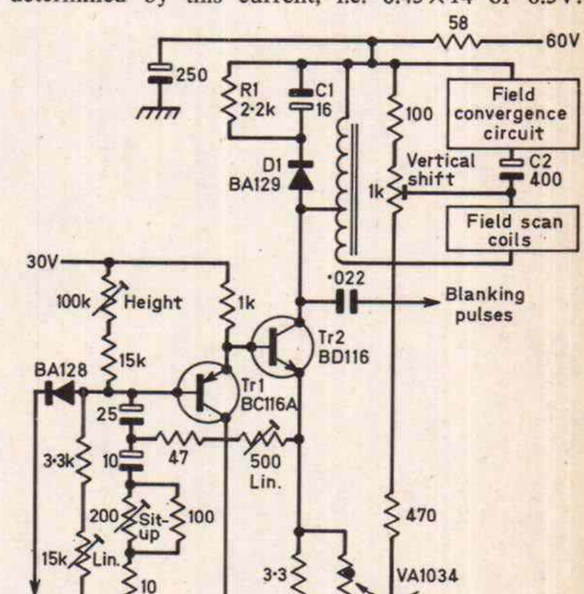


Fig. 6: Transistor driver and field output stages of the Thorn 3000 single-standard colour chassis.

This is the condition when Tr2 commences conduction again at the beginning of the next forward scanning stroke.

THORN CIRCUITS

As previously mentioned the circuit we have been discussing—in simplified form however—is used in the Bush-Murphy all-transistor colour chassis. It is also used in Pye colour receivers and the Thorn 2000 dual-standard colour chassis. With the Thorn 3000 single-standard colour chassis the transistor field output stage reverts to operation with an output transformer however as shown in Fig. 6.

In this circuit the driver stage Tr1 is again driven towards cut off during the forward scan as the 25 and 10μF charging electrolytics charge positively at Tr1 base, the driver in turn progressively driving the npn output transistor Tr2 towards saturation. Thus the forward scanning waveform is negative-going at Tr2 collector, with a positive-going pulse occurring at flyback. This is damped by the network D1, R1 and C1. The deflection and convergence coils are shown in block schematic form: C2 is effectively the same component as C3 in Fig. 3, the scanning coils being returned from the d.c. point of view to a potentiometer across the supply to provide a variable d.c. giving vertical shift control. The emitter resistor of the output transistor is, along with the other return lines of this section of the circuit, taken to a bias line 1.7V above chassis. This bias is developed across diodes D3 and D4 and sets the conditions for flyback cut-off.

TO BE CONTINUED

UNDERNEATH THE DIPOLE

—continued from page 507

millions of tiny bubbles. These vapour bubbles collapse implosively, releasing stored energy in the form of intense shock waves, on coming into contact with the film. This dislodges dirt from scratches in the emulsion as well as dust on the overall surface attracted by electrostatic charge. This method, devised by the Lipsner Smith Company, has several additional refinements. Finally the film base is reconditioned and lubricated. It is an expensive but exceedingly effective process.

There are numerous other systems for treating films; all are anti-static even if they don't actually clean the film.

THE PYE AWARDS

You can't seem to get away from merit awards these days. The annual trophies given by the Pye Radio and Television Group are administered by the Royal Television Society. The presentation this year was made by Lord Hill at the Royal Television Society's annual banquet. Here the small Westward Television Company won their third recent award, Derek Fairhead's for the best regional colour production of the year not nationally networked. A few days after the presentation Westward was invited to provide a complete programme of their films for TV for public showing at the National Film Theatre. This was the very first complete TV film programme ever presented to the public in a cinema in Britain.

GAMMA

TELEGENIC

GAMMA is a term bandied about quite a bit in television, and from the way in which we have heard some people speak of it in recent months it needs some clarification. Gamma is not an inserted characteristic of the television system, it is something that is present because of inherent distortion in the system. The term gamma is in fact a convenient way of describing non-linear distortion in a stage—i.e. where the output is not linearly proportional to the input.

Definition of Gamma

If a definition for gamma is required it can be laid down as the power to which the contrast ratio of the input signal is raised to obtain the contrast ratio of the output signal:

$$(\text{input contrast ratio})^{\gamma} = \text{output contrast ratio}$$

(γ is third letter of the Greek alphabet—gamma).

Contrast ratio is the ratio of any two signals representing light levels. The overall contrast ratio is the ratio between the peak white signal level and the lowest signal level in the blacks. It is important to realise that there must always be a signal at black level because it is impossible to have an illuminated scene with no light reflected from even the blackest, darkest corner. If there was such a thing as true black, the contrast ratio would be infinity. In practice contrast ratios in a badly lit television studio can be as high as 50 or 60:1. An evenly lit set should not have a higher contrast ratio than about 30:1 because the system as a whole will not offer faithful reproduction with ratios greater than this.

Sources of Non-Linearity

Gamma or non-linear distortion is introduced by any stage in the television system which has a curved transfer characteristic (i.e. input plotted against output). The curve in Fig. 1 for example might be the characteristic of a cathode-ray tube. Light output would then be on the vertical axis as shown and the horizontal axis would be the picture drive voltage. It can be seen from this diagram that the light output does not follow the input signal in a linear manner because low-level outputs are associated with a highly curved part of the characteristic. As a result low-level signals would produce a crushed, dark picture. The overall result would be a higher contrast ratio between the greys and peak white with a low contrast ratio in the dark areas of the picture. This is not only undesirable in that it produces a picture not that intended by the programme originator: it also means that pictures will be like soot and whitewash, with few intermediate greys.

Non-linearity is not limited to just the picture tube. The amplifiers in the chain between the camera tube and picture tube can however be designed with bias conditions which use only the linear part of their transfer characteristic so that no distortion need be introduced by them.

Gamma Correction

We can rewrite the previously given definition of gamma, taking logarithms (base 10) of both sides, as

$$\gamma.\log(\text{input contrast ratio}) = \log(\text{output contrast ratio})$$

$$\text{or } \gamma = \frac{\log(\text{output contrast ratio})}{\log(\text{input contrast ratio})}$$

If then a graph of input contrast ratio is plotted against output contrast ratio—on logarithmic scales—the slope of the waveform produced will be the value of gamma. For a picture tube a gamma value of about 2·5 is obtained. (For a linear transfer characteristic the value of gamma would be unity.)

The camera pick-up tube also has a non-linear characteristic which in this case shows itself as the signal output voltage not being linearly proportional to the scene illumination. The actual value of gamma for such tubes varies with the type—e.g. vidicon, Plumbicon or image orthicon—and on its operating conditions. For all of them however the value is below unity.

Gamma Values

We have therefore an overall transmission system which has two non-linear devices in it, and the non-linearities of these cannot be corrected by any modification to the devices themselves. It is however reasonably easy to introduce a non-linear amplifier stage to give the required correction between the two devices. This correction, produced by the *gamma correction amplifier,* is included in the camera chain.

Figure 2 shows a simplified television transmission system with a Plumbicon pick-up tube, a correction amplifier and the c.r.t. display at the end of the transmission path. Each stage has been given a gamma notation (γ_1, γ_2, γ_3) and the output of each stage is indicated. From this we can see that the output will in fact be the input raised to the power of $\gamma_1.\gamma_2.\gamma_3$. If we call the overall gamma just γ then

$$\gamma = \gamma_1.\gamma_2.\gamma_3.$$

If we now give values to these of: γ_1 0·9 (for a Plumbicon pick-up tube); γ_2 unknown (correction value);. γ_3 2·5 (for a c.r.t.); then $\gamma = 0{\cdot}9 \times \gamma_2 \times 2{\cdot}5$.

In theory γ should be unity, but in practice it is found that transmission with an overall gamma of about 1·2 gives some compensation for lack of depth and colour in the display. Taking this overall gamma figure, γ_2 will from the above formula be 0·54. This is therefore the value required in the correction stage. The actual *transmitted* gamma will

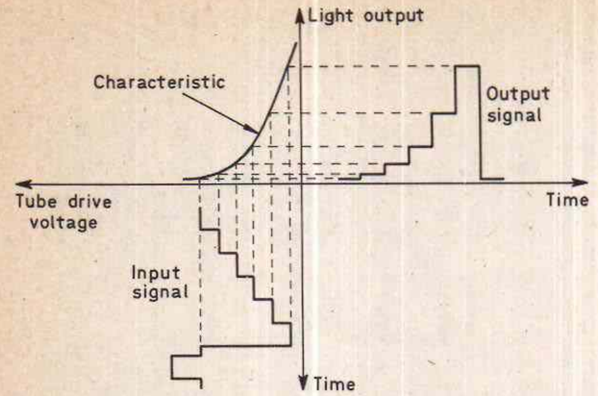


Fig. 1: The effect of a non-linear characteristic on a television signal.

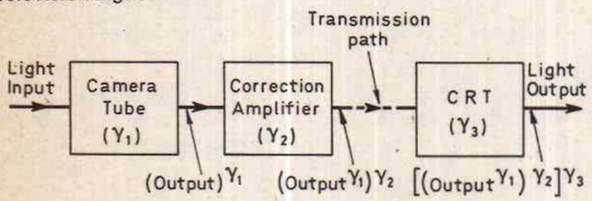


Fig. 2: Simplified TV transmission system.

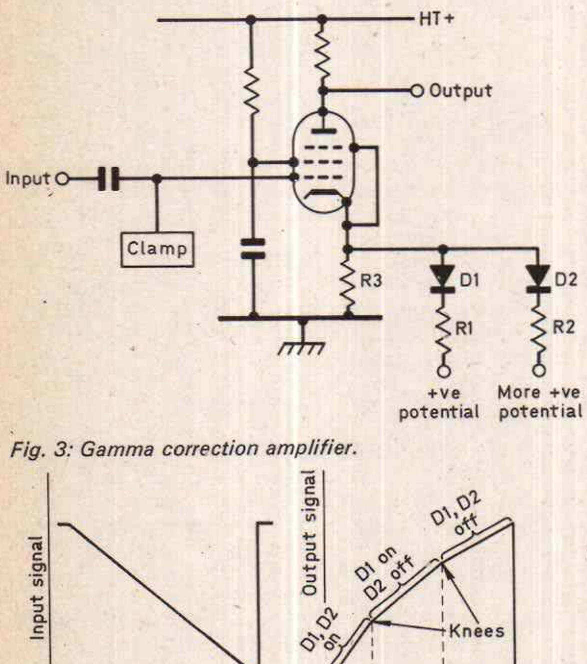


Fig. 3: Gamma correction amplifier.

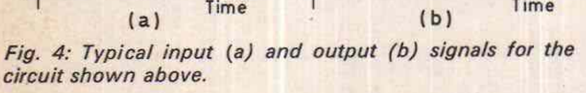


Fig. 4: Typical input (a) and output (b) signals for the circuit shown above.

be $\gamma_1 . \gamma_2$—i.e. about 0·5—the gamma contribution of the display tube in the receiver bringing this up to the overall figure.

Gamma correction (γ_2) is carried out in the camera channel itself because this makes possible some degree of control to compensate for specially lit scenes and also cuts down the receiver cost. It also gives some improvement in "apparent" signal-to-noise ratio by reducing the noise that is displayed in the darker regions of the picture where noise is always more objectionable.

Gamma Correction Amplifier

Because the eye is not very sensitive to changes in tone the correcting amplifier can be a very simple stage giving only an approximation to the desired gamma. Such a stage is shown in Fig. 3.

The operation of this stage can best be appreciated if it is assumed that a negative-going sawtooth input signal is being used—see Fig. 4 (a). The output will of course be an inverted version of this as shown at (b). Now the conduction points of the two diodes in the cathode circuit are determined by the anode current. As this increases the cathode will reach a higher potential than the biasing potentials on the diodes and they will conduct. The cathode load is then R1, R2 and R3 in parallel. As the resistors are in parallel the total cathode resistance is decreased and the stage gain increases (there being less negative feedback).

If the cathode potential is such as to allow only D1 to conduct the cathode load is R1 and R3 in parallel—a larger cathode resistance because R2 is no longer part of the cathode load. Therefore less gain is given by the stage. And when the cathode potential will not allow even D1 to conduct the cathode load will be just R3 an even larger resistance so that there is still less gain. These three conditions occur at various levels of the input signal, producing an output with two knees in it as shown in Fig. 4 (b).

The input signal to the correction amplifier must be d.c. clamped to ensure that the operation is consistent whatever the signal input level.

Effect of Gamma Correction

We have thus produced the effect of progressive white "crushing", expanding the information at the black end of the picture at the expense of compressing the information at the white end. This is the opposite effect to that of the characteristic shown in Fig. 1 and can therefore be used to overcome its undesirable results.

At the broadcast end of the TV system some variation of gamma correction is always available and in the simple circuit shown the knee points could be moved by variation of the diode biasing potentials and the slopes by variation of the diode series resistances.

Gamma in Colour TV

The correction of gamma in monochrome television is reasonably straightforward as we have seen. In colour working however the three or four tubes used in the camera have their outputs matrixed together and coded before transmission and the mathematics of this process show that simple gamma correction is impossible. At the receiving end the shadowmask tube has a higher gamma than a monochrome c.r.t. and this presents problems in transmitting a compatible picture for the monochrome viewer. This will be explained more fully in a later article. ■

YOUR PROBLEMS SOLVED

Whilst we are always pleased to assist readers with their technical difficulties, we regret that we are unable to supply service data or provide instructions for modifying 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 522 must be attached to all Queries, and a stamped and addressed envelope must be enclosed

FERGUSON 506T

There are two faults on this receiver. First the raster is only illuminated on the right-hand side of the screen as viewed from the front. The picture starts with normal brightness, gradually diminishing to the centre of the screen. Secondly there is terrific motorboating which can be varied in speed by rotating the field hold control.—E. Cole (Hull).

Check the 0.25μF capacitor which decouples pin 3 of the tube base (first anode) to h.t. If this capacitor is open-circuit it would account for the uneven illumination. As far as the motorboating is concerned first check that the volume control is well bonded to chassis together with the cable screening. If this does not solve the problem attention must be paid to the smoothing. Leakage between the smoothing and reservoir h.t. capacitors could short out the smoothing choke.

DEFIANT 3A67

All definition has been lost, the picture appearing as a sort of uniform grey with just the highlights of the whites visible. The valves and tube are OK and sound perfect. Only a slight variation in brilliance can be obtained.—W. Angus (Northumberland).

The trouble is almost certainly in the video amplifier stage (PCL84). The resistors in this stage often change value, severely clipping the response. The fault usually starts when R156 (18kΩ) changes value putting a heavy current through the 220Ω cathode bias resistor R131. Check these resistors and also R157 (2.2kΩ) and R135 (6.8kΩ). If the brilliance control is inoperative however the tube is more likely to be at fault with an open-circuit electrode.

THORN 950 CHASSIS

The u.h.f. picture has heavy snow and the width on this standard is down 1¼in. on each side.—F. Wood (Oldham).

Check the u.h.f. aerial and tuner unit—especially the PC88 and PC86 if the valved tuner is being used. Check the PL504 line output valve for lack of width: if this valve is OK check the 0.01μF S-correction capacitor C98 on this standard.

RGD 610

After about an hour all vertical lines on the picture are bent. If the width is reduced the edges of the raster can be seen and are of sinewave shape.—J. Daynes (London SW1).

The trouble is either on the printed panel (leakage between tracks) or the PCF80 valve base (less likely since the triode pins are not adjacent to the heater pins). Check the chassis bonding, earth contacts etc.

FERGUSON 3619

The fault is weak sync and roll on 625 lines only—readjustment is necessary every few minutes. The picture is very grey and lacking in contrast.—A. Button (Northants).

We feel sure you will find that R24 (47kΩ) which is connected between the screen and cathode of the PCL84 video amplifier (pins 9 and 7) has changed value. Check this resistor, the PCL84 and all associated components.

PYE 11U

A thin vertical band starts from the right-hand side of the screen, travels across to the left, reappears from the left travelling to the right and then disappearing. The picture then goes watery for a few minutes.—C. Baldwin (Watford).

The travelling vertical band is caused by interference from a nearby television receiver working on an alternative channel with a fault in its line output stage which may not be apparent to the owner of the set.

GEC 2019DS-T

After the set has been working for about five minutes the picture pulls to the right two inches from the top and then returns to normal. This keeps on happening and occurs on all channels.—D. Barnes (Wolverhampton).

Check the PCF802 line oscillator valve after checking that the line hold controls are correctly set. Replace the flywheel sync diodes MR1, MR2, if this does not cure the fault.

KB WV05

The fault with this receiver is erratic field hold. The vertical hold control is at the centre position which locks the picture OK but after about an hour the picture very slowly rolls down the screen. A very slight adjustment of field hold corrects this but after about another hour the same fault appears again. The PCL85 field output and PCF80 field oscillator valves are both in order.—R. Wilkinson (Belfast).

You should replace the 390kΩ resistor and 0·01μF capacitor associated with the vertical hold control (PCL85 triode grid circuit) if the valves are definitely not at fault.

MURPHY V430

On BBC-1 there is a good picture except that there seems to be what looks like a rope floating down the screen. On the indoor aerial, the sound is very poor and distorted with a rasping and sawing noise with bursts of humming and loud pops. Southern, on the chimney aerial, is almost as bad.—G. Simmons (Sussex).

We suggest that you check for low h.t. or faulty i.f. alignment. Suspect particularly the 6C12 second oscillator in the sound i.f. or a heater-cathode leak somewhere in the heater chain.

DECCA DM3C

The picture is normal for a time, then flyback lines appear and the picture slips downwards or becomes unsteady. At times there is about three inches of the bottom of the picture superimposed on the top. Working the controls will not effect a cure. A new PCL82 valve was tried with no effect.—R. Lyons (N. Ireland).

You should check the ECL80 valve next to the PCL82. If this is not at fault check the 680kΩ resistor to pin 2 of the ECL80 and the 0·033μF capacitor to the same pin from pin 9 of the PCL82.

ULTRA BERMUDA 6638

The picture has for some time now developed a horizontal quiver and no adjustment of the controls has any effect. BBC-1 and ITV are affected but the fault is a lot worse on BBC-2.—A. Ross (Blackpool).

We would suspect leakage between the sections of the multi-unit electrolytic on the right-hand side. However it is possible that the PFL200 is slightly defective or that a fault exists in the flywheel sync unit diodes W401-W402. The W401-W402 diode unit (SD11-7-YAG) often gives this sort of erratic line sync trouble.

HMV 1442

The sound is normal but I can only get a picture by putting a crocodile clip in the i.f. circuit which brings in ITV and BBC with good reception. When the crocodile clip is removed the picture goes off. I have checked the valves but they all seem OK.—R. Cooper (Lancashire).

The decoupling capacitor (0·01μF or 0·003μF) from pin 8 to chassis of the vision i.f. stage is open-circuit. Replace once the defective capacitor has been identified by bridging with a known good one.

PHILIPS 19TG108U

When switched on there is a white horizontal line across the screen. I changed the PCL82 and ECL80 valves on the field panel but this made no difference to the screen. I then found that by setting the inner ring of the selection switch in a particular position and moving the horizontal switch so that it oscillates more than usual the screen, after quite a long time, became filled.

On readjusting to obtain a picture this is very good. Contrast, brilliance and definition are good and controllable but the top of the picture is slightly elongated and the bottom half short. This applied to both channels until recently. We now find that the BBC picture has a honeycomb effect over it with lines running across the screen.—F. Willer (London).

The fault is a classic case of failure of the boost voltage, the field oscillator being fed from the boost rail, so that off load and increasing the energy in the line output stage by increasing the frequency increases the boost voltage sufficiency for the field oscillator to start up. Quite often there is then sufficient voltage to keep the oscillator going. Check the boost capacitor C609 56,000pF and the electrolytic capacitor C408 (100μF) in the cathode of the field output valve (PCL82).

The r.f. patterning you are now getting on BBC-1 may well be due to the excess wear that the tuner switch has endured while this fault has been present. Check the tuner contacts and adjust where necessary.

KB QV30/1

The picture is closed in on both sides. The sound remains perfect.—T. Foley (Staffordshire).

We would advise you to check the h.t. voltage output of the metal rectifier as this is likely to be on the low side.

PERDIO PORTARAMA

This set blows fuse F3 in the supply to the line output transistor X122. Sometimes a few days goes by before the fuse blows and I suspect a faulty X122. Is there a check you can give me before I replace this transistor as I believe replacement is not a simple matter. Also if I do need to replace it will an AU103 suit?—W. McAlpine (London).

Most of the faults on the Perdio Portarama and other receivers using transistorised line output stages are to do with failure of the line ouput transistor. When they go they invariably develop a short-circuit between emitter and collector. This can be easily read on an Avo.

If this has not happened check the diode and capacitors wired across the transistor before replacing it. One of these components going short-circuit could cause the fault and the diode going open-circuit will probably cause the transistor to go.

It is far safer to replace the transistor in such a stage with the correct one. Although the ratings of the AU103 are very similar it is not—as with all semiconductors—a direct replacement.

After servicing and replacement of the fuse check the h.t. rail and adjust the setting control as necessary.

BUSH M69

With the volume and brightness controls turned down to minimum there is a loud buzzing sound. If the brightness control is advanced the picture comes up and the buzzing noise disappears. When the volume control is advanced there is poor quality sound and the picture becomes brighter.—G. French (Doncaster).

The fault is in the control assembly itself. The front section is the brilliance and the rear the volume control. The two end tags of each section should join together and should connect to the metal body of the control and to the chassis tag. Check these connections.

PHILIPS G23T210A

When first switched on (say on 405) the picture is broken up due to loss of line hold. This can be rectified by turning the brightness fully up and then gradually reducing it. If the set is then switched to 625 the line hold is again lost and has to be corrected by using the preset line hold control R2155 at the rear of the set. This of course upsets the picture on 405.—J. Roberts (Penarth).

There are two ECC82 valves in the line timebase and either may be at fault. Obtain a new ECC82 and try it in each position. Set the hold control for a locked 625-line picture then switch to 405 and set the preset line hold control for a locked picture.

REDIFFUSION "CARDIFF"

The picture appears a few seconds after switching on with the sound following some five minutes later. Immediately following the appearance of the picture there is a period of complete silence, then a sound like paper being rustled near the microphone develops terminating suddenly with a click when the sound comes in.—L. A. Taylor (Epsom).

We suspect a capacitor in the circuit around the PCL86 a.f. valve, probable value 0.01μF, or a dry-joint which would give the identical symptoms. Firmly probing the components around the PCL86 should reveal the cause of the trouble.

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PRACTICAL TELEVISION, AUGUST, 1970

TEST CASE

93

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

? *A Decca CTV25 colour set had the symptoms of fluctuating colour intensity and hue variations with flesh tones taking on a green tint! This fault was first investigated at the viewer's home and since at this site the signal conditions were suspect the receiver was removed to the workshop for a more detailed test. Even though a very strong signal—via a booster system—is available at the workshop, the symptoms persisted. A signal or aerial system fault was thus discounted.*

Subjective tests gave the impression of incorrect V (bistable circuit) switching so that the hue changes produced by the V detector were in the positive-phase condition when there should have been a negative-phase signal. This could have accounted for the complementary hue variations, but could such a fault also cause colour intensity or saturation changes?

See next month's PRACTICAL TELEVISION *for the answer to this question and for another colour receiver Test Case.*

SOLUTION TO TEST CASE 92
Page 475 (last month)

A first check for the conditions detailed in the Test Case last month should be for potential at the first anode of the picture tube. Low voltage on this electrode will reduce the brightness and give the picture a nasty grey appearance. It can also affect the focus of the scanning lines and under certain conditions produce a dark patch in the centre of the picture as the brightness control is turned up.

In the set in question the first anode potential was barely 350V, a drop of about 200 or so volts. The first anode feed resistor was checked for value and the associated decoupling capacitors for value and d.c. leakage but no trouble at all was found with these. A possible cause of this trouble is a low-value boost reservoir capacitor, but this too was in good order. In fact extensive testing of the main line output stage components, including the line output and boost valves, failed to show any cause of the fault. Moreover the amplitude of the drive signal at the line output valve control grid was found to be pretty well correct on a 'scope.

About the only item left untested was the line output transformer and as a test replacement was at hand this was slipped in as a last resort. Result: perfect picture and full first anode potential. From normal basic tests and from appearance the line output transformer seemed to be perfectly normal; but this example illustrates the necessity of sometimes having to change this large component when all else has failed to reveal the trouble.

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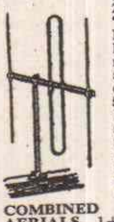

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·22	1000v.	2/8d.
·47	1000v.	3/8d.
·001	1500v.	1/6d.

WIRE-WOUND RESISTORS (3's)

10 watt rating, suitable for mains dropper sections.

1	Ohm	1/9d.
10	Ohms	1/9d.
13	,,	1/9d.
25	,,	1/9d.
33	,,	1/9d.
50	,,	1/9d.
87	,,	1/9d.
100	,,	1/9d.
150	,,	1/9d.
220	,,	1/9d.
330	,,	1/9d.
1K	,,	1/9d.
2·2K	,,	1/9d.
3·3K	,,	1/9d.
4·7K	,,	1/9d.

PULSE CERAMICS (3's) 12KV

100pf	22pf	1/1d.
120pf	47pf	1/1d.
180pf	68pf	1/1d.
250pf		1/1d.

Tubular type for use in Scan correction circuits and Line Outputs.

CERAMICS (6's)

500pf	22pf	8d.
680pf	47pf	8d.
820pf	68pf	8d.
1000pf	100pf	8d.
1500pf	120pf	8d.
3000pf	180pf	8d.
5000pf		8d.

BIAS ELECTROLYTICS (3's)

25mfd	25v.	1/6d.
50mfd	25v.	1/8d.
100mfd	25v.	1/11d.
250mfd	25v.	3/0d.
500mfd	25v.	3/8d.
1000mfd	12v.	6/0d.
1000mfd	30v.	5/9d.
2000mfd	25v.	7/0d.
2500mfd	30v.	9/0d.
3000mfd	30v.	9/6d.
5000mfd	30v.	10/0d.
25mfd	50v.	1/8d.
50mfd	50v.	2/0d.
100mfd	50v.	2/6d.
250mfd	50v.	3/8d.
500mfd	50v.	4/6d.
2000mfd	50v.	9/0d.
2500mfd	50v.	10/6d.

SMOOTHING ELECTROLYTICS

Wire ended, 450v. working.

1mfd	1/6d.
2mfd	1/6d.
4mfd	2/3d.
8mfd	2/6d.
16mfd	3/0d.
32mfd	4/6d.
50mfd	5/0d.
8/8mfd	4/0d.
8/16mfd	5/0d.
16/16mfd	5/0d.
16/32mfd	5/0d.
32/32mfd	5/0d.
50/50mfd	8/0d.
50/50/50mfd	10/0d.

CANNED ELECTROLYTICS

100/200mfd	12/6d.
100/400mfd	16/6d.
200/200mfd	16/0d.
200/200/100mfd	18/6d.
200/400/32mfd	18/6d.
100/300/100/16	18/6d.
100/400/32mfd	18/6d.
100/400/64/16	21/0d.

SKELETON PRE-SETS (3's)

25K	Vertical	1/4d.
50K	,,	1/4d.
100K	,,	1/4d.
250K	,,	1/4d.
500K	,,	1/4d.
1 meg	,,	1/4d.
2 meg	,,	1/4d.
500K	Horizontal	1/4d.
680K	,,	1/4d.
1 meg	,,	1/4d.

SUB-MINIATURE ELECTROLYTICS (3's)

1mfd	18v.	1/8d.
2mfd	18v.	1/8d.
4mfd	18v.	1/8d.
5mfd	18v.	1/8d.
8mfd	18v.	1/8d.
10mfd	18v.	1/8d.
16mfd	18v.	1/8d.
25mfd	18v.	1/8d.
32mfd	18v.	1/10d.
50mfd	18v.	1/10d.
100mfd	18v.	1/10d.
200mfd	18v.	2/3d.

THERMISTORS (3's)

Miniature	1/6d.
TH1	2/4d.

RECTIFIERS

Silicon Mains (3's)

Westinghouse S10AR2	6/6d.
BY127 Mullard	5/3d.
BY105 Mazda	7/0d.
BY327	5/6d.

CONTACT COOLED FULL WAVE

75ma	12/8d.
100ma	13/8d.
150ma	16/8d.

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Bakelite top	10d.
Egen metal	1/4d.
Single point (car radio)	2/0d.

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100K	1/6d.
1 Meg	1/6d.
2·2 Meg	1/6d.

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Chrome standard	4/0d.
Standard	3/0d.
3·5mm. metal	3/0d.

DIN PLUGS (3's)

3-pin	1/10d.
5-pin	2/2d.
Sockets	1/0d.

DOUBLE DIODE RECTIFIERS (3's)

Bush/Murphy/BRC etc.
Line/frame timebases etc.

3 leg	6/3d.
4 leg	6/3d.
5 leg	6/3d.

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1 amp, 1·5 amp, 2 amp, 3 amp. Per dozen 3/0d.

MAINS FUSES

2 amp, 3 amp, 5 amp, 13 amp. Per dozen 5/0d.

TERMINAL STRIPS

2 amp	2/3d.
5 amp	2/10d.
15 amp	5/9d.

CARBON FILM RESISTORS

½ watt and 1 watt.

The following values are packed in cartons of *six of each value.* Price 2/6d. per carton.

10 ohm	1·2K	150K	
12 ,,	1·5K	180K	
15 ,,	1·8K	220K	
18 ,,	2·2K	270K	
22 ,,	2·7K	330K	
27 ,,	3·3K	390K	
33 ,,	3·9K	430K	
39 ,,	4·3K	470K	
43 ,,	4·7K	560K	
47 ,,	5·6K	680K	
56 ,,	6·8K	820K	
68 ,,	8·2K	1M	
82 ,,	10K	1·2M	
100 ,,	12K	1·5M	
120 ,,	15K	1·8M	
150 ,,	18K	2·2M	
180 ,,	22K	2·7M	
220 ,,	27K	3·3M	
270 ,,	33K	3·9M	
330 ,,	39K	4·3M	
390 ,,	43K	4·7M	
430 ,,	47K	5·6M	
470 ,,	56K	6·8M	
560 ,,	68K	8·2M	
680 ,,	82K	10M	
820 ,,	100K	12M	
1K	120K	15M	

All the above values are available in both ½ watt and 1 watt versions.

***Special for Philips TV's:**
8·2M 2-watt, 4/6d. per pack.

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Standard spindle with flat.

Double pole switch	4/7d.
Without switch	3/6d.

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GP91/3SC. High gain version of above	22/0d.
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GENERAL PURPOSE REPLACEMENT FOR TC8's etc.	
High gain, plenty of output (Jap.)	19/10d.
Stereo version	37/9d.

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RE-BUILT			BRAND NEW	A FEW SAMPLE TYPES, REMEMBER WE STOCK EVERY TUBE
17"	@	£4 14 6	£5 10 0	CME1702, AW43-80, CRM173, MW43-80, MW43-69*, CRM172*, AW43-88, AW43-89, CME1705, CME1703, C17AF, C17SM etc.
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EABC80	12/8	EZ81	8/2	PFL200	15/9
EB91	8/2	EZ90	9/3	PL36	16/4
EBC90	10/10	GZ34	13/7	PL81	13/7
EBF80	10/10	GY501	15/9	PL81A	14/6
EBF89	10/10	PC86	14/6	PL82	10/10
ECC81	10/0	PC88	14/6	PL83	13/8
ECC82	10/0	PC97	10/10	PL84	12/8
ECC83	10/0	PC900	12/8	PL302	13/7
ECC804	15/4	PCC84	10/0	PL504	20/–
ECH81	14/6	PCC88	16/8	PL508	20/4
ECH84	12/8	PCC89	13/7	PL509	31/7
ECL80	9/6	PCC189	13/7	PY33	12/2
ECL82	12/8	PCC806	15/9	PY81	10/10
ECL83	13/4	PCF80	11/4	PY800	10/10
ECL84	11/4	PCF86	13/7	PY801	10/10
ECL86	12/8	PCF87	18/1	PY82	8/4
EF80	9/6	PCF801	13/7	PY83	13/7
EF85	12/8	PCF802	13/7	PY500	20/4
EF86	16/4	PCF805	14/11	UABC80	13/7
EF89	10/10	PCF806	13/7	UCH81	13/7
EF183	12/8	PCF808	14/11	UCL82	12/8
EF184	12/8	PCL82	11/4	UCL83	14/6
EH90	13/7	PCL83	13/4	UL41	14/6
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EF85	8/3	PCL83	12/3	U37	15/-	30FL1	12/9
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