Practical Electronics

NOVEMBER 1966

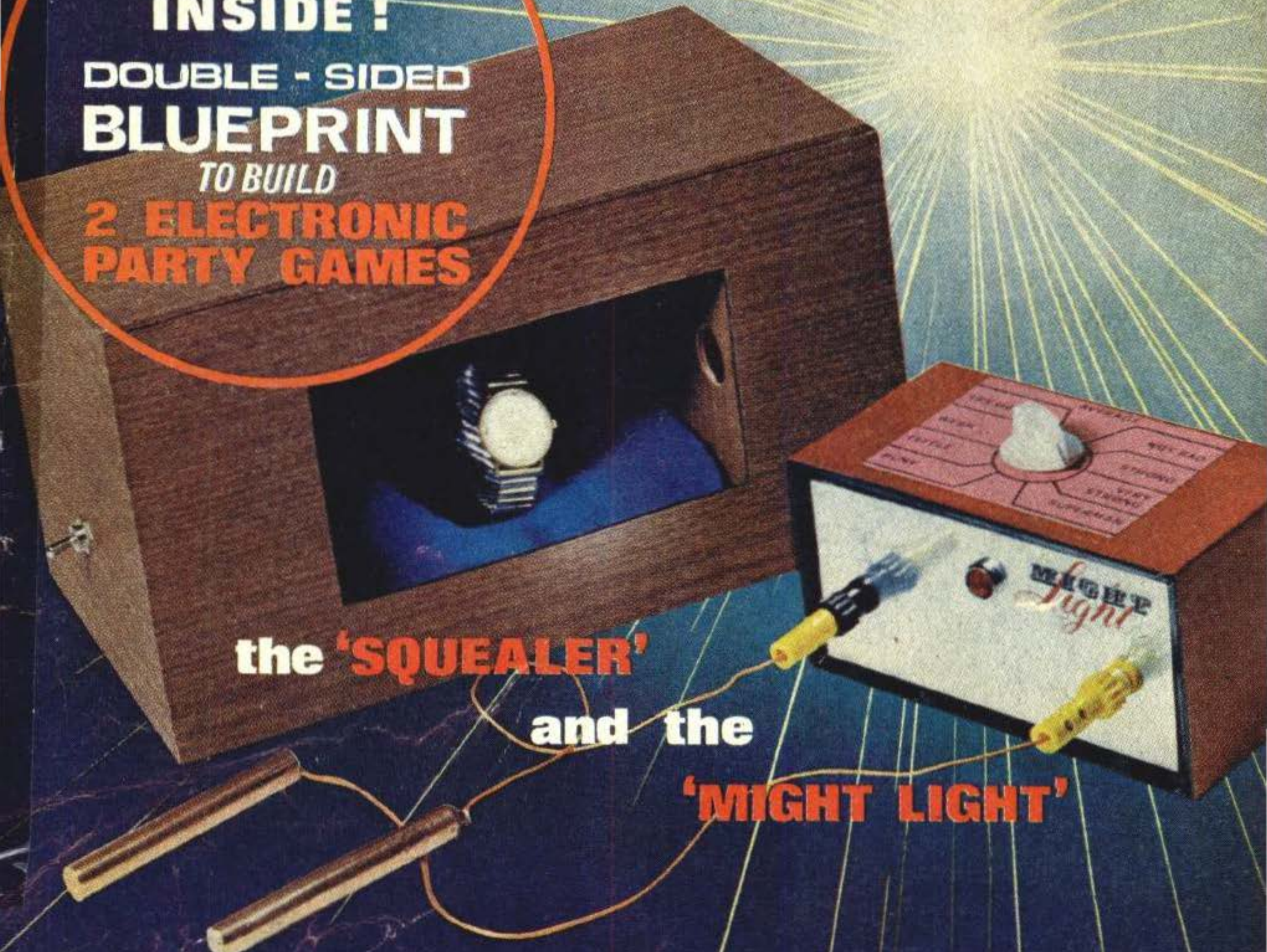
PRICE 2/6

FREE INSIDE!

DOUBLE - SIDED BLUEPRINT

TO BUILD

2 ELECTRONIC PARTY GAMES



the 'SQUEALER' and the 'MIGHT LIGHT'

THE LUMOSTAT

Photographic control unit for colour and monochrome processing

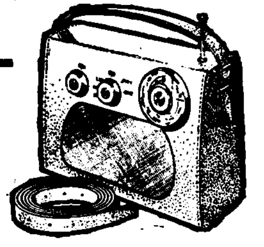
Why NOT BUILD ONE OF OUR PORTABLE TRANSISTOR RADIOS...

FIRST FOR PERFORMANCE, QUALITY AND PRICE!

BACKED BY OUR SUPER AFTER SALES SERVICE

"A wonderful range of transistor radios using first grade components for guaranteed results"

NEW ROAMER SEVEN Mk IV



7 WAVEBAND PORTABLE OR CAR RADIO

Amazing performance and specification ★ ***Now with PHILCO MICRO-ALLOY R.F. TRANSISTORS***

FULLY TUNABLE ON ALL WAVEBANDS ● **9 stages—7 transistors and 2 diodes**

Covers Medium and Long Waves, Trawler Band and three Short Waves to approx. 15 metres. Push-pull output for room filling volume from rich toned 7" × 4" speaker. Air spaced ganged tuning condenser. Ferrite rod aerial for M & L Waves and telescopic aerial for S Waves. Real leather-look case with gilt trim and shoulder and hand straps. Size 9" × 7" × 4" approx.

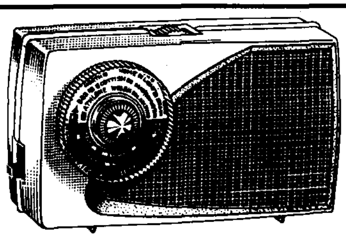
The perfect portable and the ideal car radio. (Uses PP7 batteries available anywhere.)

★ **EXTRA BAND FOR EASIER TUNING OF PIRATE STATIONS, etc.**

Total cost of parts now only **£5.19.6** P. & P. 5/6

Parts Price List and easy build plans 3/- (Free with kit)

NEW MELODY MAKER SIX



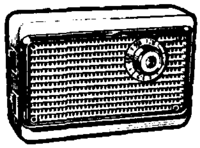
3 WAVEBAND PORTABLE. ● 8 stages. Six transistors and two diodes.

Covers Medium and Long Waves and extra Band for easier tuning of Pirate Stations, etc. Top quality 3" Loudspeaker for quality output. Two RF stages for extra boost. High 'Q' 6" Ferrite Rod Aerial. Approx. 350 Milliwatts push pull output. Handsome pocket size case with gilt fittings. Size 6¼ × 3¾ × 1½ in. (Uses long-life PP6 battery). Carrying strap 1/6 extra.

This amazing receiver may be built for only **£3.9.6** P. & P. 3/6

Parts Price List and easy build plans 2/-. (Free with kit)

NEW TRANSONA FIVE



"Home, Light, A.F.N. Lux. all at good volume" *G.P., Durham*

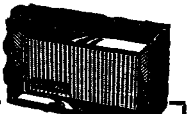
● **7 stages—5 transistors and 2 diodes**

Fully tunable over Medium and Long Waves and Trawler Band. Incorporates Ferrite rod aerial, tuning condenser, volume control, new type fine tone super dynamic 2¾ in. speaker, etc. Attractive case. Size 6¼ × 4½ × 1¼in. with red speaker grille. (Uses 1289 battery available anywhere.)

Total cost of all parts now only **42/6** P. & P. 3/6

Parts Price List and easy build plans 2/- (Free with kit)

POCKET FIVE



● **7 stages—5 transistors and 2 diodes.**

Covers Medium and Long Waves and Trawler Band, a feature usually found in only the most expensive radios. On test Home, Light, Luxembourg and many Continental stations were received loud and clear. Designed round supersensitive Ferrite Rod Aerial and fine tone 2¾in. moving coil speaker, built into attractive black and gold case. Size 5½ × 1½ × 3½in. (Uses 1289 battery, available anywhere.)

Total cost of all parts now only **42/6** P. & P. 3/6

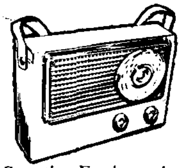
Parts Price List and easy build plans 1/6 (FREE with Kit)

STOP PRESS!

Pocket 5 Med and Long wave version with miniature speaker

29/6 P. & P. 3/-

NEW ROAMER SIX



NOW WITH PHILCO MICRO-ALLOY R.F. TRANSISTORS

● **6 WAVEBAND!!**

● **8 stages—6 transistors and 2 diodes**

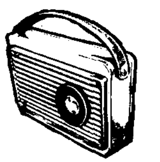
Listen to stations half a world away with this 6 waveband portable. Tunable on Medium and Long Waves, Trawler Band and two Short Waves. Sensitive Ferrite rod aerial and telescopic aerial for short waves. Top grade transistors. 3-inch speaker, handsome case with gilt fittings. Size 7½ × 5½ × 1½in. (Carrying Strap 1/6 extra.)

★ **EXTRA BAND FOR EASIER TUNING OF LUX, ETC.**

Total cost of all parts now only **£3.19.6** P. & P. 3/6

Parts Price List and easy build plans 2/- (Free with kit)

TRANSONA SIX



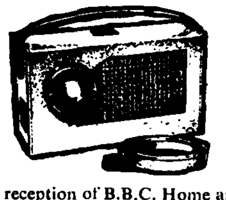
● **8 stages—6 transistors and 2 diodes**

This is a top performance receiver covering full Medium and Long Waves and Trawler Band. High-grade approx. 3in. speaker makes listening a pleasure. Push-pull output. Ferrite rod aerial. Many stations listed in one evening including Luxembourg loud and clear. Attractive case in grey with red grille. Size 6¼ × 4½ × 1½in. (Uses PP4 battery available anywhere.) Carrying Strap 1/- extra.

Total cost of all parts now only **59/6** P. & P 3/6

Parts Price List and easy build plans 1/6 (Free with kit)

MELODY SIX



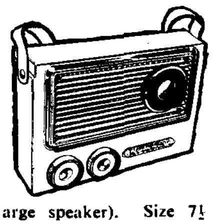
● **8 stages—6 transistors and 2 diodes**

Our latest completely portable transistor radio covering Medium and Long Waves. Incorporates pre-tagged circuit board, 3in. heavy duty speaker, top grade transistors, volume control, tuning condenser, wave change slide switch, sensitive 6in. Ferrite rod aerial. Push-pull output. Wonderful reception of B.B.C. Home and Light, 208 and many Continental stations. Handsome leather-look pocket size case, only 6¼ × 3¼ × 1⅞in. approx. with gilt speaker grille and supplied with hand and shoulder straps.

Total cost of all parts now only **£3.9.6** P. & P. 3/6

Parts Price List and easy build plans 2/- (Free with kit)

SUPER SEVEN



● **9 stages—7 transistors and 2 diodes**

Covers Medium and Long Waves and Trawler Band. The ideal radio for home, car, or can be fitted with carrying strap for outdoor use. Completely portable—has built-in Ferrite rod aerial for wonderful reception. Special circuit incorporating 2 RF Stages, push-pull output, 3in. speaker (will drive large speaker). Size 7½ × 5½ × 1½in. (Uses 9v battery, available anywhere.)

Total cost of all parts now only **£3.19.6** P. & P. 3/6

Parts Price List and easy build plans 2/- (Free with kit)

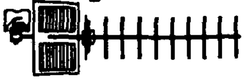
Callers side entrance Barratts Shoe Shop.

RADIO EXCHANGE Ltd

Open 9—5 p.m. Saturdays 9—12.30 p.m.

61a HIGH STREET, BEDFORD. Phone: 52367

TELEVISION AERIAL for fringe area BBC 2

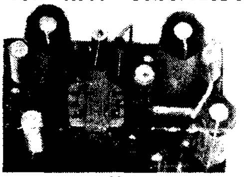


Directors and reflector mat—a really efficient model by one of our most famous makers—must improve results—45/- plus 3/6 post and ins. Low loss co-ax cable 1/6 yd., BBC 2 aerial Amplifier £4.4.0.

ELECTRIC BLANKET OUTFIT

A 13yd. 70 watt waterproof element with temperature control by Thermal balance—and a double pole blanket switch in pastel blue bakelite—with enclosed neon on/off indication—both items ideal for renovating a defunct or doubtful blanket—supplied complete with layout and other instructions only 12/6 plus 1/6 post and insurance.

750 mW TRANSISTOR AMP.



4 transistors including two in push-pull input for crystal or magnetic microphone or pick-up—feed back loops—sensitivity 5 m/v.

PRICE 19/6

Post and ins. 2/6.

Speakers 3in. 12/6; 5in. 13/6; 6in. × 4in. 14/6.

TUBULAR HEATERS

New and unused made by G.E.C.—rated at 60 watts per foot—these are ideal in airing cupboards, bedrooms, offices, stores, greenhouses, etc.—curtains or papers can touch them without fear of scorching or fire. Supplied complete with fixing brackets and available in the following sizes. Prices which are about quarter of list price includes carriage by B.R.S.

8ft.—30/-, 10ft.—36/-, 12ft.—42/-

also in twin assemblies (one pipe above the other): 4ft.—40/-, 5ft.—46/-, 6ft.—52/-

SIMMERSTAT HEATER REGULATOR

Suitable to control elements, heater, soldering irons and boiling rings up to 2,500 watt. Complete adjustable, normal price 55/- each, special snip price 12/6 plus 2/- postage and insurance.

THERMOSTATS

Type 'A' 15 amp. for controlling room heaters, greenhouse, airing cupboard. Has spindle for pointer knob, quickly adjustable from 30°—80°F. 9/6 plus 1/- post. Suitable box for wall mounting, 5/-, P. & P. 1/-.

Type 'B' 15 amp. This is a 17in. long rod type made by the famous Sunvic Co. Spindle adjusts this from 50-550°F. Internal screw alters the setting so this could be adjusted over 30° to 1,000°F. Suitable for controlling furnace, oven, kiln, immersion heater or to make flamestat or fire alarm, 8/6 plus 2/9 post and insurance.

Type 'D'. We call this the Ice-stat as it cuts in and out at around freezing point. 2/3 amps. Has many uses, one of which would be to keep the loft pipes from freezing if a length of our blanket wire (16 yds. 10/-) is wound round the pipes. 7/6, P. & P. 1/1.

Type 'E'. This is a standard refrigerator thermostat. Spindle adjustments cover normal refrigerator temperature, 7/6 plus 1/- P. & P.

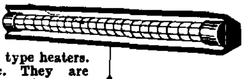
SEMI-CONDUCTOR BARGAINS

Type No.	Price	Type No.	Price	Type No.	Price
2N1727	15/-	MAT101	8/6	OC71	4/-
2N1728	100/-	MAT120	7/9	OC72	5/-
2N1742	25/-	MAT121	8/6	OC75	6/-
2N1747	25/-	OA5	5/-	OC76	5/-
2N1748	10/-	OA10	6/-	OC77	7/-
AC107	9/-	OA47	3/-	OC78	5/-
AC127	9/-	OA70	2/-	OC78D	5/-
ACY17	8/6	OA79	2/6	OC81	5/-
ACY18	5/6	OA81	2/6	OC81D	5/-
ACY19	6/6	OA85	3/-	OC82	5/-
ACY20	5/6	OA90	2/6	OC83	5/-
ACY21	6/-	OA91	2/6	OC84	6/-
ACY22	4/6	OA200	3/3	OC139	8/6
AF114	7/-	OA202	4/3	OC140	12/6
AF115	6/6	OC22	10/-	OC170	5/-
AF116	7/-	OC23	17/6	OC171	6/-
AF117	5/-	OC24	22/6	OC200	9/-
AF118	12/6	OC26	7/6	OC201	12/6
AF139	17/6	OC28	15/-	OC202	13/6
AF186	19/6	OC29	17/6	OC203	12/6
AFZ12	15/-	OC35	12/6	OCP71	19/6
ASZ21	15/-	OC36	15/-	ORP12	8/6
BC107	14/6	OC42	6/6	ORP60	5/-
BY100	5/6	OC44	5/-	SB078	6/6
BYZ13	7/6	OC45	4/-	SB305	8/6
MAT100	7/9	OC70	4/-	SB251	10/-

SPECIAL BARGAIN

Special set for amplifier or for output stage comprises OC81D and match pair OC81 only 12/6 post free.

INFRA-RED HEATERS



Make up one of these latest type heaters. Ideal for bathroom, etc. They are simple to make from our easy-to-follow instructions—uses silica enclosed elements designed for the correct infra-red wavelength (3 microns). Price for 750 watts element, all parts, metal casing as illustrated, 21/6 plus 3/6 post and ins. Pull switch 3/- extra.

THIS MONTH'S SNIP

Your opportunity to install non-flicker strip lighting at silly price—this month we offer the famous A.E.I. (Mazda) *instant start lighting transformer* suitable for one, 4ft. 40 watt tube or two, 2ft. 20 watt tubes. This transformer is listed at over £3, but this month you can buy the complete Kit comprising instant start choke/transformer two tube ends and two Terry clips to hold tube. Special snip price only 14/6 plus 3/9 post and insurance—don't miss this tremendous bargain.

GARRARD AUTO RECORD PLAYER Model 2000

This is one of the latest products of the World's most experienced maker of fine record reproducers. Its superior features include automatic playing of up to 8 mixed size records stopping and starting without rejecting, manual playing, pick-up pivots to give low stylus pressure, large diameter turntable for max. stability, adjustments include pick-up height, pick-up dropping position and stylus pressure. Size is 13¼in. × 11¼in. clearances 4⅞in. above, 2½in. below, fitted with latest hi-compliance cartridge for stereo and mono, L.P. and 78. Supplied complete with mounting template and service sheet. Offered this month at the Special Snip price of £6.9.6. plus 7/6 carriage and insurance.

ADJUSTABLE TIMER & DELAY MECHANISM

This is a fine American made unit designed for precision. The time period is adjusted by a knurled screw. The delay period can be set anywhere from hours or seconds. The end of the delay operates a microswitch and resetting can be remote controlled or manually reset. The unit is for wall mounting and is approx. 4in. × 7in. × 4in., price 39/6 plus 3/6 post and insurance.

STUPENDOUS OFFER—£11 for £2

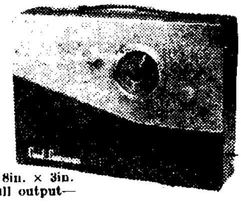
The Princess superhet described below is a very fine little set that has been carefully designed for high performance. Only recently (under another name of course) this was on offer in many radio shops for £10.19.6, but we have been fortunate in obtaining the parts at a very low price and now pass this saving on to you. If you act quickly you can purchase this for only 39/6 plus 3/6 post and insurance. Note these features:

- Long and Medium Wave
- Long clear dial with travelling pointer and slow motion drive
- Push-pull output approximately 350 m.w.
- A.V.C. and feedback
- Dust cored H.Q. I.F. transformers
- High selectivity ferrite aerial
- Six tested transistors
- Printed circuit board for foolproof assembly
- Economy output circuit gives long life from PP3 battery
- Permanent magnet moving coil speaker
- Cabinet size 4½in. × 3in. × 1½in.

Battery 1/9 extra. Data included or separately 2/6.

SUPERTONE GCV

Saves you work— It's partly built



Like its predecessors this latest Companion has a full fi performance—such as only a good wooden cabinet and hi-flux speaker can give, and due to its being partly built you will have it going in an evening. Note these features:

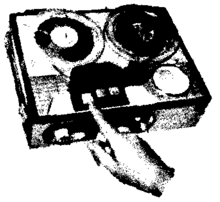
- All Mullard 6 Transistors including 3 × AF117.
- Two tone Cabinet, size 11in. × 8in. × 3in.
- All circuit refinements Push-pull output—A.V.C. and feedback, etc.
- Printed circuit board all wired only connections, e.g., to Volume control—W1C. Switch and Tuning Condenser.
- Pre-aligned IF stages complete with full instructions. Fantastic value only 79/6 plus 6/6 post and insurance.

DEAC RECHARGEABLE BATTERIES

These nickel cadmium cells have negligible internal resistance. Will deliver current you require, reduce distortion and are completely reliable. They may be recharged indefinitely. Replacements for PP3 37/-, U7 12/6, U2 32/-, U11 23/- or send for list. Note charger for these types available, 22/6. Cells for building into tape recorders and other equipment: Heavy duty 1.25 v. type 8/3. Heavy duty 9 v. type 44/-. Charger that will deal with both together or separately, £4.15.0.

TAPE RECORDER BARGAIN

Capstan Driven, 5 Transistors



SPECIFICATION: 200/7,000 c.p.s.—400 mW. output — double track — twin speed (3¾ and 7½) fast rewind time—5in. spool gives one hour playing with standard tape, weight 7 lb. Size 8 × 11 × 3in. Complete with batteries, microphone, tape spool and instruction manual. Nothing to go wrong if you use a good tape and keep heads clean. Demonstration gladly given at our Croydon shop. **Special Snip Price This Month £11.11.0,** post and insurance 6/6.

HI-FI SPEAKER BARGAIN

12in. High fidelity loudspeaker. High flux permanent magnet type with either 3 or 15 ohm speech coil. Will handle up to 10 watts. Brand new by famous maker. Price 29/6, with built-in tweeter 35/- plus 3/6 post and insurance.

MAINS POWER PACK

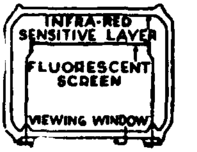
MAINS POWER PACK designed to operate transistor sets and amplifiers. Adjustable output 6v.-9 to 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries, PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer-rectifier, smoothing and load resistor, 5,000 and 500 mfd. condensers, zener diode and instructions. Real snip at only 14/6, plus 3/6 post.

ACOS GP83 TURNOVER PICK-UP CARTRIDGE

For Stereo—L.P.—and 78 records, fitted with two Styli. Diamond for LPs, Sapphire for 78s. This is mounted and is standard replacement for most record players using Garrard—B.S.R.—Collaro, etc., etc. The regular price of this cartridge is 55/-. We offer these new and perfect for 15/- (less than the price of styli), plus 2/- post and insurance.

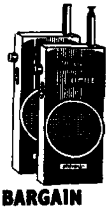
FLUORESCENT LIGHT KITS. Comprising choke, lampholders, starter and two chrome tube clips. 40 watt 11/6, 80 watt 17/6, 65 watt 17/6, 20 watt 19/6 plus 3/6 post and insurance.

SNIPERSCOPE



Famous war-time "cat's eye" used for seeing in the dark. This is an infra-red image converter cell with a silver caesium screen which lights up (like a cathode ray tube) when the electrons released by the infra-red strike it. A golden opportunity for some interesting experiments. 5/- each, post 2/-. Date will be supplied with cells if requested.

TWO-WAY RADIOS



Give communication over ½ mile. FULLY transistorised — crystal controlled, built-in telescopic aerial—press button operation—PP3 batteries—pair instruments complete and ready to use. £6.19.6, plus 5/- post and insurance. Big 5-mile range model £12.19.6 plus 5/- post and ins. These cannot be operated in U.K.

MOVING COIL METER BARGAIN

Panel meters are always being needed and they are jolly costly when you have to buy them in a hurry—so you should take advantage of this offer: 2in moving coil flush mounting meters only 5/6. These are actually R.F. meters and cost about £3 each but if you don't want them for R.F. then all you have to do is to remove the thermocouple and you will have a 2-3 m.a. meter which you can make into almost anything by adding shunts or series resistor. These are ex-government, of course.

Where postage is not definitely stated as an extra then orders over £3 are post free. Below £3 add 2/9.

ELECTRONICS (CROYDON) LIMITED

102/3 TAMWORTH ROAD, CROYDON, SURREY *(Opp. West Croydon Station)*

RADIONIC RADIO & ELECTRONIC CONSTRUCTION SYSTEM

ABSORBING AND EXCITING!

Unique and brilliantly simple. Hundreds of educational establishments—Universities, Technical Colleges, Schools, the Armed Forces—are already using Radionic for electronic instruction. Enthusiastic owners range from 9 to 82 years of age.
Selected by the Council of Industrial Design for all British Design Centres. Featured in Sound and Television broadcasts.

The system is beautifully engineered from top quality British components. No soldering. No mains. No prior knowledge needed. Simply arrange components on perforated transparent panel, position brass connecting strip underneath, fix with 6BA nuts and circuit works with full efficiency. You can then dismantle and build another circuit. Your results are guaranteed by our Technical Department and News Letter Service. All parts available separately for conversion or expansion of sets.

UNIQUE! Our "No soldering" printed circuit board for superhet portable. Simply insert components and tighten nuts.

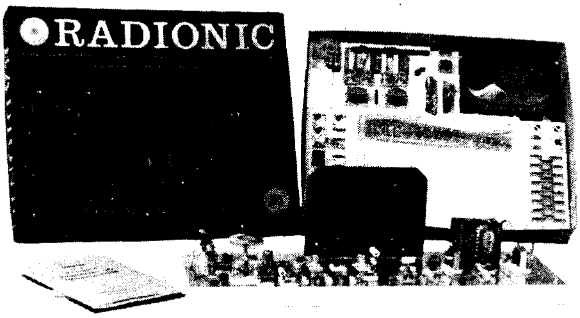
No. 1 Set	**£6.0.2.**	**14 Circuits (Earphone)**
No. 2 Set	**£7.1.5.**	**20 Circuits (Earphone)**
No. 3 Set	**£11.2.7.**	**22 Circuits (7 x 4in. Loudspeaker output**
No. 4 Set	**£15.3.8.**	**26 Circuits (include 6 Transistor and reflex superhets)**

Prices (Post Free)
(PLUS: P.T. Surcharge of 1/8d; 1/11d; 3/1d; 4/2d, respectively.)

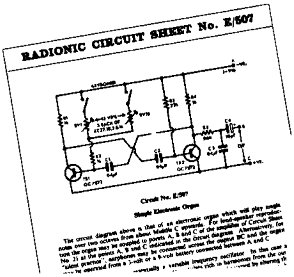
Full details from:

RADIONIC PRODUCTS LIMITED
STEPHENSON WAY, THREE BRIDGES
CRAWLEY, SUSSEX

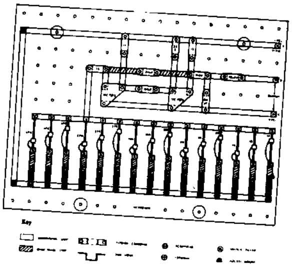
Tel.: CRAWLEY 27028 — Trade Enquiries Invited



A No. 4 SET and 6-TRANSISTOR SUPERHET

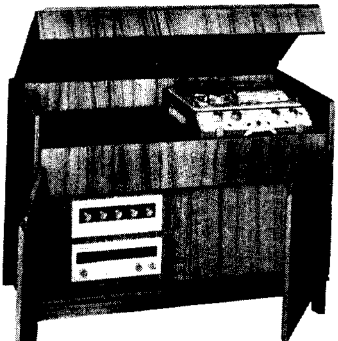


Theoretical Circuit



Practical Layout

Our 'E' Series of basic electronic circuits is available separately. Send for details of E/508, our do-it-yourself computer.



Schubert Equipment Cabinet 37 gns.

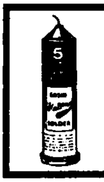
Housing Hi-Fi is our business . . . turntables, tape recorders, loudspeakers, tuners, amplifiers, records, tapes . . . there's a RECORD HOUSING cabinet to suit your equipment. Send for illustrated catalogue giving full details of over 20 different cabinets, plus stockists' list (U.K. only) to:

RECORD HOUSING (Dept. P.E.11)
Brook Road, London, N.22. *Tel.:* **BOWes Park 7487**

ERSIN Multicore SOLDER

For quick, easy faultless soldering

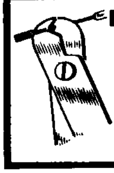
Ersin Multicore 5-core solder is easy to use and economical. It contains 5 cores of non-corrosive flux, cleaning instantly heavily oxidised surfaces. No extra flux is required. Ersin Multicore Savbit Alloy considerably reduces the wear of copper soldering iron bits.



HANDY SOLDER DISPENSER
12 ft. of 18 s.w.g. SAVBIT alloy in a continuous coil, used direct from free-standing dispenser.
2/6 each

LOW TEMPERATURE SOLDER
Size 9 pack contains 24 ft. of 60/40 high tin quality 22 s.w.g.
2/6 each
Size 10 pack 212 ft. 15/- each.

SAVBIT SIZE 1 CARTON
Contains approx. 30 ft. of 18 s.w.g. SAVBIT alloy. Also available in 14 and 16 s.w.g.
5/- each



BIB WIRE STRIPPER AND CUTTER
Strips insulation, cuts wire cleanly. Adjusts to any size.
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NOVEMBER 1966

Practical Electronics

AVIONICS

It is probably true to say that in no other field has the versatility and reliability of electronic technology been more convincingly demonstrated than in aviation.

Air transport has always been dependent upon various ancillary services—notably radio and navigational aids. Since the advent of radar, the variety and complexity—and usefulness—of these aids has increased tremendously. A large part of the electronics industry is now devoted to the development and production of these specialised equipments which are often referred to under the collective title of "Avionics".

It may not always be appreciated what a staggering variety of electronic equipment is incorporated in the airliner of today. Contained within a comparatively small area are examples from practically all the well-known branches of electronic technology. Radio, radar, instrumentation, computers and magnetic recorders, are all nowadays part of the normal airborne installation.

The safe and efficient operation of modern aircraft would be impossible without electronics, and yet more remains to be done, particularly where reliance is still placed principally on the human element. As, unhappily, we are frequently made aware, the human factor is often the weakest link in the chain. In this respect there is very encouraging news about a further significant contribution to safety under all-weather conditions as promised by the successful completion of trials of automatic landing systems. Adoption of such systems will eliminate hazards that may arise due to limitations of the human pilot.

Looking a little ahead, as the era of supersonic travel draws near, fully automated control during flight becomes not only desirable, but a necessity.

At supersonic speeds it is more than ever imperative that the prevailing situation be constantly evaluated, decisions then made and the appropriate action initiated—all within a second or so.

Unquestionably it is beyond man's ability to cope with such exacting demands—even when assisted by instruments. There is only one solution: he must relinquish control to the free electron with its unparalleled reflex action and response time and, equally important, total lack of idiosyncrasies such as characterise every human.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our December issue will be published on Thursday, November 10

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates including postage for one year, to any part of the world, 36s.

SHIP to SHORE RADIO

By S. SIMPSON

AN ACCOUNT OF THE G.P.O. COASTAL RADIO STATIONS AND THE SERVICES THEY PROVIDE

For a service so vital to the safety of shipping and to communication between shipping and the shore, it is surprising that so little is known by the general public regarding the Coastal Radio Service controlled by the General Post Office. If it were not for the infrequent news reports telling of (for example) medical advice passed to an injured seaman on board an inaccessible ship, many would never realise that there *are* radio stations performing such a service. Less is known, probably, of the numerous other duties carried out by the 12 stations strategically placed around our coastline, and manned without intermission.

THE RADIO STATIONS

Some stations, such as Stonehaven Radio, overlooking ruined Dunnottar Castle on the cliffs of Kincardineshire, are modern buildings laid out to efficiently house the radio and land-line equipment and its control systems; others, such as Portpatrick Radio (Fig. 1), standing high above the harbour once used by ferry steamers to Ireland, were adapted as the development of the service required. Wick Radio is a compromise and is almost part of a Council housing scheme. But, in almost every case, the station overlooks the sea ("overhangs" might better describe some locations) and has an unobstructed radiation field.

Fig. 1. (above). Portpatrick Radio Station prior to extension

Fig. 2. North Foreland Radio Station operations room

THE EQUIPMENT

The bow-shaped receiving desk, or console (Fig. 2), is the focal point of the complete system at each station. Centrally, it contains a multi-band receiver, a writing-desk, transmitter key, log-book, and other documents. On R/T consoles are push-buttons which bring into service an automatic answering device for use during busy periods. This device prevents interference by repeated calls from ships.

On the right, fitted into a sloping panel, are situated four keys for transmitter selection; indicator lamps placed immediately above the keys show when a particular transmitter has been acquired by one or other of the consoles. Above these lamps eight push-buttons provide frequency selection in the acquired transmitter, and here also, indicator lamps show which frequency is in use. Six push-buttons provide for high or low power operation, c.w. or m.c.w. telegraphy, or telephony, and a standby control of h.t. which enables the operator to retain the transmitter during brief interruptions in transmission.

Switches on the left-hand panel provide for the setting up and supervisory control of radio telephone calls. Facilities are provided for the selection of telephone lines, speaking to either the land-based telephone, or the ship-based telephone, or to both at once, and for transmission of a test tone. Other switches permit selection of either of two sets of line terminal equipment, operation on a simplex or a duplex system, monitoring the transmission or reception, maintenance of the carrier without modulation, and a meter reading of the volume level (in dB) of the transmitted or received signal. Lamps indicating acquisition of the line, the use of test tone, and selection of terminal equipment are placed adjacent to the keys.

At the busier stations, additional equipment is installed which provides simultaneous working facilities enabling more than one link call to be controlled at the same time. These stations are also equipped to provide a v.h.f. radio telephone service and for the large passenger vessels, special liner service equipment capable of operation on d.s.b. or s.s.b. with the use of a privacy facility when required.

TRANSMITTERS

Main and standby transmitters are used. The main transmitters are used on both W/T and R/T; on W/T the power radiated is approximately 0·5kW from a triatic horizontal aerial positioned for optimum radiation in the station's service area. A typical aerial is supported by steel lattice masts, 120 to 150ft high (Fig. 1). Since only one aerial is provided for W/T, a safety interlock circuit prevents another main transmitter selecting a W/T frequency once the aerial has been selected. On R/T, each main transmitter has its own mast radiator or aerial and safety interlock circuits prevent two transmitters operating on the same frequency.

The transmitter arrangement consists of a crystal oscillator capable of operation on any one of eight preset frequencies. Selection is made by relays operated from the console. The selected frequency is amplified in the master oscillator section, then passed to a pretuned first-stage r.f. amplifier, thence to the r.f. power amplifier whose output, on R/T, passes to the aerial via a coaxial feeder; on W/T, a direct, open-wire feeder is used. The frequencies of the first stage and power amplifier are changed by contactors simultaneously with the change of crystal frequency.

The standby R/T transmitter is of fundamentally similar circuitry and feeds approximately 60W to a vertical cage aerial suspended by a single steel mast.

Adjacent to the transmitter compartment is the drive rack containing the main crystal oscillator (Pierce), a Wien bridge crystal oscillator for m.c.w., a line termination panel and filters, a limiter to keep speech frequencies within the range 300c/s to 3,400c/s, and the modulation amplifier. Suppressor grid modulation is employed in the paralleled final r.f. amplifiers; the modulation depth is 80 per cent.

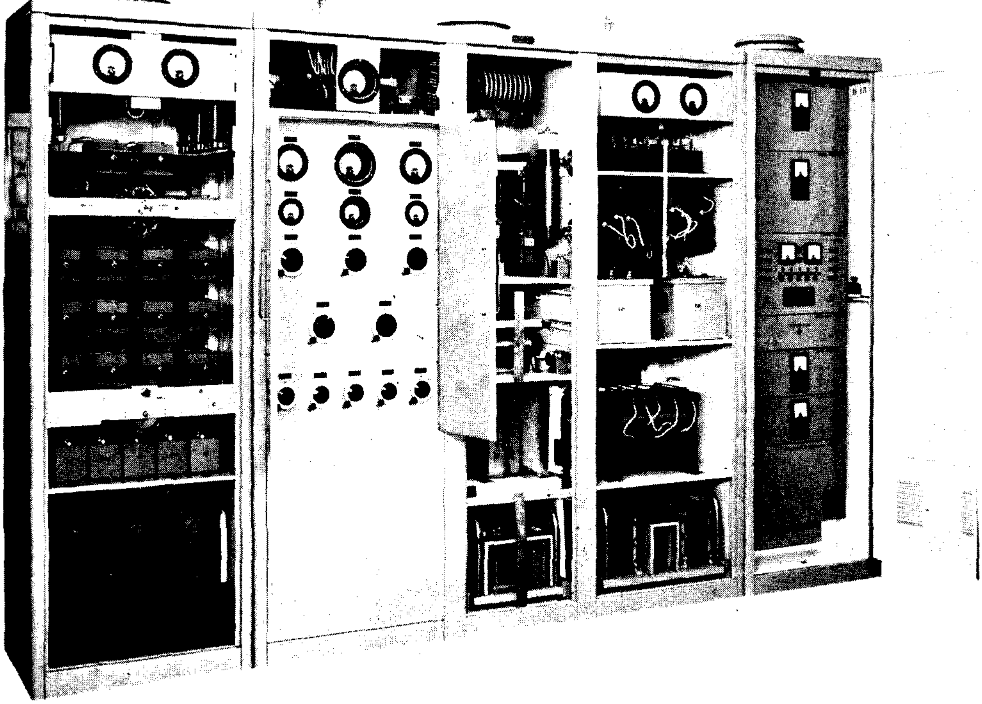
The drive rack also contains the low-voltage relays which energise the transmitter, and provide selection of frequency and mode of operation. The power supplies to operate the relays are within the rack; fuses to protect the power supply are accessible externally. A fuse, when destroyed, completes a circuit to operate a buzzer and also to light a lamp. A further safeguard against overload in the final r.f. amplifier section is given by a thermostat placed adjacent to the power valves The thermostat, when operated, disconnects the h.t. supply to the amplifier.

Typical transmitting equipment is shown in Fig. 3. On the transmitter cubicle, the front panel carries meters showing anode, screen and grid currents of the valves in the penultimate and final power amplifiers. Other meters show the main h.t. supply voltage (approximately 3kV) and the R/T and W/T aerial currents.

RECEIVER EQUIPMENT

A block schematic of the Mercury receiver employed in coastal radio stations is shown in Fig. 4, and the receiver itself, fitted into a console, can be seen in Fig. 2. This receiver provides double frequency conversion and operates over the bands 15kc/s to 40kc/s, and 100kc/s to 4·0Mc/s in four ranges. The aerial may be quite distant (one mile is not unusual) and is connected to the receiver by a 75 ohm characteristic impedance coaxial cable. In the second i.f. amplifier four degrees of selectivity are available, "wide", "intermediate",

Fig. 3. A bank of transmitter equipment



"narrow", and "crystal gate"; these provide bandwidths from 8kc/s to 150c/s.

The output from the receiver feeds a monitor loudspeaker when required, in addition to a headset and the land-line terminal equipment. There is no preselected frequency arrangement, since the tuning operation is quick and very simple. (In actual use, the operator has marks on the "slide-rule" dial relevant to his listening frequencies. In one station, these marks are coloured similarly to the colour of the push-button for the transmission frequency of the channels in use).

LINE EQUIPMENT

Ship-to-shore telephone calls employ constant-volume amplifiers in which hybrid transformers separate the transmission and reception paths and connect either to the two-wire inland telephone system. Voice-operated thermal-delay switching equipment is employed to cause a changeover from reception to transmission. The delay prevents clipping of the first syllables of incoming speech from the line equipment. The number of these equipments available depends upon the station's traffic load; Stonehaven and Portpatrick each have two (see Fig. 5).

DISTRESS EQUIPMENT

The distress equipment consists of two standby receivers permanently tuned to the distress frequencies, 2,182kc/s and 500kc/s. The outputs are fed to the loudspeakers situated on the R/T and W/T console. Two R/T auto-alarm units are mounted back-to-back for transmission and reception of the R/T alarm signal. In addition, equipment is provided for transmission of the W/T alarm signal by automatic means.

On W/T (500c/s), the alarm signal consists of 12 four-second dashes with one-second spacing. Automatic transmission of the signal is controlled from the W/T console where depression of a key operates a motorised cam which operates the keying circuit of the transmitter, already tuned to 500kc/s in the m.c.w. condition. On radiotelephony, the signal is a continuous warbling note consisting of rapidly alternating tones of 1,300 and 2,200c/s. Each auto-alarm unit functions as both receiver and transmitter and can be controlled from the main R/T console.

ACTION OF R/T AUTO-ALARM EQUIPMENT

Transmission On depression of the transmit key on the console relays set in operation a Hartley oscillator stage on the auto-alarm unit and integration circuits to produce the two tones. Alternation of the two tones is controlled by a timing relay circuit; after amplification, the two-tone output is fed into the modulation circuit of the transmitter, tuned to 2,182kc/s,

Reception. Signals received on the R/T distress watch receiver are extended to the auto-alarm unit, and the equipment now operates as a detector and amplifier. Reception of the two tones of the alarm signal operate timing and integration circuits, the correct signal operating an alarm relay circuit which lights red warning lamps at strategic locations and activates an alarm buzzer on the R/T console. After receipt of the alarm signal, the unit can be reset by depression of a key on the console and is then ready for reception of further signals.

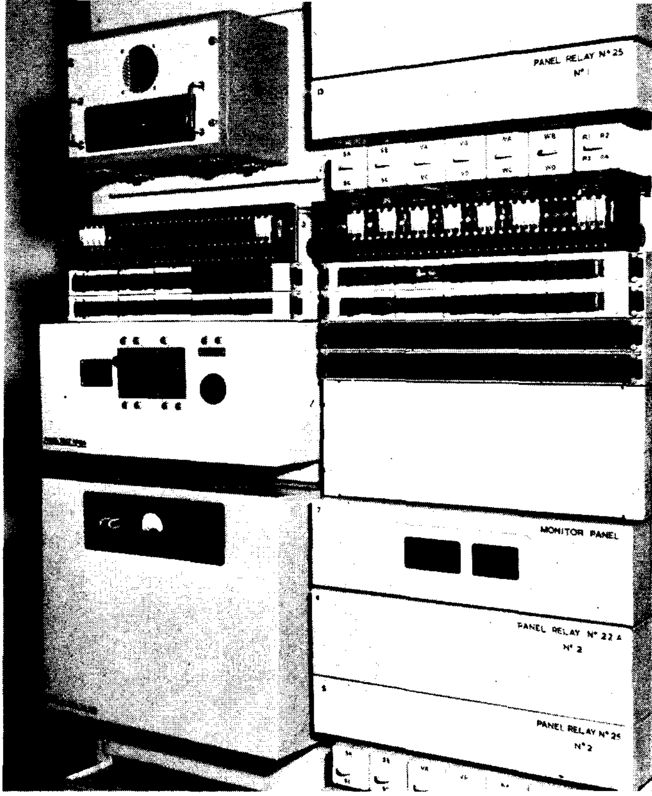


Fig. 5. G.P.O. Land-line terminal equipment. The W/T Distress Frequency Receiver is seen at top left and below it, the Auto-Alarm Equipment and associated Test Panel

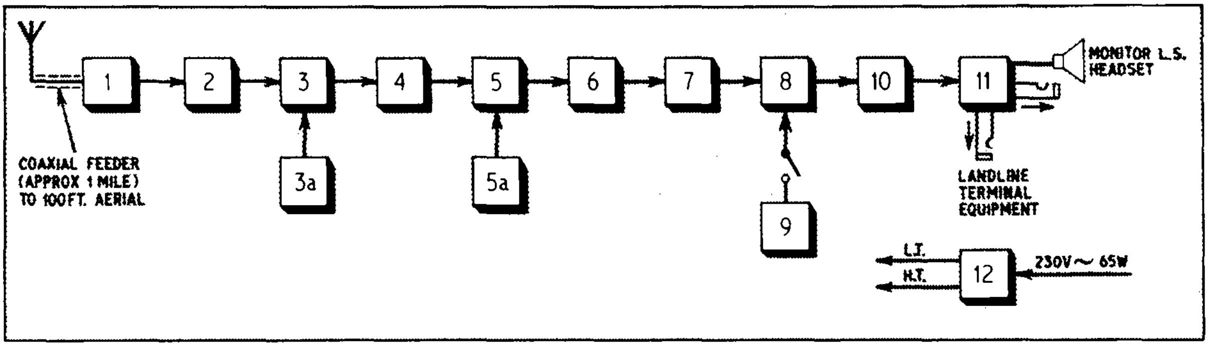


Fig. 4. Block diagram of Marconi "Mercury" receiver

1. 1st R.F. Stage
2. 2nd R.F. Stage
3. 1st Frequency Changer
4. 1st I.F. Amplifier (4·5Mc/s)
5. 2nd Frequency Changer
6. 1st I.F. Amplifier (85kc/s)
7. 2nd I.F. Amplifier (85kc/s)
8. Detector/A.V.C.
9. Beat Frequency Oscillator
10. Noise Limiter
11. Audio Output
12. Power Supply

Protective circuits are employed to ensure that the alarm unit responds only to alarm signals of the correct frequency and duration. Test facilities are provided to enable full operation tests to be carried out on both units either individually or simultaneously.

LAND COMMUNICATIONS EQUIPMENT

Radiotelegrams are transmitted to the addressee as quickly as possible by telephone, teleprinter, or Telex networks. The necessary equipment is housed in the office adjacent to the receiver room. "Service" messages between one radio station and another are normally sent by Telex equipment.

MISCELLANEOUS EQUIPMENT

Under this heading comes the standby diesel-engined power plant which can be started from accumulators by a push-button located at the mains distribution board. When the standby supply is available, neon indicators in each phase are alight, and the changeover can be made from mains to standby by a master switch. The interruption of service because of mains failure is therefore very short. Stopping the standby plant is a manual operation at the plant location.

Also fitted near the distribution board are two rectifier units; one provides 50V d.c. to operate the relays, contactors and lamps already mentioned, while the other is a standby. Input power to these units comes from the mains (service, or standby plant).

THE SERVICES

Having learned something of the station and its equipment, one is in a position to appreciate the services provided. Summarised, they are—business correspondence, social correspondence, weather forecasts, gale warnings, navigational hazard warnings, medical services, and distress messages.

Unbroken coverage to provide these services in the sea areas around Great Britain and Eire is maintained by 12 stations in the former, two in the latter. The British stations are located at Wick, Stonehaven, Cullercoats, Humber, North Foreland, Niton, Land's End, Ilfracombe, Anglesey, Portpatrick, Oban and a large establishment at Burnham-on-Sea which handles long-distance traffic and also acts as a central source of information on shipping movements and allied matters for the others. In Eire, the two stations are at Malin Head and Valentia.

Congestion in the frequency band allocated to the coast radio system is partly overcome by using a number of "working" channels shared between the stations. The channels are numbered 1 to 9; adjacent stations are allotted odd- and even-numbered channels. Ships calling any coast station, other than Oban Radio, use 2,381kc/s during the hours 9 a.m. to 5 p.m. Monday to Saturday inclusive, and 2,182kc/s at all other times. Calls to these stations are always answered on 1,792kc/s. Oban Radio maintains watch on 2,182kc/s at all times and replies on 2,182kc/s.

After contact has been established, the coast station ascertains which channel the ship's operator will use for transmission and tells him on which channel the coast station will transmit. Since all ships carrying radio equipment also carry serial Notices to Ship Wireless Stations issued by the General Post Office, London, an operator intending to work with a particular station can find out beforehand its working channel, thus the changeover from "calling" to "working" frequencies is very rapidly made.

CORRESPONDENCE

Business correspondence, whether by telephone or telegraph, occupies much of the station's time, and not wholly during shore office hours. It takes many forms, from straightforward direction of shipping movements to instructions from a managing director in the stateroom of an Atlantic liner, to his staff "somewhere in London"—or anywhere else in the world where the international telephone service operates.

Social correspondence also ranks high in importance. By radio link, a birthday bouquet can arrive literally "out of the blue", a husband is kept informed of the progress of one seriously ill, a wife arranges a holiday with her husband in a port of call, and so on.

Anyone renting a telephone can call a friend on board ship at any hour by asking his local exchange operator for "Ships' Telephone Service" giving, if he knows it, the name of the coast station through which the ship can be contacted. Provided the ship is keeping radio watch, his call will be connected within a few minutes. All calls to ships are on a personal basis,

The Ship's Letter Telegram service is also widely appreciated. By its means, a non-urgent message can be radioed to a coast station, whence it passes by ordinary post to the addressee. Since the charge for this service is very reasonable, the benefits to a ship's crew are obvious.

V.H.F. RADIOTELEPHONY

The growth of telephony traffic in recent years has brought about yet another step forward—the introduction of v.h.f. systems. Several of the stations now use the system to communicate with shipping passing close by, and it is also much used by Harbour Authorities for port operations work. Its use for public correspondence has been slow to develop but remaining coast stations will be equipped as demand arises.

WEATHER

Information on deteriorating weather reaches the coast stations at any time, and from several sources, including tramp steamers, trawlers, and coasters on regular routes. On receipt, this miscellany is sent by Telex to the Meteorological Service at Bracknell, England, where it is correlated with other weather information and a resulting forecast then telegraphed to selected stations concerned. Here, after a preliminary call on 2,182kc/s (R/T) and 500kc/s (W/T), it is transmitted on working frequencies to all ships at regular, scheduled hours.

Fig. 6. Distress Frequency Receiver (R/T)

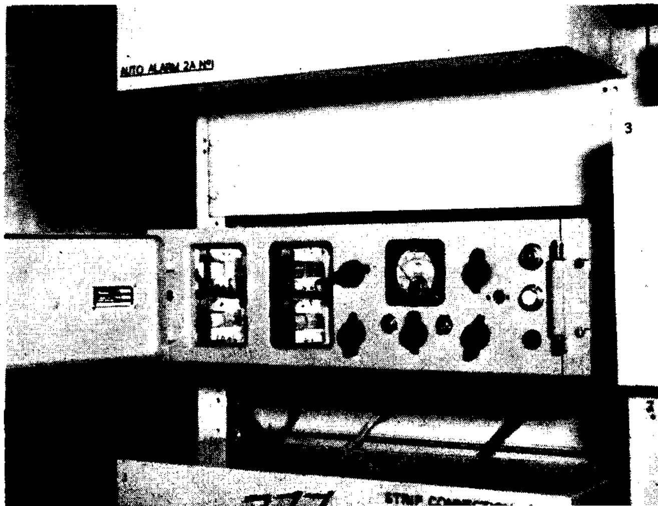


Fig. 7. Radio Officer's Remote Control Console at Anglesey Radio Station

Gale warnings are prefixed "Securite" on R/T and "TTT" on W/T. They are transmitted on the working frequency after a preliminary announcement on 2,182 and 500kc/s, immediately after the next "Silence Period" and thereafter, repeated at scheduled intervals. ("Silence Periods" are 3-minute intervals during which no transmissions should be made except distress messages, and on W/T commence at 15 and 45 minutes past each hour and on R/T, at 00 and 30 minutes past each hour.)

HAZARDS

Navigational hazards such as extinguished light buoys, partially sunken wrecks, icebergs, and similar dangers to shipping are the subjects of broadcasts, radiated, if requested, at the time of receipt of the information by the coast station, and at a number of regular intervals thereafter. The value of this service needs no emphasis. Here also, the initial call is given on 2,182kc/s, and the message on a "working" channel.

MEDICO SERVICE

An outstanding service is the ability of a ship's surgeon, doctor, or in some cases the captain, to ask medical advice or assistance to be passed to him through a coast station. The service is free and offered to ships of any nationality. It may be conducted by telephone directly with a doctor in a hospital or in his home, or may be relayed by the coast station to the nearest liaison hospital to the coast station. If the ship is nearby, a doctor may be flown there by helicopter (after arrangements made by the coast station), but when the ship is out of reach it may be that a minor operation must be carried out (perhaps by the captain) while he is guided by telephone instructions from a surgeon on shore. Transport for someone sick or injured is a very frequent demand made on the Medico Service.

DISTRESS

Perhaps the greatest service maintained by the coastal radio station is the unceasing watch for the sudden distress call from a ship in extreme danger. It may be fire, a lost propeller, a damaged rudder—or it may be a 30-foot gash in a hold because of an unmarked wreck; no matter what, if the captain decides that immediate assistance is necessary to save life and property, a coast station operator somewhere will hear in the small loudspeaker at his right hand, 12 automatically-keyed four-second dashes spaced by one-second breaks, or the two-tone warble. Auto-alarm equipments on board ships within range respond to the signals and alarm bells call the Radio Officers to their posts. On these ships and on shore, the operators, on hearing the signal, wait for the vital information concerning the ship, her position, and the cause of distress.

Once the operators have the information, the shore-based W/T operator depresses the auto-alarm key at his console, thus starting the mechanism which keys 12 accurately-spaced dashes for transmission on 500kc/s. The R/T operator simultaneously transmits the auto-alarm on 2,182kc/s as explained earlier, and both, after a short pause, transmit the distress message on much greater power than may now be available at the distressed ship. At the same time, assistance from the nearest Coastguard, Rescue Co-ordinating Centre and RN establishment is summoned.

All commercial working on 500kc/s and 2,182kc/s ceases for the duration of the distress while the work of rescue goes on—perhaps for minutes only, perhaps very much longer—with the Coastguard service co-ordinating the work and the coastal radio service co-ordinating communications between assisting ships and the main authorities.

Whichever form the *SOS* takes, whether it be the telegraphed *SOS*, or the telephoned *Mayday*, one has only to remember such disasters as the ramming of the Italian liner, *Andrea Doria*, or, more recently, the burning *Lakonia*, and compare these with the tragedy of the *Titanic*, lost with 1,200 lives after striking an iceberg during her maiden voyage in 1912, to realise how far we have advanced in safety at sea because of the existence of the fifty-six-years-old Coastal Radio Service.

ACKNOWLEDGEMENT

The writer wishes to thank the many friends met in coast radio stations in Scotland, both for their welcome, and the ungrudged time they gave him while providing the information in this article. Thanks are also extended to the G.P.O. for permission to reproduce photographs of Northforeland Radio and Portpatrick Radio and for permission to visit the stations in Scotland.

★

THIS receiver had to be small enough to fit inside the tray of a matchbox, together with its associated amplifier and relay. Needless to say it has only a single channel. The range is in excess of half a mile, and has the ability to withstand almost all the hazards a model could offer; ease of adjustment, long-term reliability, and low cost, were among other design requirements.

As a "front end" this unit will serve virtually all the basic control systems now in widespread use, catering for relay, relayless, reed, filter, and proportional systems, whilst responding to unmodulated signals if required. For this reason, its adaptability, the receiver would make a good starting point for those who have yet to investigate the extensive possibilities of control by radio.

Where pencil size soldering irons are not available, or the challenge of packing the most into the least space is lacking, construction may follow slightly larger, more conventional lines. Each stage of assembly may be monitored with a pair of headphones, minimising the need for reconstruction if a component is found to be faulty.

It was decided to furnish the receiver with its own independent power supply and let the amplifiers take their heavy demands from an alternative source. This avoids possible interaction through coupling along the supply line and does ensure freedom from variations of sensitivity due to a fast dying battery. In certain circumstances a common battery supply forms a highly efficient negative feedback loop, not always easy to identify, and can cause a serious loss of gain.

Many consider that the super-regenerative receiver is inclined to be a little fussy in operation, needing frequent retrimming for best results. The prototype of this receiver was sprayed all over with paint, so that all the components were thoroughly glued together; the only possible adjustment then required is movement of the tuning screw in L2.

Afterwards, the unit was totally immersed in water to see what would happen. Nothing did! It still continued to function reliably.

Hence if used in a model boat subjected to submergence or bilge water, it should still function.

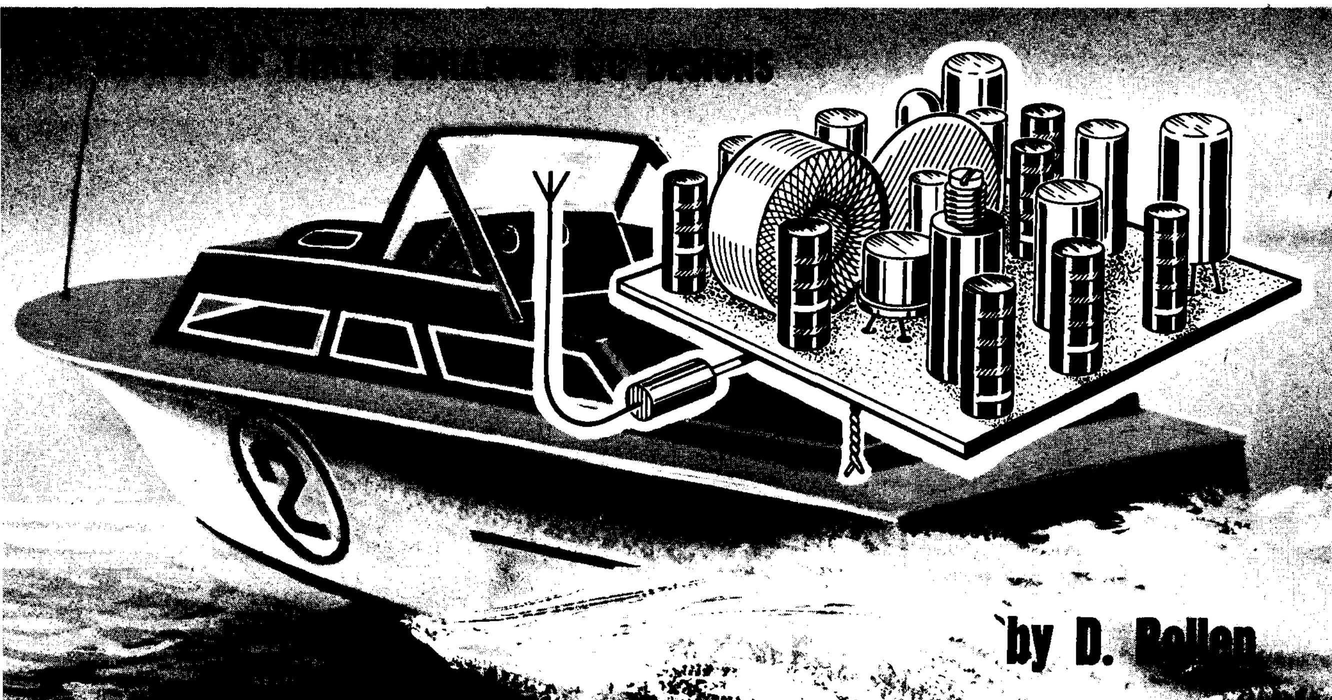
COMMON BASE TUNER

The "inverted" configuration of TR1 in the circuit diagram Fig 1, is a convenient way of showing how this *npn* transistor feeds TR2 (which is *pnp*) by means of series load resistor R4.

TR1 operates in the common base mode and is tuned to the signal frequency by C4 and L2. The coil is often the biggest single component in a receiver of this sort so some effort was made to reduce its size. L2 was wound on a $\frac{3}{16}$in former taken from a t.v. tuner. The brass screw inside such formers, which acts the opposite way to a dust core by increasing the frequency of operation when screwed right in, has a fine thread allowing critical tuning to be carried out without undue ceremony. Two complete turns of the screw covers approximately 1Mc/s.

The lower quench frequency, in this case 40kc/s, is determined jointly by R3, C2, C3, and C1. Here good quality capacitors are essential. Standard practice demands that the base of TR1 be bypassed to a.c. by an electrolytic capacitor of about 2μF, but with the arrangement shown this was not found to be necessary, contributing nothing to either stability or performance.

MODEL CONTROL RECEIVER



by D. Bollen

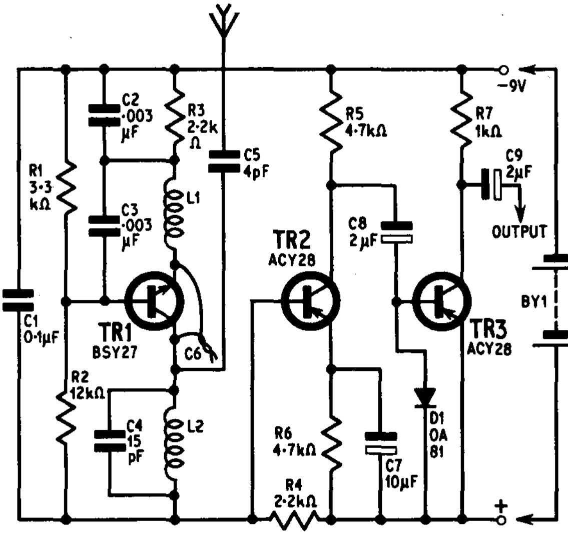


Fig. 1. Circuit diagram of the complete receiver

Subminiature electrolytics tend to have rather unsatisfactory impedance characteristics at anything approaching high frequencies, as well as undesirable resonances due to self-inductance occurring at relatively low frequencies. The overall effect is sufficiently unpredictable to discourage the use of such a component in this particular application. Any tendency towards low frequency instability can be adequately counteracted by wiring a subminiature electrolytic of a high value, say, 100µF, across the battery connector leads. Alternatively, one can use a power supply with a lower internal impedance than the normal dry battery, such as rechargeable nickel cadmium button-cell batteries.

Capacitor C6, across the collector and emitter of TR1, represents the small value of preset capacitance, obtained from a pair of 1½in 32 s.w.g. enamelled wires twisted together. This provides the required degree of positive feedback for correct super-regenerative action, without contributing materially to component density, as would be the case with a standard ceramic or air-spaced trimmer.

An r.f. choke L1 is a wave-wound type on a small carbon resistor. If the winding terminations are secured to the pi winding with small spots of glue the resistor can be carefully removed, leaving the winding intact. Although the precise inductance value of the original is not known, the choke had a self-resonance of 2Mc/s and was estimated to be slightly less than 1mH.

TWO STAGE AMPLIFIER

The function of TR2 and TR3 is fairly straightforward in that they merely amplify the low level output of TR1. No attempt was made to filter out the quench frequency by various resistance capacitance combinations in the early stages of amplification. In fact, low pass filters were studiously avoided so that a wider band of audio frequencies could be passed to permit the use of "carrier only" control and extra channels when tone filters are employed. To reduce quiescent current drain, resistors were not used to bias the base of TR3, such bias being provided by the action of D1. The bias for TR2 is automatically derived from the voltage drop across R4. The finalised circuit offered enough gain to obviate the use of a transformer.

The total consumption of the receiver on 9 volts is slightly less than 3mA, depending on the setting of C6, rising to a higher value only when the receiver is in close proximity to a powerful transmitter.

ONLY 1 INCH SQUARE

Fig. 2 shows how the components are positioned on a Paxolin panel 1in square. The $\frac{3}{16}$in coil former for L2 is close wound with 30 turns of 32 s.w.g. enamelled wire, secured in place with a layer of tape or wax. It can be wound on a former taken from a television tuner "biscuit", obtainable from television repair shops. After winding, the former may be cut down to an overall length of $\frac{9}{16}$in. The exposed portion of the former is then inserted in a $\frac{3}{16}$in hole drilled in the paxolin (Fig. 3) and glued firmly in place.

Component leads are usually long enough and sufficiently rigid to provide, in themselves, a major part of the under panel wiring. Thin insulating sleeving can be pushed over the leads where they cross. Portions of the circuit may also be linked by short lengths of tinned copper wire. It is possible, with this constructional method, to build this receiver in less than three quarters of an hour, but such haste would not normally be advised except in dire emergencies.

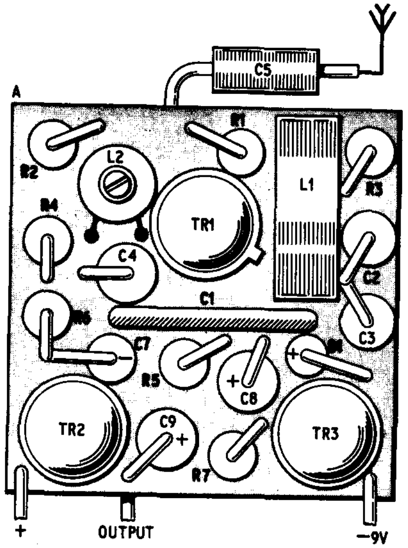
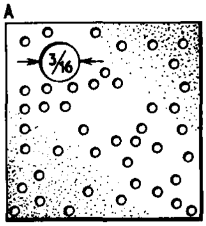
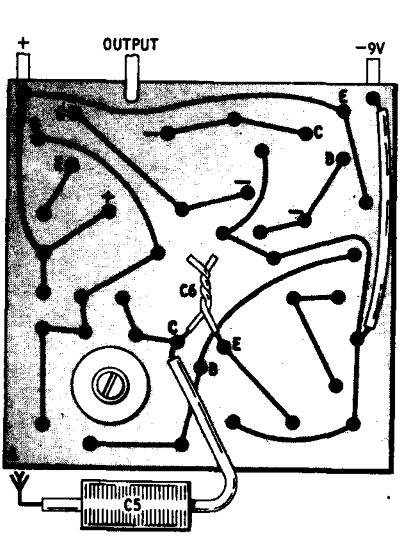


Fig. 2a (left). Layout of components on the board shown double scale

Fig. 2b (right). Wiring under the board including the capacitor C6 made by twisting two insulated wires together. Do not allow them to short

Fig. 3 (below). The drilling positions of holes $\frac{1}{16}$in diameter. Scale of board—full size





COMPONENTS . . .

Resistors

R1	3·3kΩ	R5	4·7kΩ
R2	12kΩ	R6	4·7kΩ
R3	2·2kΩ	R7	1kΩ
R4	2·2kΩ		

All 10% $\frac{1}{10}$ watt carbon

Capacitors

C1 0·1μF disc ceramic 25V	C6 See text
C2 0·003μF metallised paper 400V	C7 10μF elect. 12V
C3 0·003μF metallised paper 400V	C8 2μF elect. 15V
C4 15pF ± 1pF ceramic	C9 2μF elect. 15V
C5 4pF mica or ceramic	

Inductors

L1 R.F. choke (see text)
L2 32 s.w.g. wire for coil (see text)

Transistors

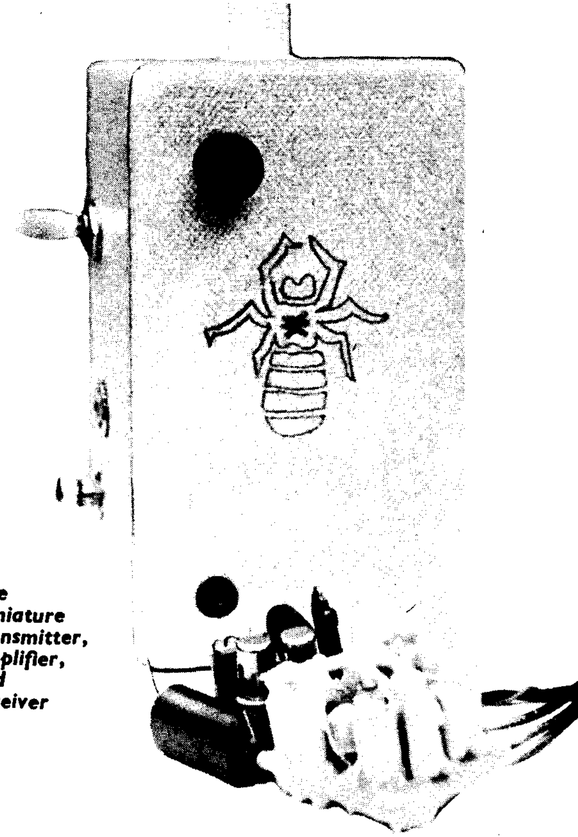
TR1 BSY27
TR2 ACY28 or OC71 (Mullard)
TR3 ACY28 or OC71

Diode

D1 OA81

Battery

BY1 9 volt (PP5 or Deac)



The miniature transmitter, amplifier, and receiver

STAGE CHECK

When the r.f. stage is wired, a pair of high resistance headphones may be substituted for R4 to check for oscillation and response to a transmitter. A hiss should be heard when a 9 volt battery is connected to the supply rails. The brass screw of L2 should be about half-way in. If no hiss is apparent, increase the capacitance of C6 by further twisting of the enamelled wires. The circuit will be functioning correctly when full adjustment of L2 slug causes no marked variation in the hiss; a strong signal should be picked up from a nearby transmitter without an aerial on the receiver. When the next stage is added the headphones can be connected to the positive battery terminal and C8 positive. Similarly check the final stage by connecting the headphones across the output.

Crash proofing and waterproofing the finished unit, with several coats of paint from an aerosol spray, should be left until the very last, after the following amplifier has been tried out. The ends of C6 must not be snipped short and folded flat against the underside of the panel until final testing is completed. The value of C6 has some bearing on the amount of background noise, and hence the standing current of the amplifier, and requires setting before the first coat of paint is applied.

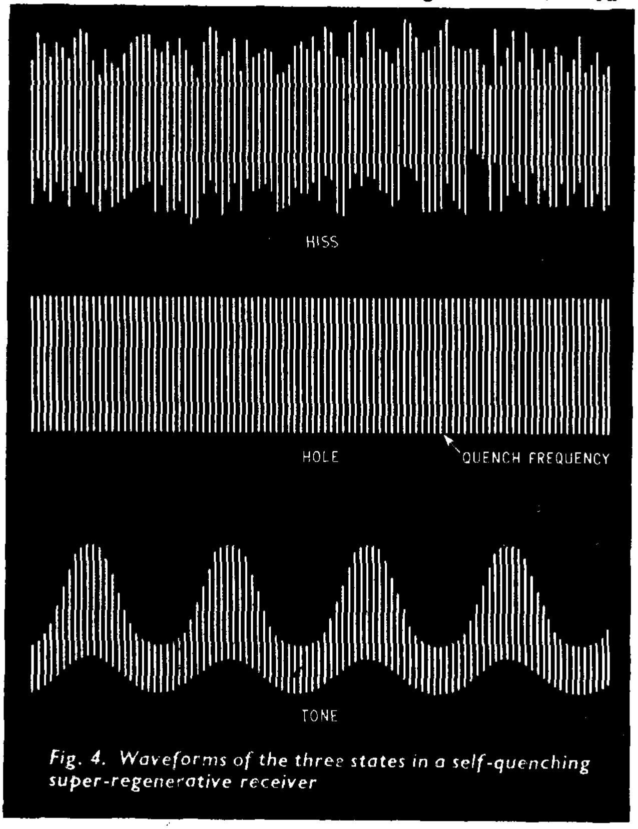


Fig. 4. Waveforms of the three states in a self-quenching super-regenerative receiver

IN OPERATION

The self-quenching super-regenerative receiver may be regarded as having three states. In the absence of a signal, random noise triggers the quench giving rise to the characteristic hiss. With plain carrier received, the noise is swamped by the signal and the quench shifts to a slightly higher frequency, and what is termed "a hole" appears in the background noise of the receiver or, put another way—silence! If the carrier is modulated by a tone this will override both hole and hiss. Representative waveforms, illustrating the three states, are shown in Fig. 4.

Noise occupies a very wide bandwidth, part of it may be selectively amplified and used to bias off a current amplifier feeding a relay. When plain carrier is received the hiss disappears and the relay operates. The sensitivity and range is somewhat inferior to tone reception but this is compensated, to some extent, by the higher radiated r.f. power of an unmodulated transmitter.

The squealer

BLUEPRINT GAME

IF YOU wish to amuse young children during the Christmas festivities, then by all means build this device, but we guarantee its strident howls will have you reaching for your soldering irons by twelfth night.

It features a beam projector and light operated electronic relay which is designed to function when any intruding, acquisitive hand, intent on a prize, breaks the beam. An oscillatory alarm, tripped by the relay, starts a rising cadence which is sufficiently startling for the hand to be withdrawn.

With the retraction of the hand, the sound produced begins to fall in pitch giving the overall effect of a siren. Apart from this simple, amusing application, the principle and circuitry involved will provide an excellent intruder alarm in many other applications.

LIGHT BEAM DETECTOR

The light detector is a cadmium sulphide cell which provides a large resistance change inversely proportional to changes in light intensity falling upon it. On stand-by, that is with the beam directed at the cell, its resistance will be low in the order of 80–300 ohms. With the hand breaking the beam and the light cut off, the resistance increases to about 10 megohms.

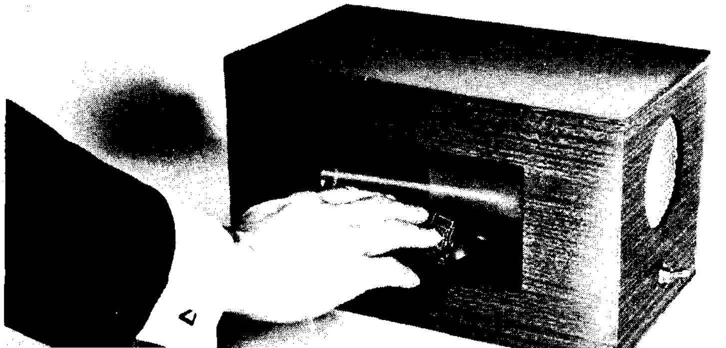
The division of supply voltage between the base resistor R1 and the photocell X1 is related to the light intensity, causing the *pnp* transistor TR1 to be biased off when the beam is shining on it, and switched hard on when the beam is broken (see Fig. 1). In the latter state, TR1 stage functions as an emitter follower with the output to TR2 being taken from the emitter, thus switching the d.c. amplifier TR2 on.

A 335 ohm relay makes up the load to this stage, it being shunted by a point contact diode to suppress any impulsive surges that could be applied to TR2 through back e.m.f. from the relay coil.

With the relay energised and contacts RLA1 consequently closed, the electrolytic capacitor C1 commences to charge by way of the potentiometer VR1. This applies an increasing positive bias voltage to the base of the *npn* transistor TR3.

TR3 and TR4 are connected in complementary symmetry. When the base of the *npn* transistor goes positive, due to the 180 degree phase reversal in a common emitter configuration, the collector goes negative which causes TR4 to conduct, TR4 collector going positive. This step is communicated through C2 to the base of TR3, producing a cumulative or regenerative effect.

During the ensuing relaxation period, C2 charges by way of the relatively low base to emitter resistance of TR3, until the complementary pair are switched off. With the discharge of C2, the switching cycle is recommenced.



THE SQUEAL

A characteristic of this oscillator is its initial rising tone effected by the time constant C1, VR1. The setting of the latter control can provide a swift hand time handicap to beat the beam if little hands tire of the seemingly insuperable task the game presents.

With the hand withdrawn, and relay contacts RLA1 open with the circuit quiescent, C1 discharges, producing a falling wail. The pitch of the note can be changed by varying the capacitance of C2. An increase in capacitance lowers the pitch of the tone and a decrease raises it.

The decay time of the siren tone can be lengthened by increasing the value of R5. It will be found that this is the most effective part of the siren circuit as the removal of the competitor's hand does not usually allow C1 to charge completely if VR1 is set to the maximum resistance, Here, of course, the desired effects will be achieved by experimenting with circuit values as outlined above.

The choice of transistors in this stage is flexible as almost any type of *npn* switching transistor could be substituted for TR3 without much change of performance, However, in view of the low cost of the BSY 95A and its easy availability, this will hardly be necessary.

MAKING UP

The layout of components on the Veroboard panel is not critical but a preference was made for a layout similar to that of the circuit diagram (see Fig. 2 on the blueprint). Notice the transistor connections vary; in the case of TR3 the locating lug on the case is between the collector and base wires; on TR4 the case acts as the collector connection, while base and emitter pins are offset from the centre. In Fig. 2a the pins are represented by the open circles while the connection positions on the board are filled in circles.

Next make up the projector (LP2) and light detector (X1) assemblies (Figs. 4 and 5). The first is perfectly straightforward, but a choice can be made in the type of torch beam head used.

More efficient lenses would reduce the light scatter and allow a much lower wattage bulb to be used. A less detectable infra-red beam could be achieved by inserting a piece of red transparent acetate sheet before or after the lens as desired. Another variation would be to use pieces of mirror so that the hand aperture could be laced with light.

The light detector case is a cigar tube shortened to about 2in long (Fig. 4). This may be obtained from many large retail tobacconists free of charge. The

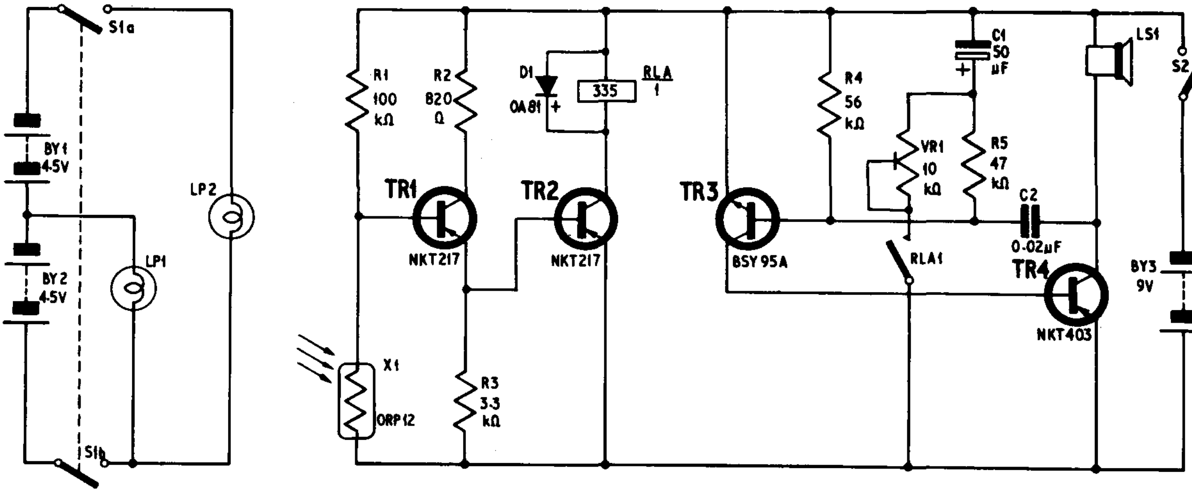


Fig. 1. Circuit diagram of the squealer

In the case of the output transistor TR4 most audio power types could be experimentally substituted.

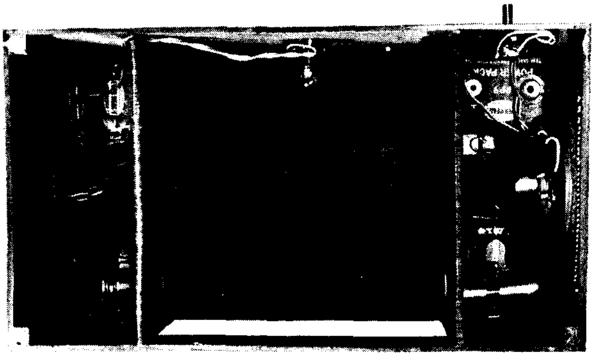
Variation in volume is dependant on the dimensions of the loudspeaker used. A 3in unit was found to give a sufficiently strident note, but it is possible to place in series in the collector line of TR4, two 3 ohm loudspeakers or, alternatively, one 5in, 3 ohm unit. A larger size would prove a little disconcerting in the average living room.

On stand-by, the current consumption from BY3 is about 10 milliamps rising to about 150 milliamps with the beam broken. Since the heavier drains are sporadic, a PP7 proved satisfactory in the protoype although two 4·5 volt flat pack batteries are to be preferred if they can be reasonably accommodated in the space provided.

internal diameter must be large enough to encapsulate the cadmium sulphide cell, this being contained in a rubber grommet to provide a push fit in the tube. It is as well to keep the cell sufficiently recessed to obviate any interaction from any other light source.

As a further deterrent to stray light being reflected along the inside of the tube, the internal surface was covered with a matt black paint.

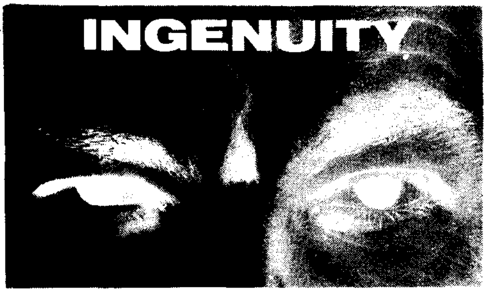
It should be noted that the Terry clip retainer of this detector assembly is held slightly away from the case by a piece of wood. This enables a more precise alignment with the light beam to be achieved, compensating for the difference between the clip sizes for projector and receiver. Whatever mounting arrangements are used the light beam should be directed straight on to the photo-sensitive surface of the cell.



When the box is completed according to Fig. 6 on the blueprint, the wired sub-assemblies should be positioned and all fixings completed. Before the dividing panels are inserted, the projector and receiver beam alignment should be carried out. This is done by placing a piece of paper over the cigar tube aperture, switching on the lamp, and then positioning the beam so that it reflects centrally on the paper. This paper can then be removed and the panels inserted. The lid is finally fixed with glue or pins.

The game of "Beat the Beam" can now be prepared. A prize suitable for the age of the contestants is placed in the box in full view of the hand aperture. The lamp switch S1 should then be switched on so that LP1 provides illumination for the prize and also a degree of masking for the beam making it less apparent to the contestant. This light should not be allowed to interfere with the function of the cell.

Switch on the "squealer" switch S2; quickly test that the unit functions properly by passing the hand through the light beam. The handicap control VR1 can be adjusted as outlined earlier in this article. ★



UNLIMITED!

IN THIS feature we hope, from time to time, to be able to publish suggestions submitted by some of our readers on the possible improvement of projects previously described in PRACTICAL ELECTRONICS; short contributions on other subjects may be included. The aim is not to find fault or undermine the abilities or knowledge of our contributors. It may well be that the original article is *par exellence* but it could be improved or adapted to suit individual requirements. The views expressed by readers are not necessarily those of the Editor.

IMPROVED TRIGGER CIRCUIT

THE trigger circuit for Solid State Ignition can be simplified as shown here in Fig. 1. The operation of the circuit is as follows:

1. *Points open.* C1 charges rapidly through R3, R2, D1 and R1. Voltage pulse developed across R1 turns the thyristor on.
2. *Points closed.* C1 discharges slowly through R1 and R2, ready for the next cycle.

Thus the very brief duration firing pulse ensures that h.t. ringing cannot occur, whilst the relatively long discharge time constant of C1 will overcome contact bounce effects.

The circuit is simple, cheap and has the added bonus of a 100mA standing current through the closed points. This represents about the optimum value for preventing their oxidation and subsequent malfunction; a problem encountered by previous workers in this field. Insulation of the normally "grounded" side of the points is very easy but is not necessary on negative "earth" systems.

When the circuit was built and tested, the output pulse exceeded 4V at 200c/s; its duration was 100μs. Fig. 2 shows the output waveform as seen on a 'scope connected across R1.

G. Beardmore,
Cheltenham,
Gloucestershire.

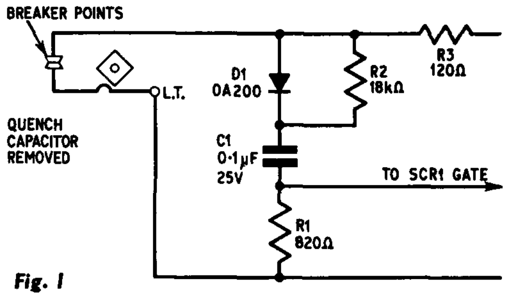


Fig. 1

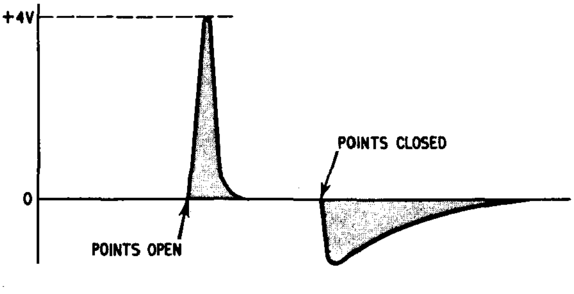


Fig. 2

EFFICIENCY DIODE TO BOOST IGNITION

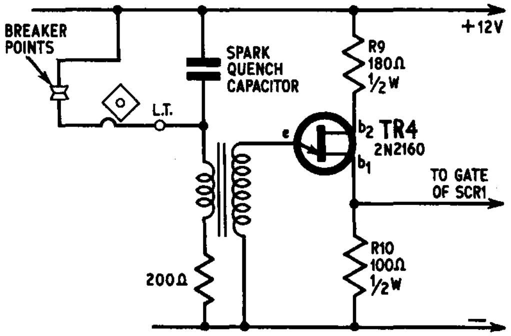


Fig. 1

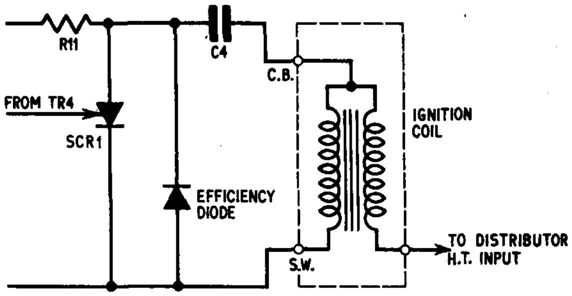


Fig. 2

I HAVE made a simple modification to the Solid State Ignition circuit which works well. In my circuit (Fig. 1), the unijunction transistor in the trigger circuit serves to reject the negative going pulse produced by the transformer (TV driver) and regulating the positive going pulses from the thyristor.

A diode connected across the thyristor, as shown in Fig. 2, can act as an efficiency diode to boost the voltage across C4, thus enabling a lower supply voltage to be used or to increase the energy stored in C4. Of course, if the second benefit is used an alternative thyristor of higher rating is needed.

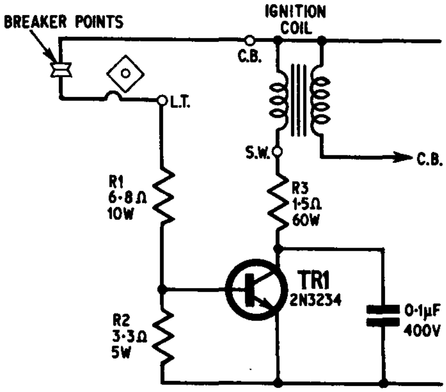
P. J. Windo,
Bridgwater,
Somerset.

SIMPLE TRANSISTOR IGNITION

I HAVE used the circuit enclosed with considerable success and it may be further cheapened (cost about £8 6s) by eliminating the ballast resistor R3 and using a Lucas B12 coil. Ideally the ballast resistor should be bypassed by a shorting relay during starting but I have not found this necessary myself.

J. T. Stockdale, A.M.I.Mech.E.,
Preston,
Lancashire.

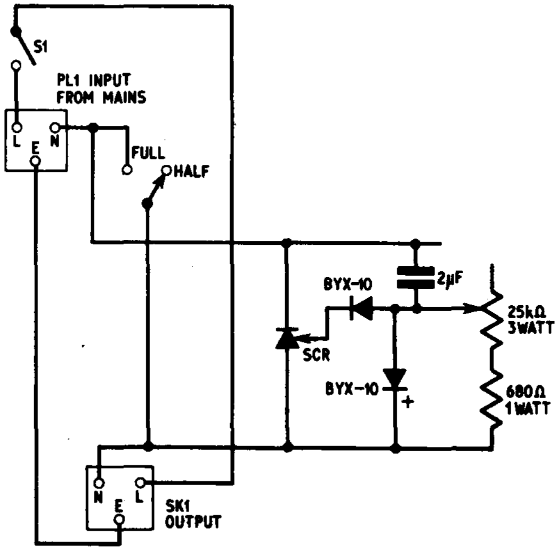
High voltage transistors, such as the one quoted, are essential to off-set the back e.m.f. from the coil. Some manufacturers can supply ignition coils specially designed for this kind of application (e.g. Lucas and Wipac). Lucas state that such voltages can be as high as 400V; this should be taken into account while advice is sought on the type of coil and transistor used.



THYRISTOR CONTROL

HAVING built up the *Thyristor Control Unit* described in the May issue, I decided to experiment by taking out components; the original control circuit contained 4 transistors, 13 resistors, 5 capacitors, 2 diodes and a Zener diode. You can imagine how surprised I was when I got to the stage of having only 2 diodes, 2 resistors and one capacitor left and finding that the circuit was still working well. My final arrangement was as shown in attached sketch. Quite ingenious?

Barry F. Pamplin,
Sutton,
Surrey.



THE LUMOSTAT

by M.L. MICHAELIS M.

PART ONE

An automatic exposure control unit for the photographic darkroom. Suitable for both black/white and colour enlargements and prints, as well as for a wide variety of other imaging processes commonly encountered.

FACILITIES PROVIDED

- **STABILISED D.C. SUPPLY FOR ENLARGER LAMP**
- **AUTOMATIC EXPOSURE TIME-CONTROL**
- **MANUAL TIME PRE-SELECTION**
- **GENERAL LIGHTING CONTROL FOR DARKROOM**

A LARGE number of initial failures in colour processing are due to exposure errors. We cannot go into purely photographic subjects in too great detail, but the following discussion is essential to justify the considerable trouble taken in the Lumostat design to provide a highly stabilised d.c. supply for the enlarger lamp.

The colour balance of the light used for exposing any colour photographic material must be suited to the relative sensitivities of the emulsion layers responding to the respective primary colours red, green, blue. If, for example, a particular lamp used for the exposure over-accentuates the red components of the visible spectrum, emitting too little green and blue light (as happens when an ordinary tungsten lamp is run at a voltage much below nominal), then the red-sensitive emulsion layer will be over-exposed.

Now each emulsion layer in a colour material develops the *complementary* pigment colour with respect to the light it is sensitive to, in order to effect the negative-positive conversion in the usual manner for colour as well as for luminance. The red-sensitive emulsion layer thus develops a blue-green (cyan) pigment. The result of exposing the colour material with a "too-red" lamp is thus to produce a picture with a cyan "cast", which in severe cases may be so strong that the picture is just cyan-toned throughout, without any other colours evident at all. In milder cases, the picture will show a cold blue-green character with very weak reds and other colours falsified too.

Conversely, if the lamp is driven with excess voltage it will be richer than normal in blue and green, so that the red emulsion layer is underexposed relative to the others. The picture as a whole thus develops too much yellow and magenta pigment, and thus obtains a red cast.

True, colour casts are produced by a variety of other factors, such as inherent differences in the speed of the three emulsion layers due to manufacturing tolerances, or the inherent "nominal" differences in spectral content between daylight and incandescent light sources. However, all these factors are constant and stable under a given set of conditions and may be compensated by placing a suitable colour balancing filter (coloured gelatine in glass frame) into the optical system of the enlarger, between the lamp and the condenser.

Changes of mains voltage of 20 or even 30 volts are by no means uncommon and would change the colour balance of a lamp by amounts comparable to the density of correction filters for the other effects. As a result, the pictures will show random and unreproducible colour discrepancies in the course of a working session, even if all other factors are kept very constant.

If the hot water tank immersion heater just happens to go on or off during an exposure, or the wife switches the washing machine or some other high-consumption domestic appliance, that sheet of colour enlarging paper may be ruined, to the accompaniment of muttering curses from behind the darkroom door!

There is another more subtle detrimental consequence of running an enlarger lamp intended (at times) for colour work on an unstabilised a.c. mains supply. The peak voltage is some 1·4 times the r.m.s. value, and the thermal lag of a mains voltage filament is not very much longer than a mains cycle. The lamp filament is thus being momentarily overheated once per half cycle, and the injurious consequences are accentuated if the mains voltage happens to be on the high side. The latter is frequently the case in the late evening or at night, when many amateur photographic darkroom sessions take place. As a result, the lamp will gradually "age" as the weeks and months go by, so that the picture produced with the same settings as used many weeks ago will not be identical to that former picture.

This is a great disadvantage, since the determination of correct colour balance filters for a given picture according to the lighting conditions of the original shot, etc., may involve some skill and patience and it would therefore be of great benefit if one could keep a log book of the final settings and then know that if further prints are required at any later date, they can be produced at once with these same settings.

STABILISED LAMP SUPPLY

Experiments have shown that lamp ageing is negligible if the lamp is operated off a *d.c.* supply, so that there are no mains-frequency temperature pulsations of the filament, and if this d.c. supply is *stabilised* to some 5 to 10 volts *below* the nominal rating of the lamp. The slight red-emphasis due to this undervoltage can be compensated in the colour balance filters.

The stabilised d.c. supply must satisfy several requirements. It must be insensitive to even very large mains voltage fluctuations. Furthermore, it must not react adversely to the tremendous switch-on surges of filament lamps. The latter have only about a tenth of the running resistance when cold, so that the peak switch-on surge of a 75 watt enlarger lamp is some 750 watts. The stabilised d.c. supply must be able to deliver such surges repeatedly without damage to its own components and without "creeping" light-up of the lamp due to failure to maintain full output voltage under the demanded surge conditions, otherwise the mean colour balance of the lamp will deviate on the shorter exposures and very short exposures will not be possible at all.

These requirements call for a stabilised power supply circuit using silicon rectifiers and television line output valves as regulators, since both these types of components have excellent surge ratings.

The Lumostat incorporates a stabilised d.c. supply for the enlarger lamp which is designed along these lines and fully meets all the requirements explained above. This supply at the same time feeds the exposure timing sections, so that these too are exceptionally stable and unaffected by mains voltage changes. The performance of the exposure timing circuits is thus greatly enhanced compared to other electronic exposure timers serving only this function and thus not warranting the expense of including a stabilised h.t. supply. Needless to say, the enlarger lamp must also be operated off the stabilised d.c. output when making black-and-white enlargements in between colour sessions, even if the latter are infrequent and most work is in black-and-white. Only thus can lamp ageing be prevented to a sufficient extent for accurate reproducibility of colour settings—and the lamp life is then longer anyway. When the lamp ultimately burns out, redetermine the colour filter correction for any previously recorded picture. The new difference will then logically apply as correction to all recorded filter values.

A recommended procedure is to record the "lamp factor" valid for the particular lamp in service separately in the colour log book. For the first lamp put in service with the Lumostat, take this lamp factor as "zero". The difference (if any) for any subsequent lamp can then be determined and recorded. When making any reprints according to logged settings, add the lamp factor to the recorded filter factor for the particular colour negative, and place filters of the resulting total density into the enlarger, also correcting where necessary for other "loading factors" when a new packet of colour enlarging paper is started. Such paper loading factors are printed on the outside of each package of colour enlarging paper.

EXPOSURE TIME CONTROL

A means of determining the correct exposure electronically is of great value even for black-and-white work. A batch of pictures may then be exposed and processed together, and one can rely on them all being exposed correctly, i.e. none having to be repeated, and all will require the same time in the developer bath so that with some experience one can leave them there with a motor and cam system rocking the bath gently whilst one is exposing the next batch.

For colour work, accurate exposure metering is more of a necessity than a mere welcome aid, for there is some interaction between exposure and colour balance filtering. At the best, it is not possible to judge a colour correction filter required for a picture of faulty colour if its density is also widely off the mark due to incorrect overall exposure.

The ideal arrangement is a fully automatic exposure meter which switches the enlarger lamp off after the correct time, according to the integrated light "seen" by a photocell. This avoids the need to transfer a scale reading to a clock setting under feeble lighting conditions and it allows one to forget all about the luminance factors of colour balance filters. This opens the way to really reliable colour processing under amateur conditions. The Lumostat incorporates a fully automatic exposure circuit of this kind. A switch is set to the speed factor of the particular paper used and a potentiometer is set to the area of the enlargement (picture size) to be made. These settings are both fixed for a run of similar pictures from a long filmstrip, so that for each individual exposure it is merely necessary to press a button to start the exposure which is then terminated automatically after the correct time.

MANUALLY SELECTED TIMES

For some types of work, on the other hand, it is undesirable to operate with automatically computed exposure times in the manner described above, but rather to expose for a predetermined time which is manually preselected on a dial. This method of "exposure to time", which is the formerly conventional method of operating an enlarger, is appropriate when microfilming written documents for subsequent (usually reduced size) archive copy production through the enlarger, or when operating the enlarger for "film-to-film copying".

A special feature of the Lumostat is that a toggle switch is provided with the two settings "AUTO" and "TIME". In the former setting, the exposure is automatic in the described manner, with the controls setting picture size and paper speed factor. In the time setting, the *same* two controls revert to coarse and fine time preselectors, and when the start button is pressed the lamp comes on for the selected time instead of for a period computed according to the input signal from the photocell.

GENERAL LIGHTING CONTROL

It is convenient to accommodate the on/off switches for the various safe-lights on the exposure control unit, and the Lumostat is provided with this facility as well. Some commercial exposure control units are fitted with a contact switching the safelight off for the duration of an automatic exposure, and on again at the conclusion thereof. This is intended to avoid excitation of the computer photocell from the safelight, which would lead to under exposure. However, it is very irritating to have the safelight going off and on in antiphase to the exposures and this hampers other work.

A better method is to choose a photocell with the same spectral response as the enlarging paper, so that it is insensitive to the safelight, and to mount the safelights such that the enlarger baseboard is in a shadow area. This approach has been adopted by the author in the Lumostat installation. In cases of extremely dense negatives needing upper-limit exposure times, the safelight can be switched off manually if necessary, since its control switch is on the Lumostat panel.

Four safelights are fitted in the author's installation. All four control switches for these lights are mounted on the panel of the Lumostat. They are all well away from the exposure controls, so that they will not be actuated in error in the dark. The one for the subdued white light is separated from the other group of three. This gives a clear grouping enabling the correct switch to be found by touch even in the dark.

STABILISED POWER SUPPLY

The stabilised power supply section employs valves V1 to V5. V1 to V3 operate in parallel as series regulator tubes. A portion of the actual output voltage derived on the bleeder R9, R10, R11, VR1 is compared with the running voltage of a neon reference tube V6. The discrepancy appears between grid and cathode of V4 which functions as a d.c. amplifier for this detected "error" in the output voltage, giving a greatly amplified error signal at its anode. This amplified control voltage is applied via respective grid stopper resistors (to suppress parasitic oscillation) to the grids of V1 to V3, in such a sense as to correct the original error.

Suppose that the output voltage tries to increase; this will make V4 grid go more positive relative to the reference voltage from V6 at the cathode, so that V4 will draw more anode current and the anode voltage will fall, so that the grids of V1 to V3 are driven in the direction of cut-off. The output voltage will consequently drop, counteracting the original attempted rise.

The converse action takes place to cancel an attempted drop in output voltage. It is clear that it does not matter for what reason the output voltage attempted to change, whether due to mains input voltage fluctuations or due to output load changes.

SPECIAL PROBLEMS

Whilst the circuit principle is more or less conventional, the details involve some unusual features to meet special problems imposed by the particular application. These are largely twofold, in that on the one hand the output current rating is unusually high as far as stabilised h.t. supplies for general electronics are concerned, and on the other hand a very high surge stability is called for in order to run-up a lamp filament in the shortest possible time without creep, overswing or injury to the circuit. Photographic enlargers commonly employ 75W to 150W lamps, requiring a normal running current of some 350mA or 790mA respectively at 200/240V mains voltages. The cold filaments have a resistance of about 10 per cent of the hot value, so that the switch-on surge currents are some 3·5A or 7A respectively.

These figures show that it is not feasible to design a straightforward circuit with standard components for a 150W lamp, but that an arrangement for a 75W lamp is possible without resorting to obscure components. The design rating is thus 350mA continuous/3·5A surge with frequent repetition, at an output voltage of 185/245V adjustable to suit lamps for any local mains voltage. The optimum setting is with 220V output for a 230V nominal rating lamp.

A 75W lamp is adequate for most amateur enlargers in any case, at least for 35mm film work and for the various rollfilm sizes at moderate enlargement.

A further problem is connected with the demand that the output voltage must definitely and reliably remain steady to within a fraction of a volt even in the face of severe mains input voltage changes. This calls for a high gain in the error amplifier stage V4, so that such small residual output errors will develop the necessary control voltage for the regulator tubes V1 to V3. Without getting involved in the additional problems of a two-stage error amplifier, V4 thus had to be a pentode operating under true pentode conditions and selected for high slope.

PENTODE ERROR AMPLIFIER

Pentode operating conditions demand a strictly constant screen voltage relative to the cathode, which is under d.c. conditions achievable only by feeding the screen of V4 from a second neon tube V5. However, the introduction of V5 brings a second useful advantage to the circuit, for it can be arranged to pre-stabilise the input supply to the anode resistor of the reference neon

V6 for the actual error-comparison circuit. Under these conditions V6 develops a particularly stable running voltage with high long-term constancy. The value of R15 is chosen such that V6 draws the specified current of 5·5mA quoted by the makers for optimum performance. The type 85A2 neon tube used for V6 is specially recommended for stable reference voltage applications, whereas type 150C2 used for V5 is intended primarily for power purposes where slight residual drifts are of no avail. An EF184 was finally selected for V4 on account of its very high slope.

HEATER CIRCUIT

The aforementioned surge rating of the power supply called for valves with pulse cathodes for the series regulators V1 to V3. Numerous industrial valves are available for this purpose with almost any heater ratings one might think of, yet among commonly available receiver valves one is virtually confined to television line output valves. These have awkward heater voltages for direct operation off a transformer instead of in a.c./d.c. heater chains of a television receiver. It was finally decided to adopt valves of the common and very cheaply available type PL36, requiring a 25 volt heater supply.

The EF184 requires a normal 6·3V heater supply, as does the ECC82 in the exposure computer section. A 24V d.c. supply is required for the relays, and the h.t. windings of the transformer(s) must deliver 350/400mA.

A little consideration showed that some juggling with the interconnections provided all the required supplies from a pair of *identical* mains transformers each having a 250V 200mA single h.t. winding and a pair of ordinary 6·3V windings of any current rating as long as it is at least 2A per winding.

All four 6·3V windings connected in series give a nominally 25·2V supply which is just right for the three PL36 valves. Any one 6·3V winding alone will supply the heaters of V4 and V7 correctly, whilst the remaining three 6·3 windings in series, when rectified, will peak up to the required 24V d.c. relay supply across the reservoir capacitor C6. The only remaining point which had to be settled was how and where to earth this heater circuit, i.e. how to provide a d.c. path to chassis without conflicting maximum heater/cathode voltage ratings of the valves. It is not permissible to operate valves with an entirely floating heater circuit having no definite d.c. path to chassis (to cathode, to be more exact). Makers generally stipulate maximum heater to cathode d.c. resistances of external circuitry in the region of 20 to 100 kilohms.

Suppose one side or the centre of the four series-connected 6·3V windings were connected directly to chassis. This would bring the cathodes of V4 and V7

COMPONENTS . . .

Resistors

R1	100Ω 1W	R15	10kΩ 2W 5%
R2	100Ω 1W	R16	22Ω 1W
R3	100Ω 1W	R17	22Ω 1W
R4	10kΩ ½W	R18	4·7kΩ 1W
R5	10kΩ ½W	R19	39kΩ 1W
R6	10kΩ ½W	R20	100kΩ ½W
R7	150kΩ 1W	R21	1MΩ ½W
R8	12kΩ 10W ww 5%	R22	2·7kΩ 2W
R9	3·9kΩ 10W ww 5%	R23	10MΩ 1W
R10	1kΩ 5W ww 5%	R24	22MΩ 1W
R11	2·7kΩ 10W ww 5%	R25	22MΩ 1W
R12	100kΩ ½W	R26	1MΩ ½W
R13	27kΩ ½W	R27	15MΩ 1W
R14	100kΩ ½W		

All carbon, ±10% unless otherwise stated

Potentiometers

VR1 100kΩ linear, carbon, preset
VR2 5kΩ linear, carbon 2W

Capacitors

C1	100 + 100μF elect. 450V	C12	47nF	C22	1·5nF
C2	100 + 100μF elect. 450V	C13	68nF	C23	2·2nF
C3	8μF elect. 350V	C14	0·1μF	C24	3·3nF
C4	0·1μF paper 250V	C15	0·15μF	C25	4·7nF
C5	2μF paper 250V	C16	0·27μF	C26	6·8nF
C6	500μF elect. 35V	C17	0·33μF	C27	10nF
C7	100μF elect. 35V	C18	0·47μF	C28	27nF
C8	100μF elect. 35V	C19	0·68μF	C29	47nF
C9	0·1μF paper 500V	C20	1μF	C30	68nF
C10	15nF C11 33nF	C21	1nF	C31	100nF

NOTE: C10 to C31 inclusive are used in the timing bank. Values quoted above are nominal. See text for "trimming" procedure.

Valves

V1	PL36	V4	EF184	V7	ECC82
V2	PL36	V5	150C2 neon	V8	90AV Photocell
V3	PL36	V6	85A2 neon		

Rectifiers

D1–4 Silicon mains rectifiers ½A, 5A surge. Type OY5066 or similar (4 off)
D5–8 Silicon l.t. rectifier ½A, 100V p.i.v. Type OY5061 or similar (4 off)
D9 Zener power diode 100V 5mA. Type ZL100 or similar

Switches

S1 Double pole on/off, toggle
S2–5 Single pole on/off, toggle (4 off)
S6 Double pole changeover, toggle
S7 G.P.O. type keyswitch. Latch up; 2 changeovers. Non-latch down; 1 changeover (or 1 make)
S8 Double pole changeover, toggle
S9 Two pole 11-way ceramic wafer (Radiospares "Makaswitch")

Relays

RLA Mains contact breaker. 24V d.c. coil. 250V a.c./d.c. 5A double contact (see text)
RLB 24V 50mA d.c. coil. Two changeover contacts. Siemens Trls 152a TBV 63016/63d
RLC 15kΩ 100V d.c. coil. One make contact. Siemens Trls 154c TBV 65403/93d

Plugs

PL1 Three pole mains connector, panel mounting
PL2 Six pole mains connector, panel mounting Bulgin SA601. Plug free socket SA1934
PL3, 4 Coaxial plug, panel mounting (2 off)

Sockets

SK1 Three pole mains connector, panel mounting
SK2 Two pole mains connector, panel mounting
SK3, 4 Coaxial sockets, free (2 off)

Fuses

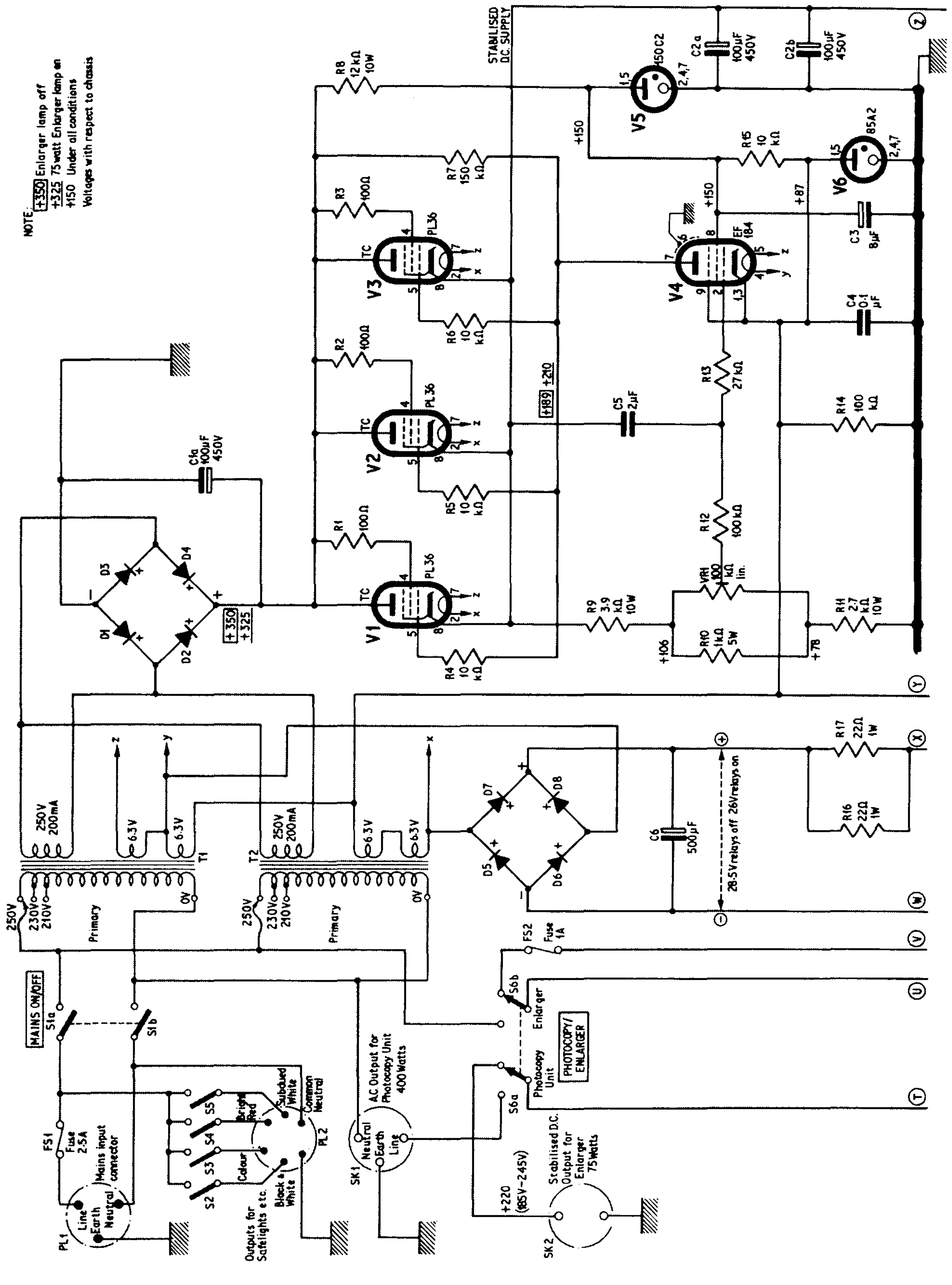
FS1 Mains fuse 2·5A
FS2 H.T. fuse 1A

Transformers

T1, 2 Mains transformer. Tapped primary. Secondaries: 0–250V 200mA; 6·3V 2A; 6·3V 2A. All current ratings are *minimum* permissible (2 off)

Miscellaneous

Three ceramic octal valve holders and three top caps. Two ceramic B9A valve holders. Three ceramic B7G valve holders. Two pointer knobs. Two panel mounting fuse holders. Material for chassis.


NOTE:
+350 Enlarger lamp off
+325 75 watt Enlarger lamp on
+150 Under all conditions
Voltages with respect to chassis
STABILISED D.C. SUPPLY
MAINS ON/OFF
PHOTOCOPY/ ENLARGER
A.C. Output for Photocopy Unit 400 Watts
Stabilised D.C. Output for Enlarger 75 Watts
Outputs for Safelights etc.
Mains input connector
28.5V relays off 26V relays on

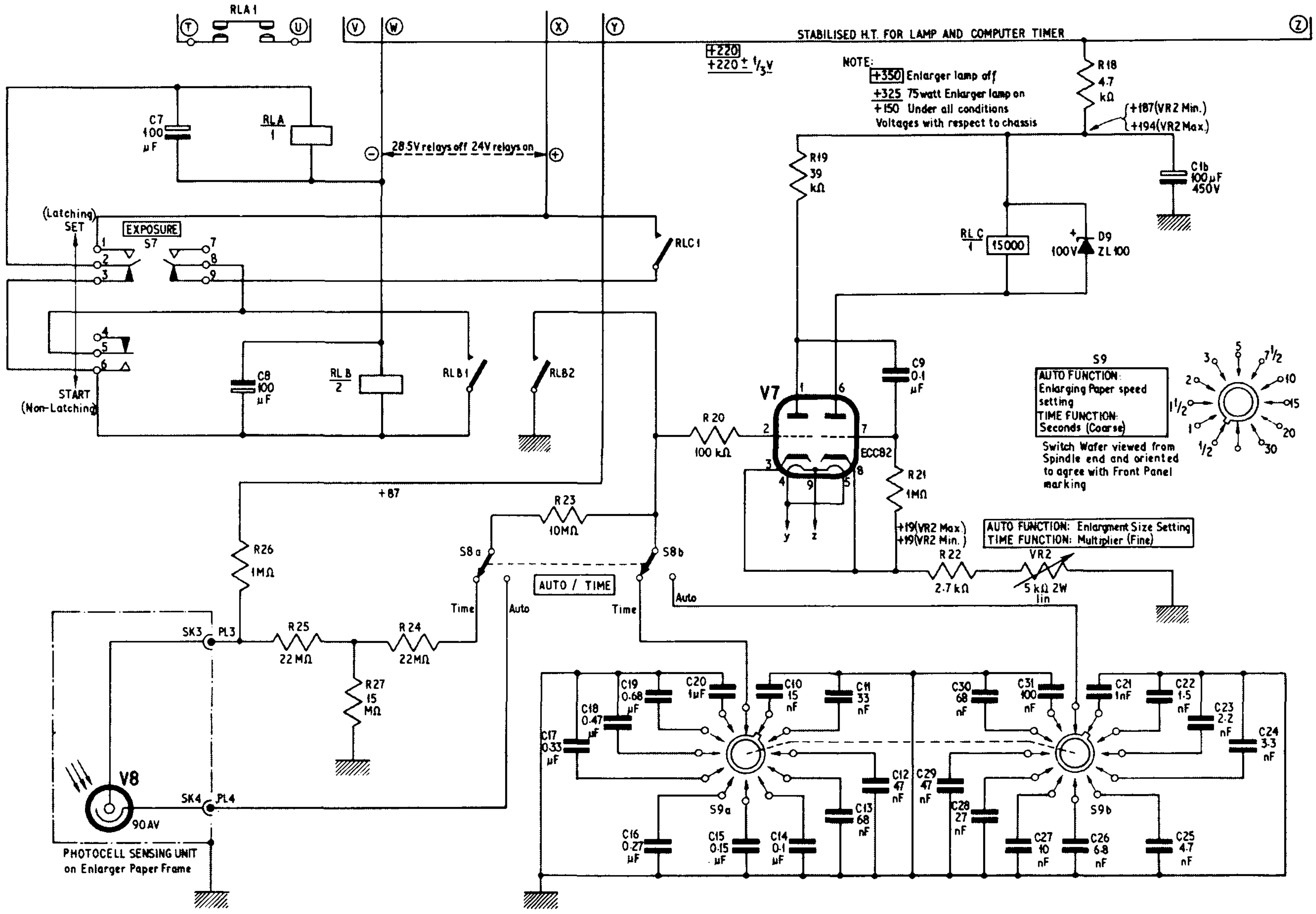


Fig 1. Circuit diagram of the Lumostat automatic exposure control unit

to small and tolerable positive voltages with respect to their heaters, but throw the full 220V output voltage between the heaters and cathodes of the PL36 valves, in addition to which would come the periodic a.c. peaks of the heater voltage itself. This would over-run the ratings for a PL36, which are 200V absolute maximum sum of a.c. peak and d.c. components between heater and cathode. Direct earthing of any point on the heater windings is thus not satisfactory.

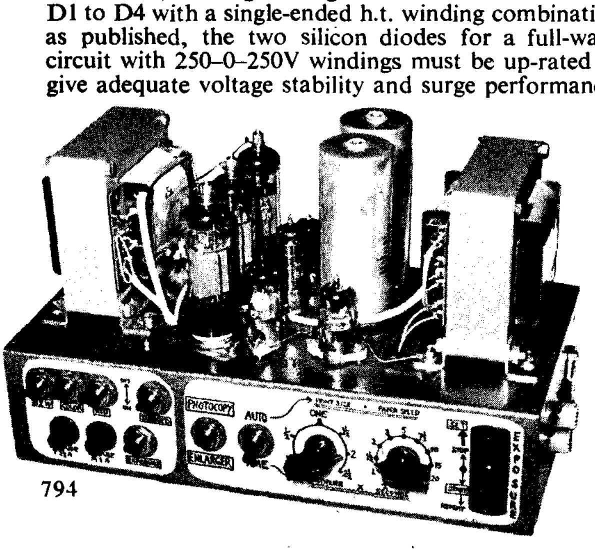
The satisfactory arrangement finally adopted was to connect the centre point of the four heater windings to the cathode of V4 which is held at about +85V with respect to chassis by virtue of the neon tube V6. This leaves no d.c. component between heater and cathode for V4, makes V7 cathodes slightly negative to the heater and places 135 volts d.c. between the heaters and cathodes of the PL36 with an additional a.c. peak of about 20V. The peak sum voltage between the PL36 heaters and cathodes is thus 155 volts, which is well within the ratings. The 24V d.c. relay supply is therewith up above chassis potential by the cathode voltage of V4 plus a small a.c. component, but this is not in any way objectionable since there is no imperative need to establish any chassis connection on an alternative route in the relay energising circuitry and the displacement voltages with respect to chassis are tolerated by all switches and relay windings. The intermeshed circuit is therewith entirely satisfactory for the present purpose and obviates any call for separate windings for each function.

R14 was added to complete a d.c. path to chassis for the heater circuit upon switch-on before V6 has struck and to complete the discharge path for C3 and C1a upon switch-off.

H.T. WINDINGS AND RECTIFIERS

Silicon rectifiers are essential in this circuit to provide the necessary surge performance. Selenium rectifiers, other metal rectifiers, or valve rectifiers are *not* suitable as substitutes. If transformers are obtainable with only 250–0–250 volt h.t. windings in place of a single winding for a bridge rectifier circuit, then use a conventional full-wave rectifier circuit. Connect the three points of the h.t. windings on the two transformers respectively in parallel and then use two silicon diodes in standard full-wave rectifier circuit, i.e. with the common centre tap of the transformer windings to chassis, the anode of one diode to each outer point and the two cathodes connected together to C1a.

Whilst standard silicon mains rectifiers of 0·5A continuous/5A surge rating are suitable in the bridge D1 to D4 with a single-ended h.t. winding combination as published, the two silicon diodes for a full-wave circuit with 250–0–250V windings must be up-rated to give adequate voltage stability and surge performance.



1A continuous/10A surge types with 1,000V p.i.v. rating are required in the full-wave circuit. The additional expense of these, coupled with the higher price of transformers with full-wave windings, make it desirable to obtain simple transformers for the published circuit wherever possible. Electrically, however, the two circuits are fully equivalent.

It is *not* permissible to use transformers with 300V or 350V windings in this circuit, although the 250V tappings of universal types (either full-wave or single-ended) may certainly be used. The PL36 valves will be seriously overrun as regards anode dissipation if the a.c. input voltage from the transformer h.t. windings exceeds 250V. The maximum ratings are already exploited to the utmost at 250V input. Consider the voltage readings as measured on the prototype at the salient points. With the 75W enlarger lamp running, the current drain is (to use conveniently rounded figures) 360mA, i.e. 120mA per PL36. The anode voltage at the PL36 valves under these conditions was measured to be 325V and the cathodes rest at the 220V stabilised output level; the effective h.t. voltage for the PL36 valves is thus 115V. At 120mA this represents 13·8 watts combined anode and screen dissipation in each PL36.

SMOOTHING ARRANGEMENTS

The use of a smoothing choke or a smoothing resistor in this power supply is not possible in the conventional manner, since no standard components are available for the high current rating and the surge performance would be impaired thereby anyway. Neither is it permissible to use a very large reservoir capacitor for C1a, since the surge ratings of the silicon rectifiers would thereby be overrun, leading to early destruction of these components. 100μF is the maximum safe value for C1a and this leaves a high ripple at the anodes of the PL36 valves, at full load.

To a certain extent the three PL36 valves behave as a smoothing resistor, which in conjunction with C1a and C2a,b constitutes a conventional smoothing circuit. But it is easy to see that this is very inefficient at full load, because the effective impedance of the three PL36 valves at full load (360mA/approx. 120V drop) is only about 333 ohms. The impedance of C2a,b at 100c/s (full-wave rectification gives ripple at double mains frequency, true for bridge circuit too) is about 8 ohms, so that the straightforward ripple reduction factor is some 40. This on its own would still leave a few volts of ripple on the output at full load.

Now the large value of C2a,b has been chosen for a different reason, since there is a much simpler and more efficient way to reduce ripple in a series regulator circuit of the kind here used. C2a,b will store about 5 joules of energy, sufficient to provide a good contribution to the lamp-surge upon switch-on without undue voltage sag. Furthermore, this high capacitance value damps out any tendency to overswing or damped oscillation of the regulator circuit before settling down after a lamp switch-on surge.

Ripple is reduced with the aid of C5. This feeds any residual ripple in the output to the error amplifier grid, where it is greatly amplified and applied as an antiphase signal to the regulator tube grids V1 to V3. This has the same effect as placing a capacitor across the output equal to the actual value of C5 multiplied by the product of the dynamic slope of V4 and the combination V1 to V3. The resulting virtual smoothing capacitor across the output is thus some thousands of microfarads in the present circuit and it is easy to see that this reduces the output ripple to negligible proportions even with the effective smoothing resistance of only 330 ohms presented by V1 to V3 at full load. The actual output ripple was measured to be 25mV with the lamp off and 50mV with the lamp on (full load). This does not change greatly if C2a,b are replaced by an ordinary 8μF capacitor, proving the point that most of the effective output capacitance results by electronic multiplication of C5.

EXPOSURE COMPUTER CIRCUIT

The exposure computer circuit is a monostable multivibrator (flip-flop or univibrator as it is also variously called) built around an ECC82 valve V7. Grid pin 2 is normally well below cathode potential, so that the first triode section rests cut-off and the other triode section conducts heavily holding RLC in the anode circuit energised and its contact closed. Each response pulse whenever grid pin 2 lifts above cut-on will make the roles of the two triodes swop over in the conventional manner, by cumulative multivibrator feedback via C9. This response lasts for a time determined by the product of C9 and R21, which is about a tenth of a second. For this brief interval the second triode section is thus cut off and relay RLC drops off, opening its contact, whereafter it energises again when the circuit flops back to its former resting state.

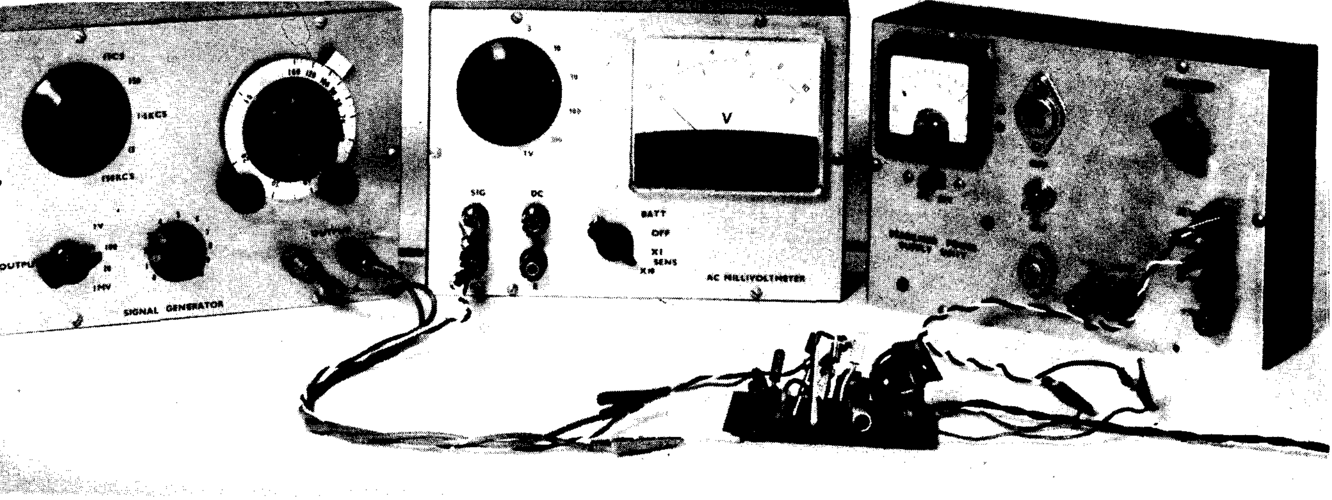
GRID CIRCUIT INTEGRATOR

The grid circuit of V7a is a charge integrator arrangement, for the auto as well as the time functions. In other words, S9 and its associated bank of timebase capacitors places a definite selected capacitance between the grid and chassis and a response pulse can take place only when this capacitor has accumulated sufficient positive charge through a charging resistor. On the "auto" function, this charging resistor is a vacuum photocell V8; on the "time" function it is a network of high-value carbon resistors R23 to R27.

Considering the "auto" function first of all, it is clear that this arrangement is equivalent to the manner in which correct exposure of a photographic film or paper is determined by the product of light intensity and time of exposure to this light. The intensity of illumination of a vacuum photocell determines the resulting photoelectric current in direct linear proportion and this current is used to charge the capacitor selected by S9. The voltage this capacitor has reached will be directly proportional to the time for which the charging current has been flowing. The rise of capacitor voltage, and thus of the voltage at grid pin 2 of V7, is linear with time, not exponential, because the anode current of a vacuum photocell under correct operating conditions is independent of the voltage between anode and cathode of the cell, being determined solely by the intensity of illumination.

If the photocell V8 is mounted in a suitable manner on the frame holding the enlarging paper, so that it can see the light reflected from the image projected onto the paper being exposed, and if the value of the capacitor selected with S9 is chosen to correspond to the speed of the paper, then it is evident that V7 grid pin 2 will reach cut-on at the exact moment when the paper has also integrated sufficient light corresponding to optimum exposure. V7 grid pin 2 cuts on at this moment, giving the already described univibrator response pulse making RLC momentarily break its contact. This causes the relay circuit to switch off the enlarger lamp.

Part two of this article next month will complete the circuit description and commence constructional details.



USING THE TEST GEAR TRIO

by R. HIRST

THE amateur constructor more often than not is unable to enjoy to the full the fruits of his labour. This in the main is due to the lack of testing arrangements that in the normal course of events are considered the perogative of a commercial establishment. Equipment is quite readily available upon the market to enable the required testing procedures to be carried out but usually this equipment is comparatively expensive. In order to relieve the economic burden and at the same time promote some working knowledge of test instruments the *Test Gear Trio* was published in the three previous issues of this magazine.

These three articles described theoretical and constructional details of what many would consider to be the basic essentials, apart from a multi-range meter, that should grace the constructor's workbench. However, to know when, where, and how to use such tools tends in itself to promote an altogether different problem.

There are many different configurations that are contained under the term "electronics" so in the first instance let us, for example, consider the test procedure that would revolve around a 10 watt power amplifier, designed to use transistors and function in class B operation.

SUPPLY CURRENT

There are two prime conditions of supply current in class B operation, these being (a) during a quiescent period and (b) for maximum r.m.s. signal output.

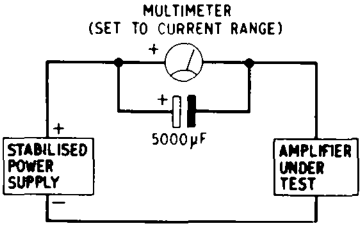


Fig. 1. Quiescent current measurement

Measurement of quiescent current requires neither the services of the signal generator nor the a.c. millivoltmeter and may be simply indicated by a d.c. current meter set to the highest range and then connected, in correct polarity, in the "non-earthy" lead from the power supply unit as shown in Fig. 1.

The d.c. current meter should be decoupled with a large value capacitor. Having supplied the unit under test with power, adjust the meter range switch to the appropriate range to indicate the current flowing. The quiescent current will vary between one circuit and another, but it is highly improbable that it will exceed about 20mA for a single class B amplifier. If it is much higher than this, switch off immediately and assume that the circuit is incorrectly wired up.

The current for maximum r.m.s. output on the other hand could be anything between 50mA and 1·5A depending on the load and the supply voltage. It will be greatest when the load is small and supply voltage low.

In order to check this latter condition we should connect our test equipment as shown in Fig. 2. The input signal from the signal generator is increased until the output shown by the a.c. millivoltmeter is as specified by the manufacturer of the amplifier.

If the output is specified in watts calculate the voltage reading required from $V_{out} = \sqrt{(\text{power} \times \text{load resistance})}$. At this maximum r.m.s. signal output, the

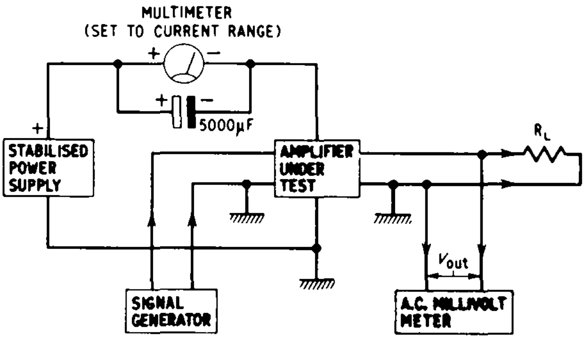


Fig. 2. Current drain measurement for maximum r.m.s. output

supply current is noted and checked with the specification. The check of quiescent current should always be the first test to be carried out when working with any amplifier capable of delivering high power. It will be seen from Fig. 2 that the output terminals must be terminated in the stipulated load; it is an advantage to have a small stock of 10 watt wirewound resistors to hand, useful values being 3 ohms, 7 ohms, and 15 ohms.

SENSITIVITY

In simple terms, the sensitivity of a unit implies that, for a certain maximum input voltage, the output should not be less than a stipulated figure. If the input voltage has to be raised above the specified figure to promote that value of output, then we must assume that the unit is faulty.

There is, however, one most important point that must be understood if the input signal is to be measured correctly. In normal circumstances, if the voltage of the signal that is being provided by the signal generator is measured, then the a.c. millivoltmeter is connected in the manner suggested in Fig. 3, set to the appropriate range and the appropriate reading taken. However, due to the normal relatively low input impedance characteristics of transistors, this reading would change if the same signal is fed into a low impedance input. It is usual in these circumstances for the manufacturer to qualify the input figure of the unit under test, in terms of source impedance.

To see this more clearly, assume that the signal generator has an output impedance of 1,000 ohms and set the output voltage at 1 volt without any external load. Connect a 1,000 ohm resistor across the two terminals; the reading would reduce to half of its original value and now read ½ volt.

Therefore the correct source impedance must be met under all conditions to maintain accurate observation of the input signal. The simplest method is to place a resistor in series with the output lead of the signal generator as indicated in Fig. 4, the value of which may be calculated in the following manner.

Taking the recommended value of source resistance to be 2,000 ohms, subtract from this value the output impedance of the generator. Therefore, if the generator impedance is 100 ohms, then the series resistor (R_{source}) will be 1,900 ohms. The a.c. millivoltmeter should then be placed at the millivoltmeter side of the series resistor.

Another point with regard to the source impedance revolves around the quite possible shunting effect that a lower impedance source may have upon the circuit, reducing the feedback to such a degree that it will not only alter the sensitivity of the amplifier, but also change the frequency response and the distortion figures to a marked degree.

The set-up of Fig. 5 considers the procedure that one would adopt in order to measure the sensitivity of the 10 watt amplifier, bearing in mind the previous pitfalls. Suppose the amplifier is powered from its own internal power pack so as to reproduce the actual working conditions. From the setting-up data we should be in a position to extract the required output voltage that should be present across the load.

Next turn the amplifier volume control up to its maximum setting and ensure that the tone controls are set in the "flat response" condition, that is to say, in the condition that promotes neither lift nor cut of any frequencies contained within the amplifier range. Then set the signal generator to a mid-frequency, something in the order of 1kc/s and advance the signal generator output voltage until the output from the amplifier under test reaches the specified limit, this being measured on the a.c. millivoltmeter.

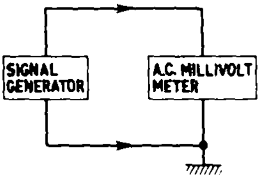


Fig. 3. Measurement of signal generator output—no load condition

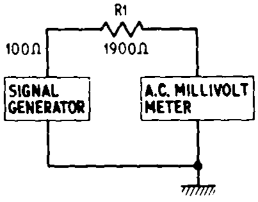


Fig. 4. Simulating the correct source resistance for the amplifier to measure the amplifier input voltage

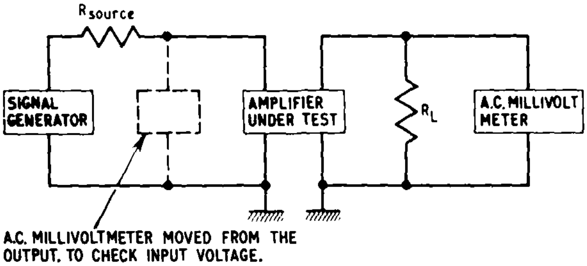


Fig. 5. General set-up for measuring sensitivity, frequency response, and signal-to-noise ratio

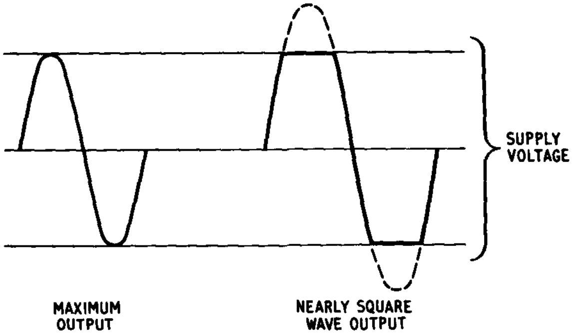


Fig. 6. The effect of boosting any frequency above specified maximum voltage causes distortion

Having ascertained this output level, the millivoltmeter should be transferred to the input so that the input signal may be checked to see that it corresponds with that indicated in the setting-up procedure.

At the microphone socket of such an amplifier the input reading should be somewhere in the order of 1 millivolt or so; at the radio or gramophone input socket this reading should approach about 250 millivolts. Both these readings are only indicative of an average amplifier and quite obviously there could well be wide variations between different designs.

FREQUENCY RESPONSE

By maintaining the layout as indicated in Fig. 5 the frequency response is measured without any further addition to the test equipment. The first operation will be to reduce the signal output of the generator by 10 times (20dB) from that which was required to promote the full output from the power amplifier for sensitivity measurement. If this is not done the measured output would barely change when the treble or the bass controls are increased. This can be easily explained by reference to Fig. 6.

At full power output (Fig. 6a) the output voltage swing is almost at the maximum that could be extracted before distortion occurs. Increase this output level, at any frequency; the output would tend to take the shape of a square wave, clipping both top and bottom of the sine wave, giving a reading that bears no relation to the required output (Fig. 6b).

Having reduced the signal generator by 20dB, it is usual to switch the signal generator to its lowest frequency range, then sweep through all the ranges taking note of the output at spot frequencies for various settings and combinations of the tone controls.

Table 1: SPOT FREQUENCIES FOR MEASUREMENT OF FREQUENCY RESPONSE

Frequency c/s	Output Voltage	Frequency c/s	Output Voltage
20		4,000	
60		6,000	
100		8,000	
250		10,000	
500		12,000	
1,000		15,000	
2,000		18,000	

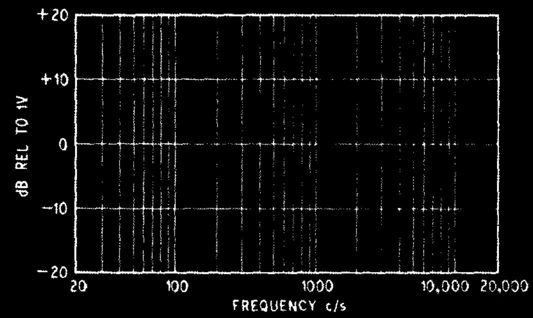


Fig. 7a. Graph scale used for plotting frequency response in decibels (output voltage) against frequency

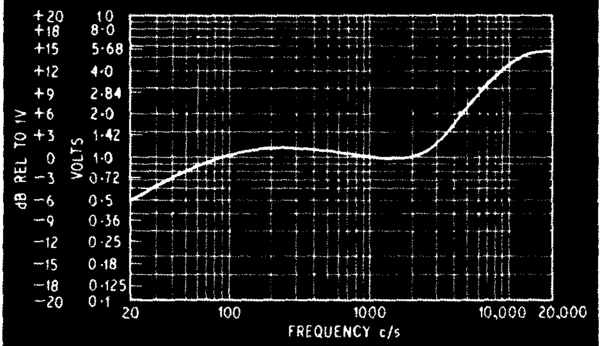


Fig. 7b. A typical graph of the frequency response of an audio amplifier with treble boost. The output is plotted in volts (log scale) or decibels (linear scale) against frequency (log scale)

Table 1 is probably a good indication of the best choice of spot frequencies that would cover the frequency range of almost any type of audio amplifier. A graph may then be drawn of the results, plotting output voltage on the vertical scale against frequency on the horizontal logarithmic scale. It is usual to convert the voltages to decibels relative to the level at one particular frequency—1,000c/s.

There are several ways of doing this:

(a) calibrate the meter in decibels on a logarithmic scale; plot the graph with a vertical linear scale (Fig. 7a).

(b) calculate each voltage reading in terms of decibels by using the formula

$$20 \log_{10} \frac{V_{out}}{V_{in}}$$

and plot the graph with a vertical linear scale (Fig. 7a).

(c) Plot the voltages on a logarithmic vertical scale. Make the level at 1kc/s equivalent to 0dB and mark the remainder of the scale, as shown in Fig. 7b in decibels so that half the voltage at 1kc/s is equivalent to −6dB and twice this voltage is equivalent to +6dB. The rest of the decibel scale will be linear.

SIGNAL-TO-NOISE RATIO

There are two ways of expressing signal-to-noise ratio that are in general use when referring to domestic equipment. One is a measurement in voltage and the other a measurement relating to power.

In effect both methods of approach provide us with the same result but the confusion tends to exist when these values are referred to in terms of pure ratio rather than the more usual term, decibels. In this particular instance we will refer to the signal-to-noise ratio as a voltage measurement in order to obviate any need for calculation.

For this operation the signal generator and the a.c. millivoltmeter are set up in the first instance to check for sensitivity. Fig. 5 indicates the method of connection and again it will be noted that the system is terminated in the correct value of working load.

The volume control of the amplifier should be advanced to its maximum setting. The signal generator output should be increased until full power output is measured across the load of the power amplifier. If output *voltage* is not stipulated in the amplifier specification then this figure may be derived from $V_{out} = \sqrt{}$ (power × load resistance).

For an amplifier with an output of 10 watts working into a 15 ohm load then the voltage across the output load will be $\sqrt{(10 \times 15)}$ or about 12·25 volts.

Once this has been established then the connection from the signal generator to the amplifier should be removed at the amplifier end and noise figure measured across the output load. This value is then divided into the output signal voltage that was measured under full power output conditions. Be careful to observe consistency in the units measured, i.e. the noise may be in millivolts, therefore should be divided by 1,000 to convert to volts if the signal is in volts.

The resultant figure is the ratio of signal voltage to noise voltage. This ratio is then referred to decibel tables and converted into decibels, which is a more usual reference figure.

Sometimes the signal-to-noise ratio is quoted for a certain value of input resistance; if this is the case for the unit under test then the appropriate value of resistor should be placed across the amplifier input terminals. This resistor should be well screened to prevent the true noise reading being obscured by any spurious hum pick-up. It is advisable to use a high stability resistor for this application.

DISTORTION

The distortion factor of an amplifier is obviously of prime importance but the accurate measurement of this parameter is difficult. Low distortion figures have been achieved but it is improbable that the same measurement can be reproduced on two consecutive occasions even in the most well equipped laboratory.

STAGE GAIN

By connecting the amplifying stage to the measuring equipment as shown in Fig. 8 the gain of the device can be measured. First of all set the stabilised power supply unit to provide the correct d.c. voltage, then connect into circuit the a.c. millivoltmeter, switching it to a range in excess of the anticipated output voltage.

Now reduce the output of the signal generator to zero and connect the instrument to the input, not forgetting to ensure that the input capacitor is wired in the correct polarity. Switch the a.c. millivoltmeter to the range required and then slowly advance the output from the signal generator until the output measured on the a.c. millivoltmeter is of the required value. It is usual to make these measurements at a frequency somewhere in the region of 1kc/s.

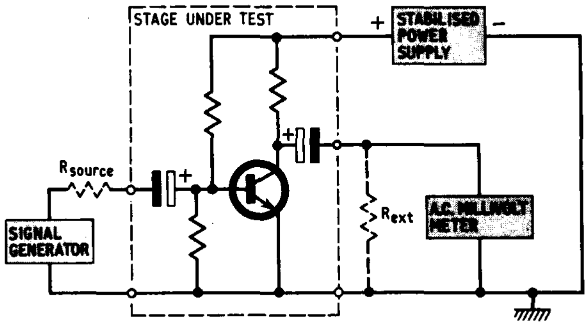


Fig. 8. Set-up for measuring distortion and stage gain

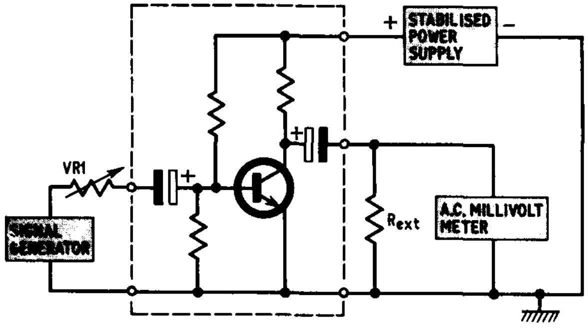


Fig. 9. Set-up for measuring input impedance

However, it is reasonable to assume that if you can hear the distortion then the system is faulty, but if you cannot, why worry? In the majority of applications referred to in the popular domestic field the distortion factor is usually quoted as a total harmonic content of a given output signal. Almost the only time that this procedure is departed from is when reference is made to the bias oscillator contained in a tape recording system.

The test procedures referred to above are of a general nature and whether the amplifier has a low or high power output, then the procedure remains the same. However, when some experimenting is in the offing then matters become a little confusing as we may quite well have built an audio circuit about which we know nothing. It is for these instances that the following exploratory test rigs are set up.

Considering a very simple single stage transistor amplifier, our first concern will be centred around whether we have provided the system with the correct d.c. working conditions.

The d.c. collector to emitter voltage should be three times the anticipated a.c. r.m.s. output voltage; the d.c. voltage across the collector load resistor should also be of this proportion. In more simple terms, referring to Fig. 8, the d.c. voltages are measured with a multimeter and the a.c. output signal voltage is measured by means of the a.c. millivoltmeter.

This signal is derived from the signal generator, being of correct amplitude to promote the required output signal at the collector of the transistor. If the voltage gain of the stage was, say, 100 then the input signal would need to be in the order of 10mV to provide an output of 1 volt at the collector of the transistor.

Having made a note of the output voltage from the amplifier, transfer the a.c. millivoltmeter to the input of the amplifier as shown in Fig. 5 and reduce the range of the a.c. millivoltmeter until a reading is indicated. During the transfer of the millivoltmeter it is essential to make sure that the controls of the signal generator have not been disturbed at all otherwise the reading will have changed.

The voltage gain may be calculated by dividing the output voltage noted in the first instance by the voltage measured at the input as shown in Fig. 5. Therefore in simple terms voltage gain $= V_{out}/V_{in}$.

It must be remembered that this measurement has not taken into account any loading of the stage that would be occasioned by a following transistor or similar device. To obtain a reading of this nature it would be necessary to connect a resistor of the correct value in parallel with the output of the amplifier; this resistor is dotted in Fig. 8 and marked R_{ext}.

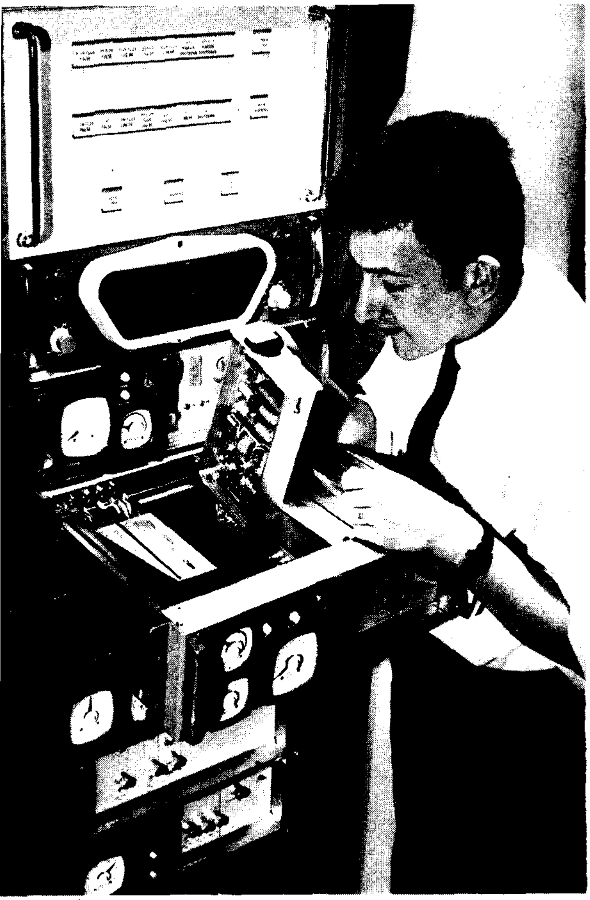
Another most important point is to make sure that the input is fed from the required value of source resistance. For instance, if we required the amplifier to be driven from a crystal cartridge, and we had made no arrangements to increase the input impedance of the amplifier proper, then we will have to insert a resistor in series with the input of the amplifier, the value being somewhere in the region of 1 megohm.

This value may be reduced or increased as desired, an increase in value improving the bass response and a reduction in value limiting the bass response. A usual value to be found in domestic equipment is somewhere in the order of 470 kilohms.

continued on page 808

ELECTRONORAMA

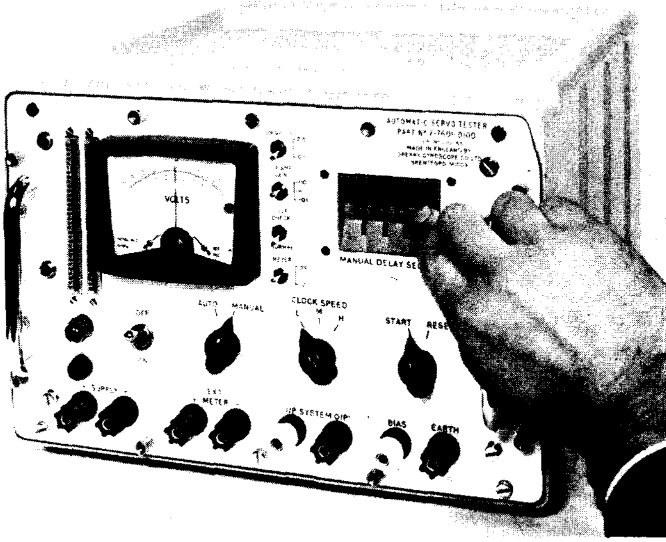
HIGHLIGHTS FROM THE CONTEMPORARY SCENE



◀ Nuclear Power Monitor

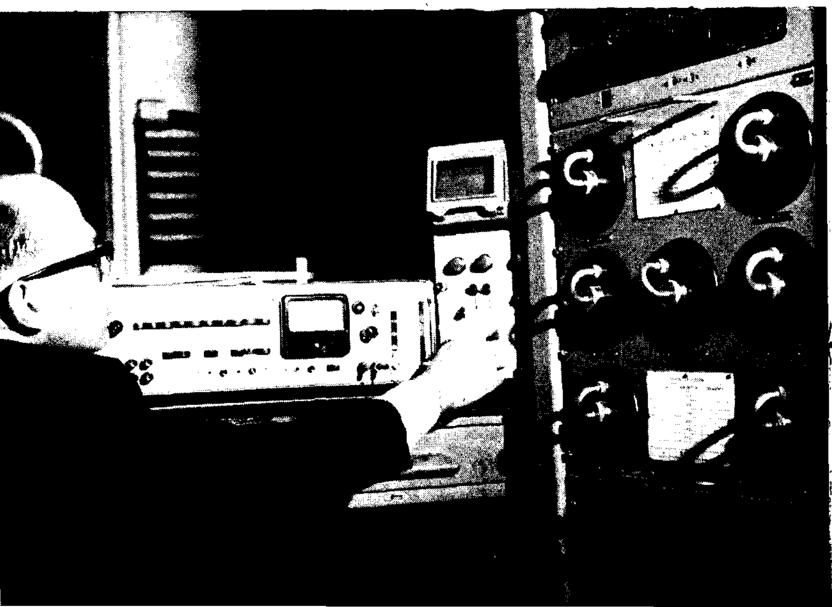
ELLIOTT-AUTOMATION has developed, from an original concept by the U.K. Atomic Energy Authority, a device to monitor nuclear reactor power and to initiate the shut-down of the reactor if the preset limits are, or likely to be, exceeded.

It is called the 8000 Series and is shown (left) with a sub-module hinged upwards for servicing whilst remaining operational.



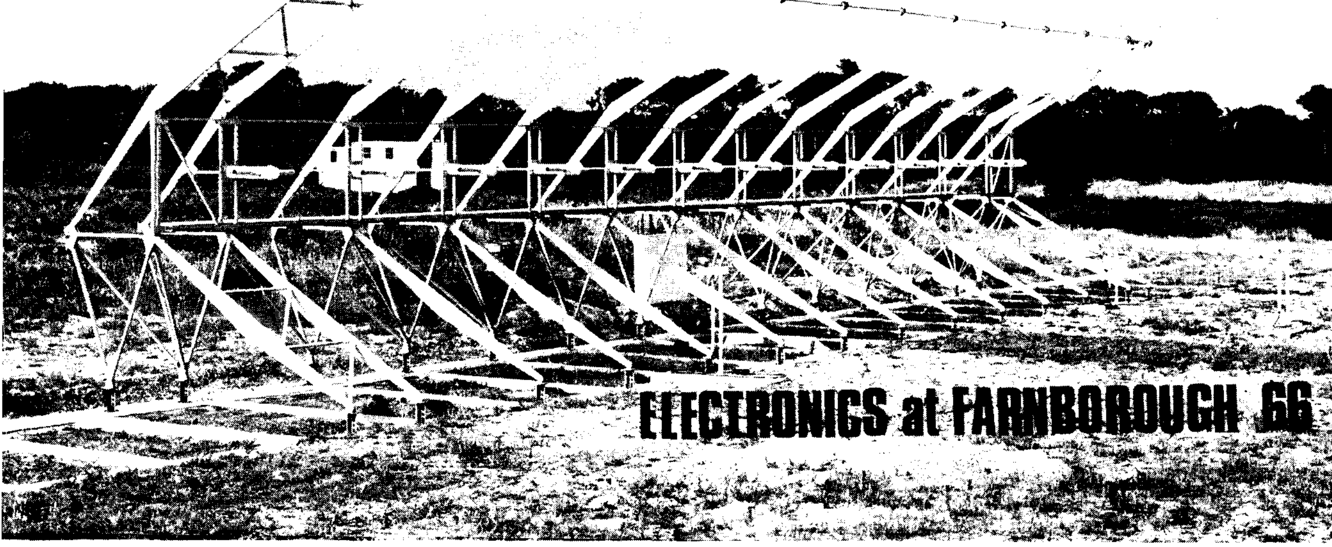
"Inspection" Servo Tester ▲

ALTHOUGH they are generally known for their precision gyro systems, Sperry develop a variety of ancillary equipment for aircraft. The instrument shown above is a general servo tester. It gives a quick and clear GO/NO GO indication and demonstrated at Farnborough how it can check guided missile control systems.



Stereo Check

◀ AN engineer at the BBC Wrotham v.h.f. transmitting station is carrying out checks with a multiplex signal generator, developed by Radiometer of Copenhagen for basic multiplex stereo transmitter tests. This generator provides three push button frequencies 80c/s, 1kc/s and 5kc/s. This instrument (left of picture) is imported by Livingstone Laboratories.



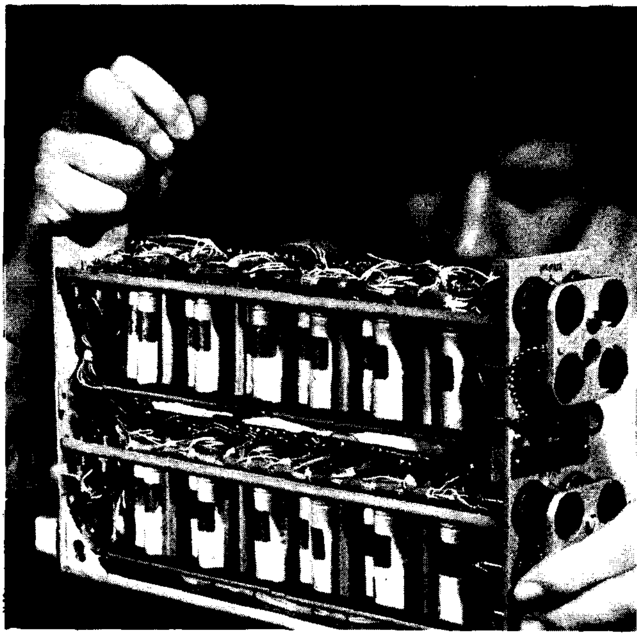
ELECTRONICS at FARNBOROUGH 66

I.L.S. for All Weathers

OUR picture above shows an aerial array with a difference. It is the new S.T.C. STAN 37/38/39 instrument landing system array used for "all-weather" landings of aircraft. The electronics are completely solid state and the system is said to be for operational performance Category III laid down by the International Civil Aviation Organisation and known as a "low approach" system.

Selective Calling System

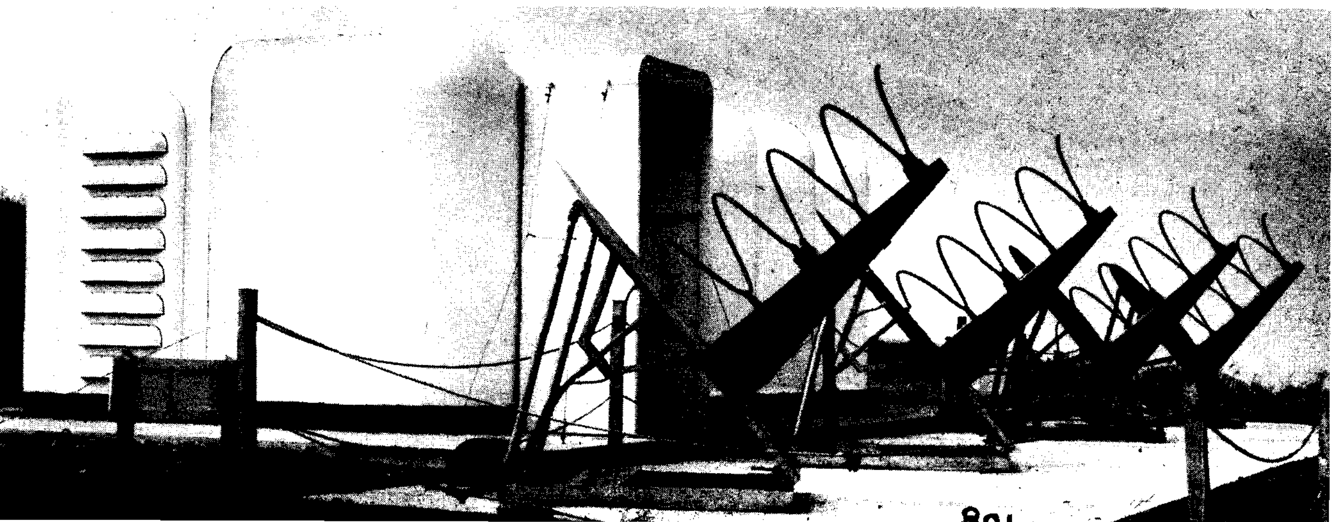
THIS new selective calling equipment, SELCAL, was shown for the first time at Farnborough by Marconi. The equipment is fully transistorised, and can contain either one or two selection units. The ground station transmits a two-pulse code to call up a given aircraft, and an aural or visual signal then warns the pilot that he is "wanted on the radio-telephone". In this way, SELCAL relieves the pilot of the task of continuously monitoring the radio channels for messages intended for him.

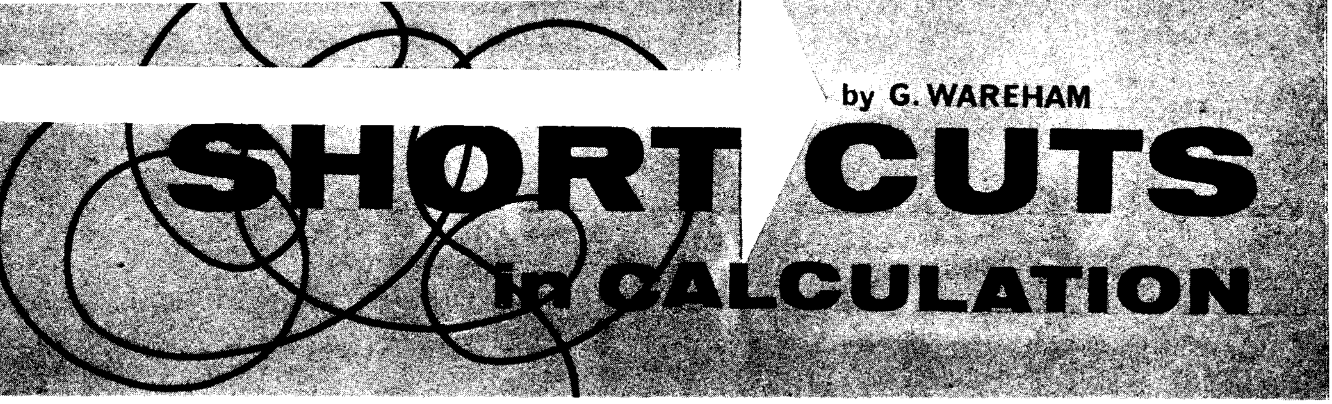


Missile Destruction

WREBUS Mk. 4 Receiver—the airborne component of the missile destruct system developed by the Weapons Research Establishment—was on display. Designed by Bush Murphy Electronics, this latest receiver initiates the destruction of a missile on receipt of a special coded radio command signal from a ground installation.

The photograph below shows the ground installation and aerial arrays which trigger the airborne receiver in the missile.





PART THREE—AS EASY AS PI

ONE of the quantities most frequently encountered in electrical calculations is the fraction $1/(2\pi)$. Now, $1/(2\pi) = 0{\cdot}159$, which is an awkward number. We can eliminate the decimal point by writing it as 159×10^{-3}. This is usually helpful in calculations, because 10^{-3} can be merged with one of the other "powers of ten" which invariably creep in when one is dealing with kilocycles, millihenries, and microfarads. Moreover, one can usually write 160 for 159 without serious loss of accuracy, since the error introduced is less than one per cent.

By exercising a little common sense, one can often simplify calculations in another way. Here is an example: How can one ensure that the coupling between valves V1 and V2 in the audio amplifier shown in Fig. 1 passes a wide range of audio frequencies? Now it is well known that, once R_a and R_g are fixed, the cut-off frequencies depend on the circuit capacitances. At low frequencies, the impedance of C1 becomes sufficiently large in comparison with R_g that a substantial amount of the output from V1 is lost in C1.

LOW FREQUENCY CUT-OFF

A convenient way of describing the performance of the coupling circuit is to state the frequency at which C1 causes a 3dB loss. This means that only about 70 per cent of the voltage at V1 anode reaches V2 grid. This cut-off frequency is given by $f = 1/(2\pi C_1 R_g)$, but we are interested in calculating the required value of C1 when R_g and f are fixed. Rearranging the formula gives:

$$C_1 = 1/(2\pi f R_g) = (159 \times 10^{-3})/fR_g \text{ farads}$$
$$= (159 \times 10^{3})/fR_g \text{ microfarads}$$

Now, the choice of f is usually fairly wide. The lower limit of audibility is about 15c/s, but is not definite. We are perfectly at liberty to take it as 15·9c/s, and this makes the arithmetic much easier:

$$\frac{159 \times 10^{3}}{15{\cdot}9 \times 10^{6}} = 10^{-2} = 0{\cdot}01\mu\text{F}$$

In many practical audio systems, the bass cut-off frequency is made higher than this. For example, the available loudspeaker may not be able to handle frequencies below 30c/s. In this case one can take the cut-off as $2 \times 15{\cdot}9$c/s and C_1 becomes $0{\cdot}005\mu$F.

On the other hand, in a negative feedback amplifier one may wish to make the cut-off much lower and define the low-frequency limit elsewhere in the circuit. One can make it 1·59c/s ($C_1 = 0{\cdot}1\mu$F) or $2 \times 1{\cdot}59$c/s ($C_1 = 0{\cdot}05\mu$F), choosing the nearest multiple or sub-multiple of 1·59 which is appropriate.

HIGH FREQUENCY CUT-OFF

The high frequency cut-off depends on the value of the anode load resistance R_L (which is equal to R_a in parallel with R_g and the output resistance of V1) and the stray capacitance C_s, which includes the output capacitance of V1, input capacitance of V2, capacitance to earth of C_1, R_a, and R_g, plus wiring and valveholder capacitances. These capacitances can and should be very low.

The formula for cut-off frequency is $f = 1/(2\pi C_s R_a$, and if C_s and f are fixed this determines R_a at $1/(2\pi C_s f)$ or $(159 \times 10^{-3})/C_s f$ where C_s is in farads and f in cycles per second. Practical units to handle are often picofarads and kilocycles, so we multiply C_s by 10^{-12} and f by 10^3, and the formula as a whole becomes:

$$R_a = \frac{159 \times 10^{-3}}{C_s \times 10^{-12} \times f \times 10^{3}} \text{ ohms}$$
$$= \frac{159 \times 10^{6}}{C_s f}$$

So all we have to do is choose 15·9kc/s as the upper limit of audible frequencies to make the arithmetic easy. A possible value for C_s is 50pF, in which case:

$$R_a = \frac{159 \times 10^{6}}{15{\cdot}9 \times 50} = 2 \times 10^{5} \text{ ohms} = 200 \text{ kilohms}$$

RESISTANCES IN PARALLEL

This is a typical value for a pentode voltage amplifier. In practice, the cut-off frequency may be higher than

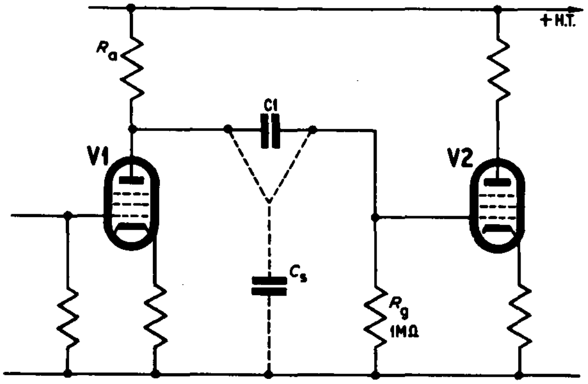


Fig. 1. Coupling components between two audio amplifier stages

16kc/s with the circuit values stated, because R_a is shunted by R_g and the output resistance of the pentode. Assuming these to be 1 megohm each, what is the net parallel resistance? A resistance of 200 kilohms is the same as five resistances of 1 megohm in parallel. R_g and the pentode's output resistance add another two 1 megohm resistances in parallel, making seven in all, so the net resistance is $10^6/7$ ohms = 143 kilohms.

In practice, the output resistance of the pentode is usually unknown and often considerably more than 1 megohm. Assuming it to be infinite makes little difference. In our case, the net resistance is then $10^6/6$ ohms = 167 kilohms. What then, is the true cut-off frequency? There is clearly no serious error in taking the resistance to be 159 kilohms to make the arithmetic easier. Then, with our values,

$$f = \frac{159 \times 10^{-3}}{159 \times 10^3 \times 50 \times 10^{-12}} \text{ c/s}$$
$$= 20\text{kc/s}$$

Suppose, however, that we wish to make R_a as high as possible consistent with a cut-off frequency of about 16kc/s. As we have seen, R_a in parallel with R_g must be 200 kilohms. Since this is the same as five 1 megohm resistances in parallel, and R_g is one of them, R_a must be made up of the remaining four in parallel, so $R_a = 250$ kilohms.

Note that in all these calculations we could have written 160×10^{-3} for $1/(2\pi)$ and taken frequencies such as 16c/s and 16kc/s, *without introducing any error in the final result*. All because we do not need to specify the cut-off frequency precisely.

TUNED CIRCUIT

The resonant frequency of an LC circuit is given by the formula $f_0 = 1/(2\pi)\sqrt{(LC)}$. However, one is usually interested in finding L or C when the frequency is fixed. In this case the first step is to square the formula:

$$(f_0)^2 = 1/(2\pi)^2 LC \text{ cycles per second}$$

which gives

$$L = 1/(4\pi^2 f_0^2 C) \text{ henries}$$
$$\text{and } C = 1/(4\pi^2 f_0^2 L) \text{ farads}$$

For rough estimates $4\pi^2$ is not much of an embarassment, since it is very nearly 40, a nice round number; so $\frac{1}{40} = 0{\cdot}025$. But if we are to be precise, $1/(4\pi^2) = 0{\cdot}02533 = 2533 \times 10^{-5}$. This is awkward, but we can often make the arithmetic simpler by choosing values of L or C which cancel with 2533.

Example. A 100kc/s crystal oscillator incorporates an LC circuit tuned to the same frequency. A dust-cored coil adjustable from 10–13mH is available, and the required tuning capacitance has to be calculated. To make arithmetic easy, we choose a value for L which divides exactly into 2533. In this case, the required value is $25{\cdot}33/2 = 12{\cdot}665$mH, which is 1/200 of 2533.

$$\text{Hence } C = \frac{2533 \times 10^{-5}}{10^{10} \times 12{\cdot}665 \times 10^{-3}} \text{ farads}$$
$$= 200 \times 10^{-5} \times 10^3 \times 10^{-10} \text{ farads}$$
$$= 200 \times 10^{-5} \times 10^3 \times 10^{-10} \times 10^{12} \text{ picofarads}$$
$$= 200\text{pF}$$

This gives us an accurate pair of values for L and C. But is it the best pair? Clearly not, because the capacitor is subject to tolerance limits and will also be modified by stray capacitance. To compensate for this variation we want to use a value for L which gives a good range of adjustment in either direction, high or low.

Our assumed value, 12·665mH is too near the upper limit of 13mH. We need something near 11·5mH, which is the half-way mark. There is nothing sacrosanct about 12·665mH. We used it merely to make calculation of a possible value of C easy and it can now be forgotten. The trick is to remember that tuning depends on $L \times C$. If one is increased the other must be decreased by the same factor to keep the frequency constant. To be precise, for constant frequency the relation $LC = mL \times C/m$ must be satisfied, where m is the incremental factor.

If we make $m = 0{\cdot}9$ then 12·665mH becomes 11·3985mH (which is almost 11·4) and 200pF becomes 222pF. Now, 11·4mH is practically at the centre of the range of adjustment of L, which is satisfactory. The only remaining difficulty is stray capacitance. How big is it? Assuming a coil self-capacitance of 15pF and valve and wiring capacitance of 7pF we have to make C = 200pF to get the total correct. We have about 10 per cent margin on L, so if C is a 5 per cent tolerance component this leaves another 5 per cent (10pF) to compensate for errors in estimating stray capacitances. Unless our estimate is seriously out, a 5 per cent tolerance 200pF capacitor will be satisfactory. We may, however, want to vary the tuning slightly so as to "pull" the crystal to exactly 100kc/s, in which case a closer tolerance would be desirable.

Meetings . . .

THE INSTITUTION OF ELECTRICAL AND ELECTRONIC TECHNICIAN ENGINEERS LTD

LONDON

Date: October 17
Title: Technical Education in the Modern World
Lord Bowden of Chesterfield, M.A., Ph.D., M.Sc.(Tech.), C.Eng., M.I.E.E.
Time: 6 p.m.
Address: I.E.E. Lecture Theatre, Savoy Place, London, W.C.2.

SOCIETY OF ELECTRONIC AND RADIO TECHNICIANS

GLASGOW

Date: October 18
Visit to Honeywell Controls Ltd., Airdrie
Time: 7 p.m.

Further information from The Secretary, 33 Bedford Street, London, W.C.2.

JOINT MEETINGS

Date: October 24
Title: A Slow-motion Videotape Recorder
P. Rainger
Time: 5.30 p.m.
Address: I.E.E., Savoy Place, London, W.C.2.

(Sponsored by the I.E.E., I.E.R.E., and the Television Society).

Date: October 25–26
Title: Euston Main-line Electrification
Time: 5.30 p.m.
Address: I.E.E., Savoy Place, London, W.C.2.

This a joint conference sponsored by the I.E.E. and the I.Mech.E. Registration forms are available from Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

Audio TRENDS...

A Commentary on Sound Reproducing Equipment by Clement Brown

It is generally true that exhibitions, whether for the public or a comparatively limited trade audience, are often used as the occasion to unveil new products. Certainly this was so with the Television and Radio Show, to which can be attributed the arrival of some interesting audio equipment.

Held in London at the end of August, this trade-only exhibition placed particular emphasis on colour television and mass-produced stereo radio, but some new ranges of high fidelity units (which would have been the focus of attention at any Audio Fair) had also been prepared for a first showing. Tape recorder manufacturers and importers have also been very active. Unlike earlier public Radio Shows, this year's event was international.

Integrated tuner-amplifiers, presented as neat shelf units for use with separate speakers, have been growing in popularity and were evidently accepted in Continental and Scandinavian countries before making any real impact here at home. Now the extension of the BBC's stereo service in London and the South-East may well increase demand for such units.

Numerous imported examples are equipped for stereo reception, and it is easily demonstrated that separate, compact speakers give better fidelity as well as more accurate stereo. New receivers of this type are by Arena, Telefunken, Grundig and Philips. Another is the Korting 400: this hybrid transistor-valve design offers stereo f.m., the s.w., m.w. and l.w. bands and 10 watts per channel—all for 65 gn.

DECODERS FOR TUNERS

Enthusiasts who own f.m. tuners designed for conversion to stereo can in certain cases obtain decoders at moderate cost. Here, "designed for conversion" means the provision of the power supply for a decoder as well as facilities for deriving two channels from this extra unit.

For their tuners, Rogers are introducing a decoder in two versions. One is unpowered and for use with this firm's latest tuner only. An alternative version is mains-powered and suitable for other Rogers tuners. Prices have yet to be announced. A decoder was announced some time ago from Armstrong.

Heathkit say that their transistor decoder will be available during November at £8 10s in kit form. An assembled unit will cost £12 5s. Points from the specification are: output 250mV per channel; input 400mV from the tuner discriminator stage; and frequency range 50–15,000c/s.

HI-FI UNITS

Sony, the Japanese manufacturer well known for tape recorders, now introduces several items of professional disc equipment. For example, there is a most impressive two-speed turntable for which a wow and flutter figure of 0·05 per cent is quoted. Its most unusual feature is a servo-controlled d.c. motor, claimed to give vibrationless, low-noise operation.

Then there is the VC8E stereo cartridge, a high-compliance model employing the moving-coil principle. Response range is quoted as 10–25,000c/s; the playing weight range is 0·5 grammes and an elliptical stylus is fitted. With such an advanced specification it is no surprise to learn that the price is to be about 26 gn. Two Sony pick-up arms with every conceivable refinement are also in the professional price range.

Audio units from Philips—a dozen in all, made in Holland—are bound to attract considerable attention. The electronic units are up-to-the-minute in design and fitted in teak-veneered cases for shelf mounting. Stereo tuner-amplifier GH930, at 93 gn, is an all-transistor a.m./f.m. model rated at 7W sine-wave power per channel into 8 ohms. Switchable "silent tuning" eliminates interstation noise on f.m.

Transistor amplifiers range from the GH925 (4W per channel, price 22 gn) to the GH919 (57 gn) which gives 20W per channel and has every control facility the enthusiasts could desire as well as inputs for magnetic and crystal pickups (but not ceramics, oddly enough), tuner, tape recorder and other equipment.

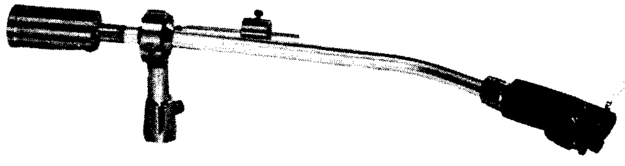
Then there are the GH926, a simple f.m. tuner at 23 gn, and a more elaborate a.m./f.m. model. Other items include speaker systems and a most attractive transcription player unit which, at 39 gn, incorporates the magnetodynamic stereo head. Specifications are available from Philips Electrical Ltd., Century House, Shaftesbury Avenue, London, W.C.2. The prices mentioned here exclude the current purchase tax surcharge.

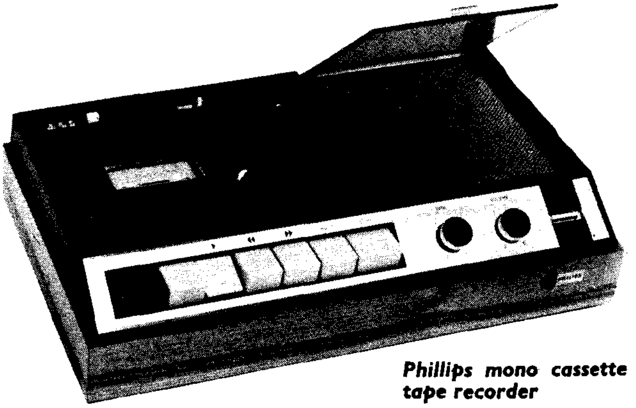
FOR THE CONSTRUCTOR

A remarkable array of components and audio units for the constructor and experimenter is offered by B. Adler and Sons (Radio) Ltd., 32a Coptic Street, London, W.C.1. The imported Eagle range, now considerably extended, includes a variety of small components for electronic projects as well as dual-cone speaker units and such items as mixers, cartridge pre-amplifiers and headphone junction boxes.

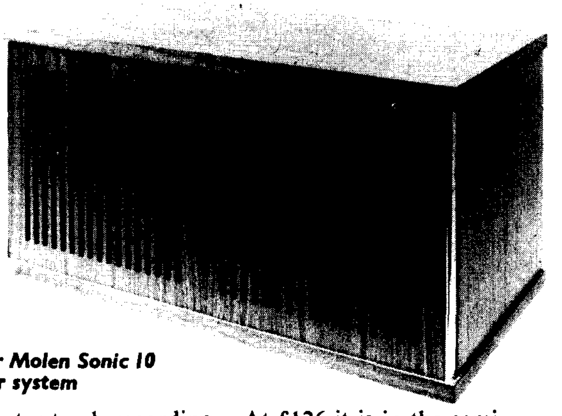
Ready-made audio units, all at moderate prices, include the Eagle SMX52 stereo tuner-amplifier (49 gn),

The Japanese "Neat" pick-up arm





Phillips mono cassette tape recorder



Van der Molen Sonic 10 speaker system

an a.m./f.m. tuner, and the SA100 amplifier rated at 5W per channel. There are also compact speakers and numerous microphones.

Among the simpler examples of disc equipment is the Neat arm, now imported from Japan by Howland-West Ltd. Selling at a little over £10, this component has a high quality finish, adjustable counterweight and pivot pedestal, and a plug-in shell which accepts most makes of cartridge. Outputs are brought to a four-way socket in the pedestal base and cables are provided for connection to an amplifier.

Another item in the low-cost category is the Sonic 10 speaker system. This bookshelf speaker is distinctly unusual in that it incorporates a simple transistor amplifier rated at 10W as well as a 6½ in bass unit and separate tweeter. It is intended for use with tape recorders and radios of limited output. Feeding their low-level outputs to the Sonic 10 will give improved fidelity at, of course, a higher volume level. This ingenious solution to a long-standing problem is priced at 19½ gn and made by Van der Molen Ltd., 42 Mawney Road, Romford, Essex.

TAPE RECORDERS

The Beocord 2000 De Luxe is a new version of a Bang and Olufsen stereo tape recorder which was already familiar in the U.K. Mixing and control facilities are improved and it is possible to achieve variable echo effects and sound-on-sound recording. Also introduced are the Beocord 1000, a mono plinth-mounted machine, and the Beocord 1500 De Luxe. The latter is a stereo tape unit without output stages, designed for use with hi fi systems and priced at 105 gn.

An unusual head arrangement is used in the 2000 and 1500 models. There are separate heads for half-track recording and playback, but an additional head is also fitted for quarter-track playback, In this way it is possible to reproduce commercial tape records and benefit from the technical superiority of half-track recording. Beocords have Perspex covers and rosewood or teak plinths.

New Sony recorders are two stereo models and the high quality TC800 mono portable (£61 19s) which has two speeds and facilities for mains or battery operation. Model TC530 is a transistorised stereo machine for quarter-track recording. At £126 it is in the semi-professional class and features a wide-range speaker system, 5W per channel output and three speeds.

A stereo tape unit, model TC350, is suitable for use with hi-fi equipment and is also recommended for experimental work and teaching. Priced at £78 15s, this all-transistor unit has the 7½ and 3¾in/sec speeds, three heads and inputs for microphones, radio and record player. Features include sound-on-sound recording, track transfer and 0·17 per cent maximum flutter at top speed. Sony and Bang and Olufsen Sales Divisions are both at Mercia Road, Gloucester.

CASSETTES

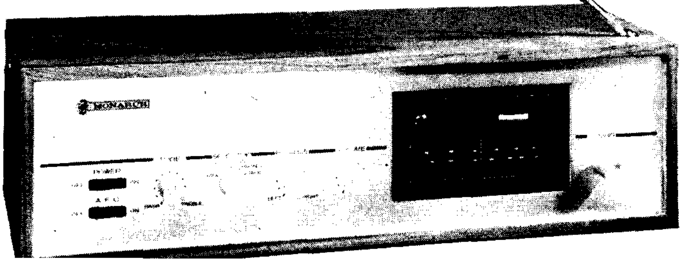
Tape cassettes, which have become available in several forms during the past few years, are enclosed containers of tape for use on specially designed recorders. The elimination of tape threading and manipulation is attractive to those who normally find recorders too "technical" or inconvenient.

All one does is play the tape through (or record on it, as the case may be) and then turn the cassette over for the use of another track. The experimenter has no use for this, of course; he requires open spools so that he can edit his tapes.

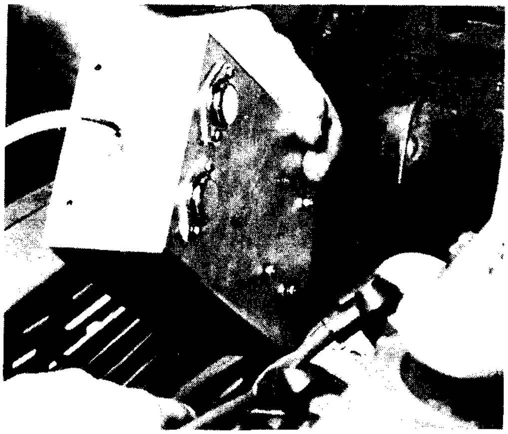
There is new activity in this field with the introduction of Musicassettes by Philips and E.M.I. These are tape records of popular music (classical issues follow later), equivalent to LP discs and available in stereo and mono at £2 each. Similar to the cassettes of unrecorded tape already popularised by Philips, the Musicassettes operate at 1⅞in/sec and employ a quarter-track system on ⅛in wide tape.

Philips have mains machines for playing stereo and mono Musicassettes and there is also a battery portable —the gramophone industry's answer to the transistor radio. Other firms, including Elizabethan, are also making cassette recorders. There are, however, other cassette systems, notably a Continental one using ¼in tape at 2in/sec.

Eagle SMX52 stereo tuner-amplifier



Bang and Olufsen Beocord 2000 tape recorder



solid state IGNITION

Refinements and modifications to suit Negative "Earth" Systems

by E. BARNETT

As a result of the great deal of interest, albeit some critical, shown in the *Solid State Ignition* system (September 1966 PRACTICAL ELECTRONICS) there follows a few circuit improvements and answers to some of the problems raised in the bulk of the correspondence.

A popular request, was for a possible modification of the circuit to suit cars with negative "earth" systems. Such a conversion is treated here in detail and as such it allows us to make some amendments to the components list and Fig. 5b in the original article. Some readers were quick to spot some printing errors: C4 was incorrectly terminated in Fig. 5b and some of the resistors showed inconsistent ratings on Fig. 3 and the components list. These inconsistencies are resolved in Figs. 2a and 2b and the components list (given in this article), which has been enlarged to include some extra components. The inclusion of these will be explained, and the addresses of the suppliers of the transformer and invertor transistors have also been added.

NEGATIVE EARTH CONVERSION

Few alterations are required to the electronic ignition system to enable it to be fitted to a negative "earth" system. The changes are mainly confined to the trigger circuit and installation details. The only changes in circuit components occur in the trigger circuit. Fig. 1 in this article shows the modified trigger circuit only. TR3 and R6 have been removed since they are no longer necessary (the earthy side of the contact breaker is negative). Capacitor C6 has been added to retain the small delay (approx. 500μs) necessary to overcome contact breaker point bounce. Also added are capacitor C7 and diode D5. A full explanation of the latter two components is given later. New components C7 and D5 are required for *both positive and negative systems.*

The circuit operation is similar to the positive "earth" system. When the points open the potential at the TR4 emitter rises to its intrinsic value (approximately 6 to 8 volts) at which point the emitter-base 1 (b1) junction of the unijunction transistor TR4 conducts, producing a short pulse across R10 and causing the thyristor to fire.

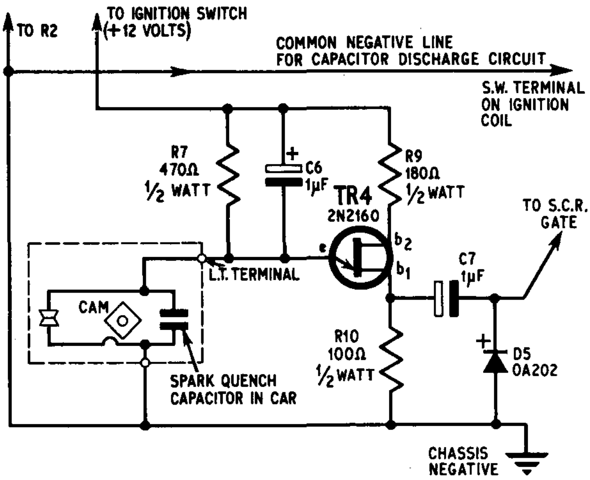
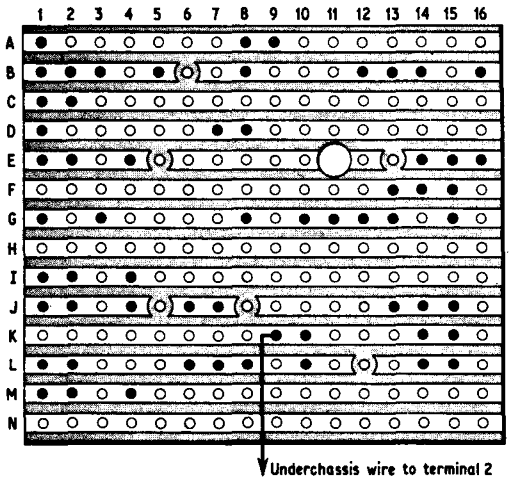


Fig. 1. Amended circuit of the trigger for negative "earth" systems

It has been decided to add D5 and C7 for these reasons. After the points have opened and the thyristor has fired, a small residual voltage remains across R10 while the points are open. The time for which the points are open is longer than the spark time and hence the voltage (although no greater than 1V at maximum) could possibly cause the thyristor to fire irregularly and increase heat dissipation in the convertor transistors and transformer T1. So C7 has been included (for both positive and negative "earth" systems) to block any residual d.c. voltage across R10 while passing the initial firing pulse. Diode D5 prevents the thyristor gate from going negative which could occur due to the presence of C7. It is advisable for any reader contemplating building this system to include the above addition.

Fig. 2a shows the complete wiring and component layout of the modified unit for negative "earth" systems.



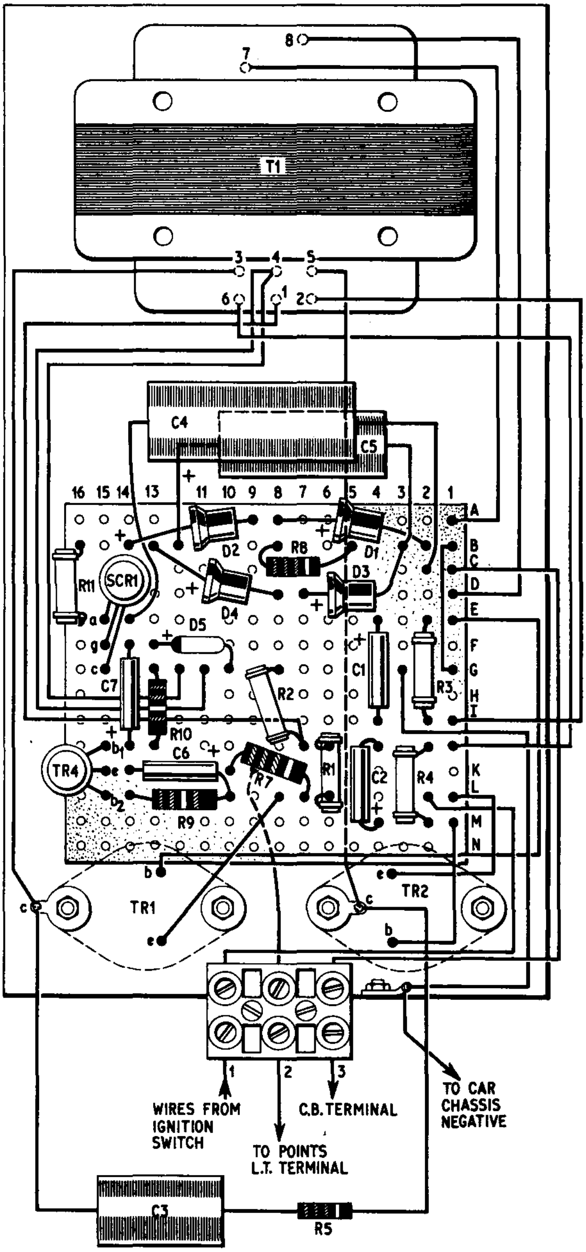


Fig. 2a (right). Modified wiring and layout for negative "earth" systems

Fig. 2b (above). Underside view of the component assembly board after modification

INSTALLATION FOR NEGATIVE EARTH

The following instructions for negative systems are to be carried out with reference to Figs. 5a and 5b on page 632:

(1) Remove the earth wire from present connection at position L2 on the Veroboard and reconnect it to position G3.
(2) Remove the wire from present connection at position G16 on the Veroboard and reconnect it to position L2.
(3) Remove the wire from present connection at position J10 on Veroboard and reconnect it to position K9.

In the original article the installation instructions were given in three paragraphs (a), (b) and (c) on page 632.

Of these instructions only (a) and (b) are still to be followed for negative earth installation. Paragraph (c) should be amended to read as follows for negative systems:

COMPONENTS . . .

Resistors

R1	3·3Ω 3W wirewound	*R6	4·3kΩ
R2	560Ω 2W carbon	R7	470Ω
R3	3·3Ω 3W wirewound	R8	220kΩ
R4	3·3Ω 3W wirewound	R9	180Ω
R5	10Ω 3W wirewound	R10	100Ω
		R11	1·2kΩ 2W

All resistors 10%, ½W carbon except where otherwise quoted

Capacitors

C1 25μF elect. 25V
C2 25μF elect. 25V
C3 0·25μF paper 150V
C4 1·0μF polyester 400V

Transformer

T1 Repanco Type TT51 (Repanco Ltd., 203 Foleshill Road, Coventry.)

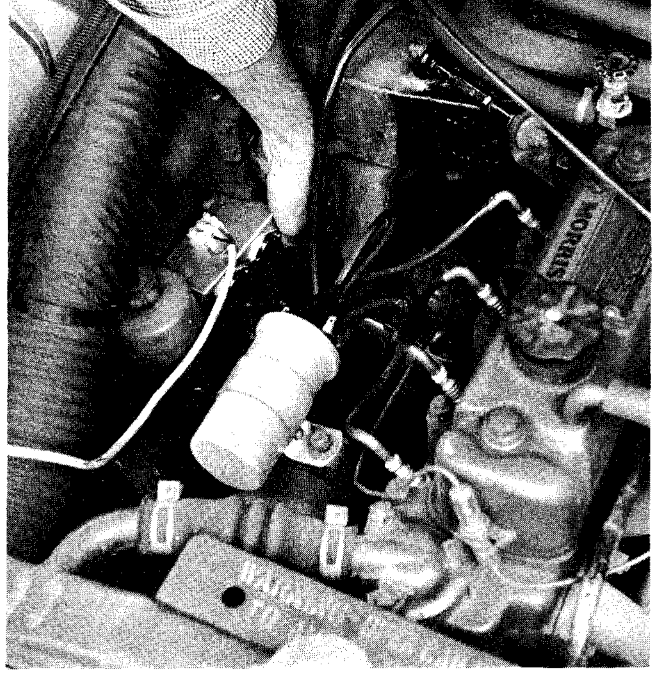
Semiconductors

TR1 OC20 (Mullard)
TR2 OC20 (Mullard)
*TR3 OC201 (Mullard)
(Radio Crosland Ltd., 24 Foley Street, London, W.1.)
TR4 2N2160 (International Rectifier, Hurst Green, Oxted, Surrey)
SCR1 2N1599 (Davis and Whitworth Ltd., 220–4 West Road, Westcliff-on-Sea, Essex.)
D1–D4 BY100 (4 off) †D5 OA202 (Mullard)

Miscellaneous

Chassis 6in × 4in × 2in with cover plate
Veroboard, 2in × 2½in, 0·15 hole matrix
Heat sink compound (International Rectifier)
Terminal block strip, bushes and mica insulators
Solder tags and wire

* *Denotes components deleted for negative "earth" system*
† *Denotes component additions for positive and negative "earth" systems*



Mount the unit away from heat source and in the direct path of air flow to keep it cool

(c) Remove any wires connected to SW terminal on ignition coil and join them to the lead from terminal block position 1 of the ignition system. Next, connect the SW terminal of the ignition coil to the car chassis (i.e. battery negative).

OTHER POINTS RAISED

The opportunity has been taken in this text to answer some general queries raised in letters to the Editor about the original article.

Some readers were concerned that in the article no mention was made of the capacitor (usually $0{\cdot}1\mu F$) normally found across the points of most cars. It was intended that the capacitor should remain *in situ*. In fact with R6 in the circuit diagram (Fig. 3 page 630) it provides approximately $500\mu s$ delay necessary to overcome point bounce which was mentioned earlier in the article.

Another query raised the fact that in the circuit diagram there was no apparent method of connecting the ignition system to the negative side of the car battery supply. On page 632 sub-paragraph (c), it was mentioned that a wire from the ignition unit was attached to the SW terminal of the coil; Fig. 5b shows this wire attached to terminal block position 1. Since no mention was made of removing any wires connected to the coil SW terminal, it was to be assumed that the wire from the ignition unit would join those already attached to the SW terminal. In fact, Fig. 1 does show the negative line of the unit connected to the SW terminal.

Many of our more technically minded readers provided criticism of the rating of R11. The author does admit that this is underrated for six cylinder cars and should be increased to 5 watts in this application—however, for four cylinder engines, the mean power dissipated in this resistor will find an adequate rating in the 2 watts specified.

Finally, in reply to the motor cycle enthusiast, the system is NOT suitable for 6 volt operation without considerable circuit re-design. ★

USING THE TEST GEAR TRIO

continued from page 799

This resistor is also shown in Fig. 8 and is marked R_{source}.

If the input is provided by a moving coil microphone then the series resistor R_{source} should be of a value indicated by the manufacturers of the microphone. This value varies considerably but in the absence of any information in this regard then a resistor of 220 ohms should prove to be near enough to indicate the value of stage gain.

INPUT IMPEDANCE

The measurement of input impedance is the most difficult parameter to arrive at without resorting to a considerable amount of calculation. Therefore in Fig. 9 a relatively simple approach to the problem is given that will still produce quite workable results.

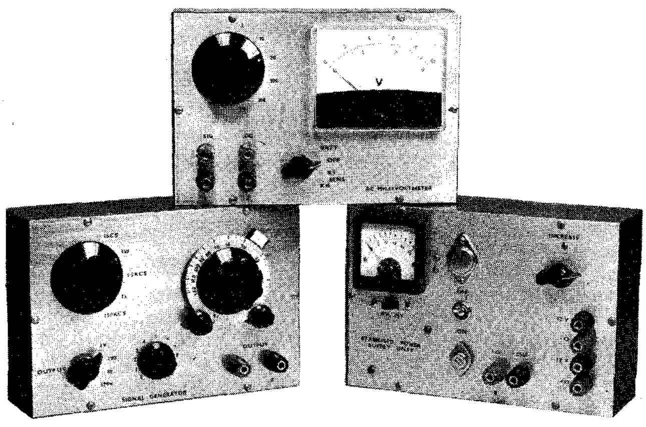
Connect up the instruments as indicated, then increase the output of the signal generator until an output is measured with the millivoltmeter, that is within the collector swing capabilities of the stage under test, with VR1 set at zero resistance. Now increase the value of VR1 until the output measured by the millivoltmeter has reduced by half. That is to say, if the initial reading was 1 volt r.m.s. then the reading after adjusting VR1 should be 0·5 volt.

The next step is to remove VR1 carefully from circuit ensuring that the spindle is not turned inadvertently and then measure its set resistance. This value of resistance is a good indication of the input impedance of that stage.

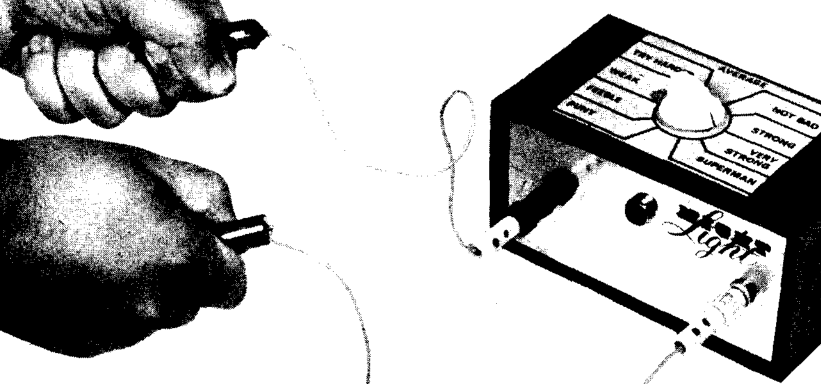
It must be appreciated however that this measurement has been made with a source resistance that has varied as the input condition has been changed and that the final value of set resistance indicated by VR1 in effect becomes the source resistance if the generator output impedance is comparatively low.

This is a most difficult measurement, being tied up with source resistance, feedback over the stage itself and also the values of the bias stabilising resistors; however a reasonable indication may be obtained in this manner. As in the case of stage gain measurement the external load presented to the collector of the transistor can have a considerable effect upon the input impedance.

Quite obviously we have only ventured some small way into testing procedures but all types of test programmes follow in a similar manner and practical experience in one aspect soon leads to more enquiry and efficiency in an altogether different field. ★



THE MIGHT LIGHT



BLUEPRINT GAME

This simple and amusing game (not to be taken too seriously) employs the principle of "body resistance" to operate a relay and indicator lamp. The control knob is set to determine what degree of body resistance is required to bring the lamp on. The scale is purely arbitrary, hence the somewhat humorous effort ratings.

It is emphasised that this is a competitive game between two or more persons to see who may have the "strongest" grip. The word strongest in this context is used in a relative sense.

SIMPLE CIRCUIT

The circuit is very simple, the whole unit can be made for less than £1.

The circuit diagram in Fig. 1 shows a pair of copper tubes as the hand grip conductors which, when shorted out present a very low current path through the two potentiometers to the base of the transistor TR1. This causes the collector current to rise from about 40μA to 15mA due to the collector voltage falling. The voltage across the relay rises to almost full battery potential. These figures are quoted for conditions whereby VR1 and VR2 are set to zero resistance.

If the base resistance is increased by adjusting one or both of these potentiometers, the collector current will not rise to such a high current. They can be set to a value which gives a collector current rise just sufficient to operate the relay; this is in the region of 10mA for a base resistance of about 45 kilohms.

If we remove the short between the hand grip terminals and use human body resistance by holding the tubes in the hands, a variable element is introduced to the base circuit. The potentiometers are then adjusted to supplement the body resistance and provide the required operating conditions. VR2 is a course control to take up a large part of the supplementary resistance while VR1, being a relatively low value, acts as a fine control, which can be scaled as shown in the photograph and blueprint drawing.

The diode D1 across the relay coil damps any transient peaks from back e.m.f. in the coil, and so avoids the possibility of damaging the transistor.

The rest of the circuit is straightforward; the relay closes contacts RLA1 to connect the lamp across one of the 6 volt battery packs. This gives an indication of the relay operating current which is inversely proportional to the body resistance.

Since the base current is dependent on good contact between the grip tubes, the hands must necessarily be in good contact with them. Therefore the tighter the grip on the tube the lower will be the total resistance. Moisture or perspiration on the hands will act as a good conductor and improve physical contact.

One word of assurance to anyone who is afraid of harm resulting from current being passed through the body; the current here is extremely low. No ill effects or sensations will be experienced. Even a baby can play this game, and indeed has done so.

COMPONENT NOTES

All details for the construction work are shown on the blueprint and should not present any difficulty. This project, in fact, is ideally suited to a schoolboy or a beginner.

Most of the components and materials are easily obtainable but one or two notes may be helpful to the constructor (see blueprint).

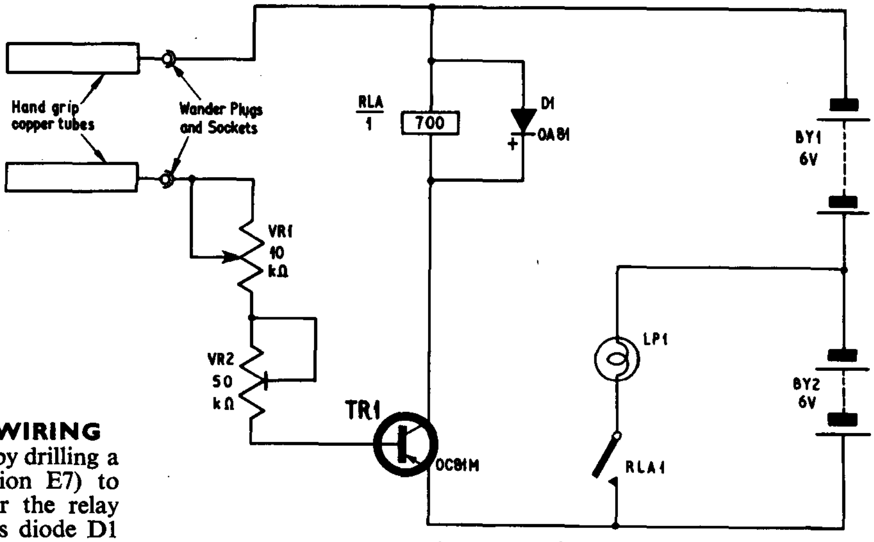
Both potentiometers are panel mounting types; VR1 is fitted with a pointer knob, VR2 will require a "screwdriver slot" cut in the end of the spindle using a hacksaw. When doing this operation, grip the spindle in a vice to avoid damaging the component.

The transistor is quoted as an OC81M because these are obtainable quite cheaply through some of our advertisers. An OC81 or OC81D will serve just as well.

The batteries (eight HP7's in all) are neatly held in two plastics holders, obtainable from many advertisers including Home Radio and G. W. Smith & Co.

Copper tube might turn out to be expensive at the moment but brass may be used as a substitute. Copper is preferred because of its high conductivity properties.

Fig. 1. Circuit diagram of the Might Light game. This is also shown with all other drawings on the blueprint



CONSTRUCTION AND WIRING

Start the construction work by drilling a hole in the Veroboard (position E7) to take the mounting screws for the relay (Fig. 2). Fit the relay with its diode D1 across the coil tags. The transistor is wired onto the board with p.v.c. sleeving over the wires. The collector is the wire nearest a white stripe or dot on the side of the encapsulation. The base is the centre wire.

Connect stiff p.v.c. covered wire between the contact tags (furthest away from the coil tags) and hole 15. Similarly do likewise between the relay coil tags and holes D4 and A5. The rest of the wiring can be done with flexible wire. Solder 6in lengths onto the centre tags of the relay contacts and holes B1, F1, I1 and B2. Leave one end of each of these hanging until the box is made and other components mounted.

Fig. 3 shows the dimensioned details of the box, which is made from ¼in plywood with a triangular section wood trim round the front. A ⅜in diameter hole is bored in the centre of the top to take VR1. Another is bored in the back plate for VR2. Do not fix this rear panel until VR2 is wired up.

The grip tube connection details are self explanatory (Fig. 4); the knot and stopper idea is to take the strain off the soldered connection. The tubes should be cleaned and polished for maximum efficiency.

Sheet aluminium 18 s.w.g. is cut and drilled according to Fig. 5 then polished with steel wool and oil.

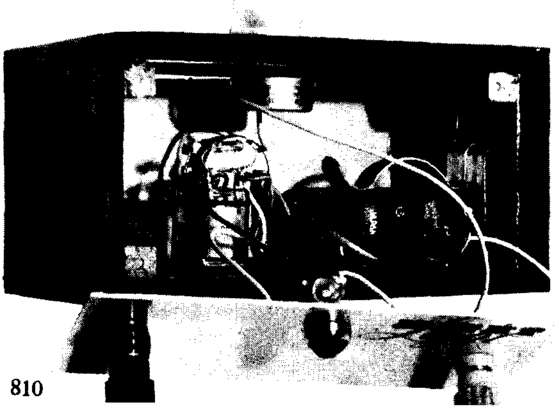
Once the box is made and finished to look attractive, the rest of the wiring can be done (Fig. 2). The battery connectors should be connected to the flying leads from holes B1 (BY1 negative) and I1 (BY2 positive). Note that another wire is taken from the lampholders to the joining link between BY1 positive and BY2 negative.

The flying lead from hole F1 is taken through to VR2 on the back panel. The wiper and the outer tag of VR2 goes to VR1. The wiper and other outer tag of VR1 are connected to one of the wander plug terminals. Connect the flying lead from hole B2 to the other terminal.

All that remains now is to connect the relay contact centre tags to the lampholder, fit the bulb and batteries—observing polarity very carefully—then try it out.

If desired a scale of some kind can be fitted on top of the box; a suggestion is shown in Fig. 6 full size.

The potentiometer should be mounted so that the non-operational arc of knob rotation coincides with the blank space on the scale.



PLAY THE GAME

To check that the circuit is working, rotate both potentiometer spindles fully counter-clockwise and short-circuit the two terminals. The relay should operate and lamp light. Now plug in the grip tube leads after removing the shorting link, and let one tube touch the other. The lamp should come on again.

Separate the tubes, turn VR2 fully clockwise and VR1 to about mid-scale. Grip one tube in one hand and the other tube in the other hand. Then ask a friend to turn VR2 very slowly until the lamp just comes on.

This setting is used as your reference point. Turn VR1 fully clockwise then let go of the tubes and ask someone else to grip them. If the light does not come on rotate VR1 back until it does; this point will be his "effort rating" in comparison to yours.

Remember that VR1 should be fully clockwise (maximum resistance) before each competitor has a try. It may be necessary to adjust VR2 occasionally so that competitors' ratings can be accommodated within the scale of VR1.

Certain conditions can influence the ratings, so practice in the discrete use of VR2 can cause some amusement.

During a trial run this device was tried by males and females of a wide variety of ages. Young children were found to operate the light much easier than adults. One lady was hardly able to operate it at all within the same range as her competitors.

It will probably be found that it is more difficult to operate when the tubes are cold. After a little use the tubes will warm up from the heat of the hands and make it easier. Perspiration naturally aids conductivity so to be fair all competitors should start with clean dry hands.

The relay will have a certain degree of residual magnetism so the competitor should release his grip for each try otherwise misleading results may occur. ★

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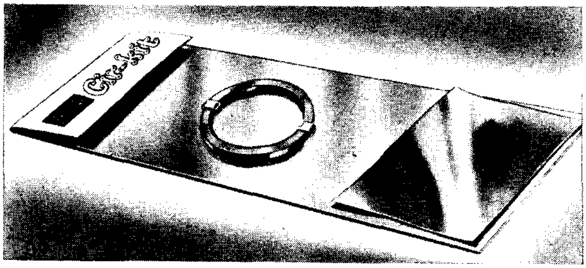

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6 EXPERIMENTS in LOGIC DESIGN

by S. T. ANDREWS

It is only fair to admit at the start that division is not at all easy. In many commercial computers, division, and also multiplication, is carried out not by a lot of extra electronics but by a special programme which is held permanently in part of the storage area of the machine. This programme is called into use whenever a division is required and issues instructions to the adding and subtracting circuits in the same way as an ordinary programme supplied by a programmer.

These "built-in" programmes have to be kept in the machine's store all the time and are usually responsible for many of the more advanced functions; they are collectively referred to as *software* while the actual electronics is called the *hardware*. Division is commonly handled by software but for the sake of completeness we will consider just the basis of a hardware system to do it. It will be necessary to make several detours from the main subject while doing so.

THEORY OF DIVISION

When discussing multiplication we saw that there were two ways of multiplying x by y. One method was to add x to itself y times, and the other was standard long multiplication involving the formation of partial products; it was this latter method we used. There are, naturally, other ways such as logarithms, but these are beyond the scope of our equipment.

In division there are again several methods available for dividing x by y. It would be possible to subtract y from x repeatedly until an answer of zero was obtained. This would be extremely tedious. Alternatively long division may be used and it is this technique which is to be discussed here.

In our usual fashion we shall consider a decimal example first, say 120633 ÷ 237. In the standard decimal method the calculation proceeds as follows: an attempt is made to subtract 237 from the left-hand three digits of 120633 but this turns out to be impossible since it involves (120–237) and for the moment we are not concerned with negative numbers. Thus 237 is moved to the right one place and it can now be subtracted 5 times:

```
       5
237)120633
     1185
     0021
```

next, the left-hand 3 in 120633 is brought down and added to the right of the remainder of the subtraction, an attempt is made to subtract 237 from this but again this is impossible and so the last 3 is brought down. The resulting number, 2133, is exactly divisible by 237, nine times, so the calculation ends:

```
               509
          237)120633
               1185
               0021
               00213
               002133
237 × 9 =      002133
               000000
```

In the binary system this process is simplified since there are only two possible numbers. Consider 110110 ÷ 1001 and, when working this out, we shall make all numbers up to six bits by adding 0's where necessary.

```
        110
1001)110110
     100100
     010010
     010010
     000000
     001001
```

negative result here—ignored

In this, and all future discussion on division, it is necessary to assume that x/y equals a whole number. In the simple arrangement to be discussed here any remainders will be lost and if x/y is not an integer then the result obtained will be the next lowest whole number. The type of division where the answer is approximated to the nearest whole number is called "rounded division". What we have here is not strictly rounded division since all answers are rounded down to the nearest whole number below.

The example worked out above gives the beginning of a flow diagram for the division of x/y. First it is necessary to shift y to the left until its most-significant 1 is in the same digit position as the most-significant 1 of x (i.e. it is necessary to ensure that these two 1's are above each other as in the example above). It is possible to arrange for this to happen but this is difficult, a simpler arrangement simply goes on shifting y left until a 1 is found as the most-significant bit.

Once this has been done the division loop can be entered for the first time. The actual loop is somewhat similar to the one used for multiplication but with a subtraction instead of an addition. The shifted value of y is subtracted from x and, to begin with, only the sign of the number produced is considered. If it is positive, or if the result is zero, then a 1 is written into the answer as the most-significant bit. If the result was negative then the shifted value of y was greater than the value of x, in this case y is shifted logically down one

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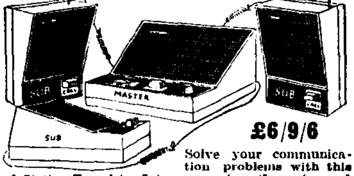

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place and the process repeated, and in this case the most-significant bit of the answer would be a 0. In the case of a positive result y must also be shifted down after the calculation so the overall flow diagram so far is that shown in Fig. 6.1.

NEGATIVE NUMBERS

In building up this loop we have made reference for the first time to negative numbers in the machine; this is an entirely new concept as we have avoided them until now. It is essential to have some means of representing negative numbers; complements could be used but these would be no good by themselves since there would still be no way of telling if a given group of 1's and 0's represented a positive number or the complement of a negative one. To overcome this problem let us say that in any given binary number used as an operand in the machine all but one of the bits is a number digit but the one other bit is a sign bit and shows if the number is negative or positive. To avoid splitting the number the sign bit must be at one end of the number and, for reason to be explained shortly, the convention to be used here will make the extreme left-hand bit into the sign bit. A 1 in this position indicates a positive number and a 0 shows a negative one.

If we re-complement 101101, the apparently wrong answer, we get 19 and since the sign bit is a 0 the number, by our convention, is negative, so the result is −19 which is correct. What we said before about subtraction is still true but it can now be modified. After performing a standard subtraction the sign bit is tested; if it is a 1 then the remainder of the answer is the direct numerical result and is positive; if the sign bit is a 0 then the number is negative and must be complemented to give the correct numerical result. In division, negative numbers do occur sometimes but it is not necessary to re-complement the result since the only important point is the polarity of the number; the numerical value is irrelevant.

DIVISION, SPECIFICATION

In the multiplication circuits the y operand had to be written into a separate register, Q, unlike all previous functions where both operands were sent straight to the adder. In division this is taken a stage further and both operands have to be sent to special registers. This is inevitable because the whole adder is required when a subtraction is being performed and both input registers are occupied. When we come to construct the final machine we shall see that this is not really a dis-

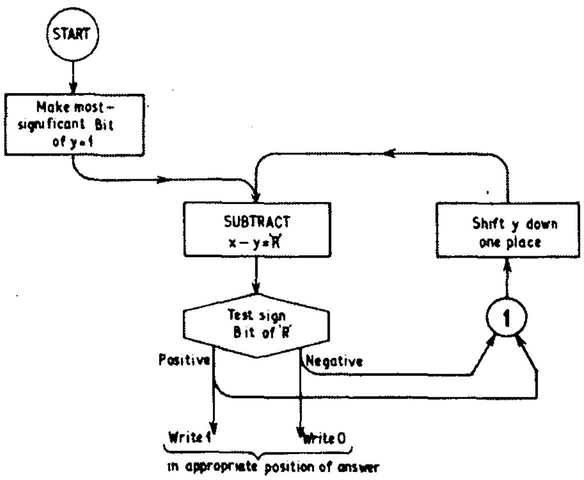


Fig. 6.1. Basis of a flow diagram for division operation

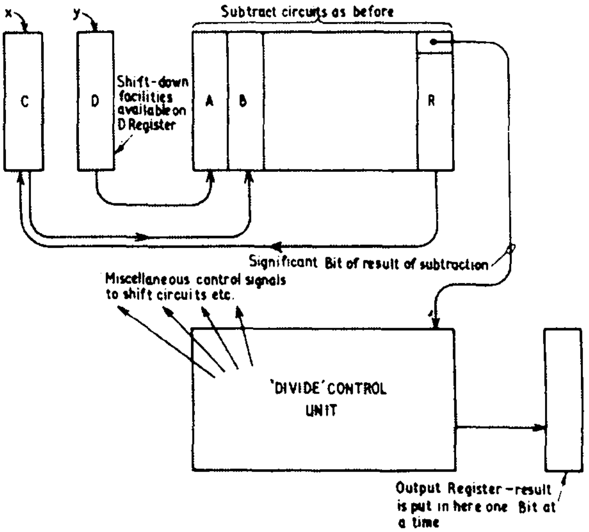


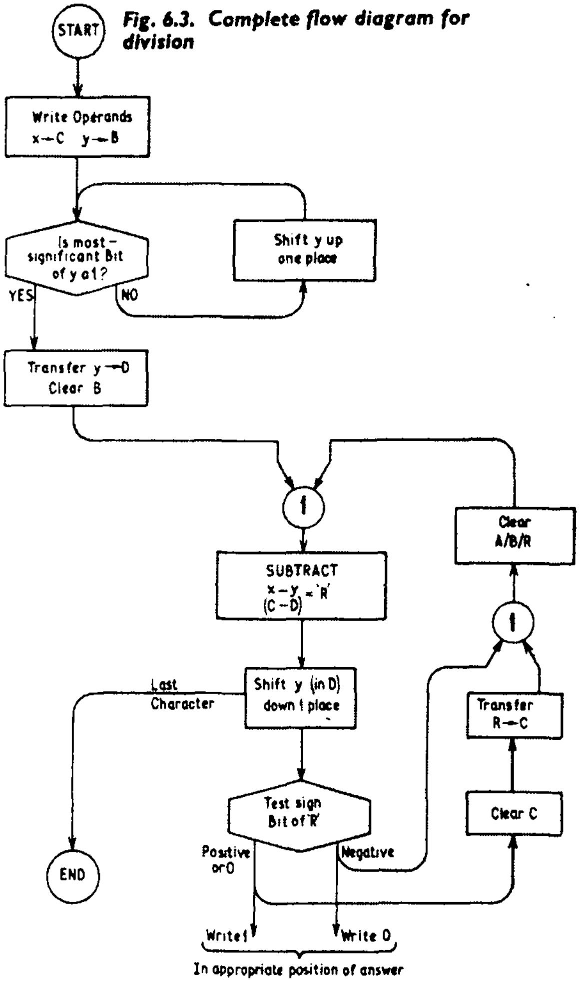
Fig. 6.2. The special registers C and D are required to hold both operands during the division process

When discussing subtraction we saw that in the subtraction (x − y) when x > y the (positive) result was a binary number with up to the same number of digits as the operands, but with an apparantly erroneous 1 in the digit position above. Now let us reverse the numbers used in the subtraction example and try to do: (14 − 33), i.e. 001110 − 100001; using the subtraction techniques as before we get the logical negative of 100001, 011110 add one to give the complement 011111 and then add this to the other operand, 011111 + 001110 which is (0)101101. The result is surprising, mainly because it appears to be wrong; the answer is −19 not +45 as apparently seen above, also it is seen that the sign bit, i.e. the bit to the left of the number-bits, has changed to a 0 and is not the 1 usually found in the result of a subtraction.

advantage but for the moment we shall simply define two new registers, C and D, in which the operands are held during division. These two registers must have rapid access to the adder input; the overall set-up is shown in Fig. 6.2.

Fig. 6.1 was the beginning of the divide flow diagram, the complete flow chart is given in Fig. 6.3 and the mode of operation is as follows. First, y is written into the adder B register and shifted up until its most-significant bit is a 1. Then the main loop is entered, the subtraction (x − y) is performed after which y is shifted down one place by the shift-down circuits attached to register D. The sign bit of the subtraction result is tested; if it is a 0 then the subtraction has produced a negative result and a 0 is written into the output register in the appropriate position. All the adder

Fig. 6.3. Complete flow diagram for division



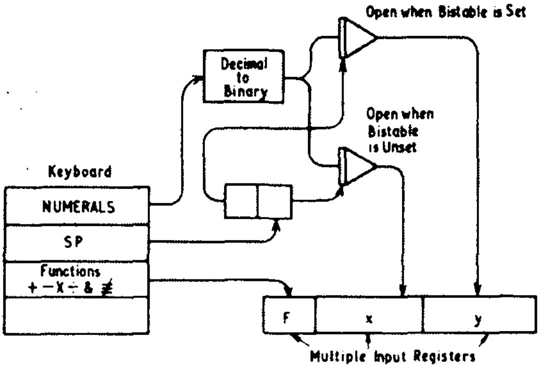


Fig. 6.5. Basic numerical input arrangement

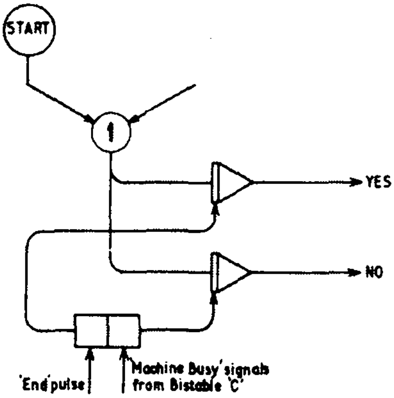
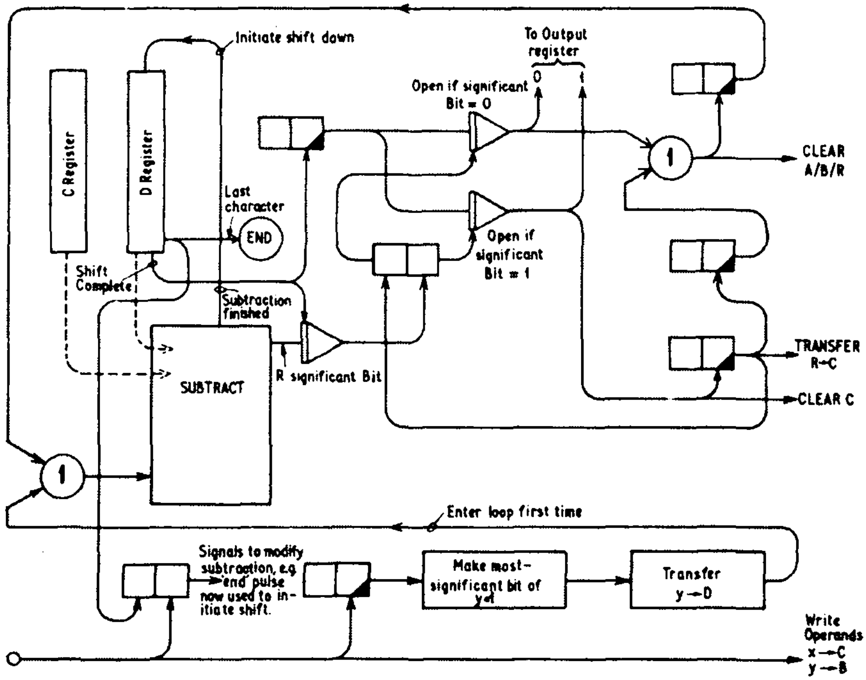


Fig. 6.6. Interrogation circuits

Fig. 6.4 (below). The overall logical system for division, minus the shift-down or write-answer-digit circuits



registers are cleared and the loop is re-entered using the shifted-down value of y.

If the result of a subtraction is a positive number then C is cleared and the result of the subtraction is written into it. Also, a 1 is written into the appropriate place of the answer register, then all the adder registers are cleared as before and the subtraction is repeated using the shifted-down value of y in D and the result of the last subtraction in C.

It is not proposed to give a full logical system for division. The shift-down circuits around register D are similar to the shift-up circuits used in multiplication except that they start at the bottom and work up. A "last-character" signal must also be used; again this is similar to the multiplication system in its operation. Similarly, in the multiplication circuits, the Q register was arranged so that whenever a "test-Q" pulse was applied the content of the next bit of the register was read out on a common output wire. A similar arrangement can be used to write digits into the separate bits of the answer register of division.

Fig. 6.4 gives the overall logical system without showing details of the shift-down or write-answer-digit circuits. It must be realised that this division system is included mainly for academic interest only, and such arrangements, being very cumbersome, are not often found in practice.

THE COMPLETE MACHINE

The discussion of the division circuitry brings to a close the description of the individual calculating circuits. What we now have is a number of disconnected circuits each capable of doing one kind of function and to complete the story we will consider how to make this into a practical design.

The ideal system of operation would be one where calculations were performed by the operator typing the problem onto a keyboard and then operating some sort of "start" switch which would then cause the calculation to be performed and the result typed back. We shall assume that this is the actual requirement and that, to add two numbers, the operator would simply type: 10722 + 936 followed by a start symbol. This could well be the = sign, so that after the operands were typed, and the = key pressed, the result would appear to the right of the = giving the final format: 10722 + 936 = 11658 which would be very satisfactory. The only other requirement is that there must be provision for preventing numbers from being read in while a calculation is already in progress. Thus before the operator can type a problem he must operate an overall START control which interrogates the machine to see if it is free. If it is then a light comes on indicating "You may start". If the machine is already busy with a problem then a "wait" lamp comes on and remains on till the end of the calculation, then the "You may start" lamp is lit and the calculation can be begun. Finally, the circuits must be self-clearing, i.e. everything must be re-set to zero after each calculation. These then are the design requirements needed to convert the machine from a laboratory toy to something approaching a useful machine. We shall now consider the extra equipment needed to do this.

Since the numbers (operands) are fed into the machine one after the other, they must be held in a small store until needed. Similarly, the function, addition, etc. must be retained because at a later time it will determine which part of the machine is to be used. Fig. 6.5 shows the beginning of the numerical input circuits. Assuming that the bistable is initially unset then the first number typed on the keyboard will be converted to binary and stored in the x input register. Pressing the space bar (called SP) on the keyboard at least once sets the bistable so that the second number typed will enter the y input register. The function is stored, in any suitable coded fashion, in the F input register. This arrangement, incidentally, gives a remarkable latitude as far as the input format is concerned. The only real rule is that the two operands must be typed in the sequence: x, at least one SP, y. Thus x + y; +xy xy+ will all result in the same digits being stored in the input registers. When the = key is pressed a gate is opened allowing the stored function to enter the decoder. This is merely a system of gates working on the function digits; it triggers one or other of the function inputs.

This, and the rest of the circuit, is shown in Fig. 6.7. The digit input circuits are as in Fig. 6.5 and the = gate output is seen to open the gate output from the F register. Each function calls in the operands x and y whenever it wants them, this being done by the "write x" and "write y" wires which are part of each function and which open appropriate gates. The "end" or "calculation finished" pulse of the functions opens a gate allowing the result in R or elsewhere to pass through a binary-to-decimal converter and then pass to the keyboard for printing. After a short delay the "end" pulse clears all registers and passes up to the input side, unsetting bistable C on the operand input.

OPERATOR INPUT SECTION

The last section is the operator input section. When the operator wishes to start a calculation he presses the Start switch. This sends a pulse through an OR gate to the "machine free?" circuits which are simply a combination of a bistable and two gates as in Fig. 6.6. If the machine is free a "you may start" lamp is lighted, gate B is opened and bistable C is set; this sends "machine busy" signals to the above unit until the calculation is finished. Gate B, now being open, allows the operands to be typed on the keyboard and fed to the input registers. When the calculation ends the various events already listed take place and also the "end" pulse unsets C thus indicating that the machine is now free.

If an attempt is made to use the machine while it is already engaged then the input Start pulse will leave the "machine free?" unit on the "no" line. In this case it will set bistable D so the "wait" lamp lights; also gate E is opened. Consequently when the "end" pulse appears it has yet another function; it goes through gate E and unsets D, extinguishing the "wait" lamp. After a short delay it is applied to the Start input through the OR gate and since the machine must now be free it will light the "you may start" lamp as before. The two extra registers required in division, C and D, can be made equal to the x and y input registers; this is quite reasonable.

FINAL COMMENTS

It must be realised that the machine described in this series of articles is not a computer in any sense of the word. What has been described here is, at the best, only the basis for a simple *electronic calculator*. A computer would have a vastly greater number of possible functions and would almost certainly use software to handle division and multiplication. Computers have the ability to store operands and instructions and then carry these out in a predetermined sequence. Our machine is only capable of performing one very simple step at a time.

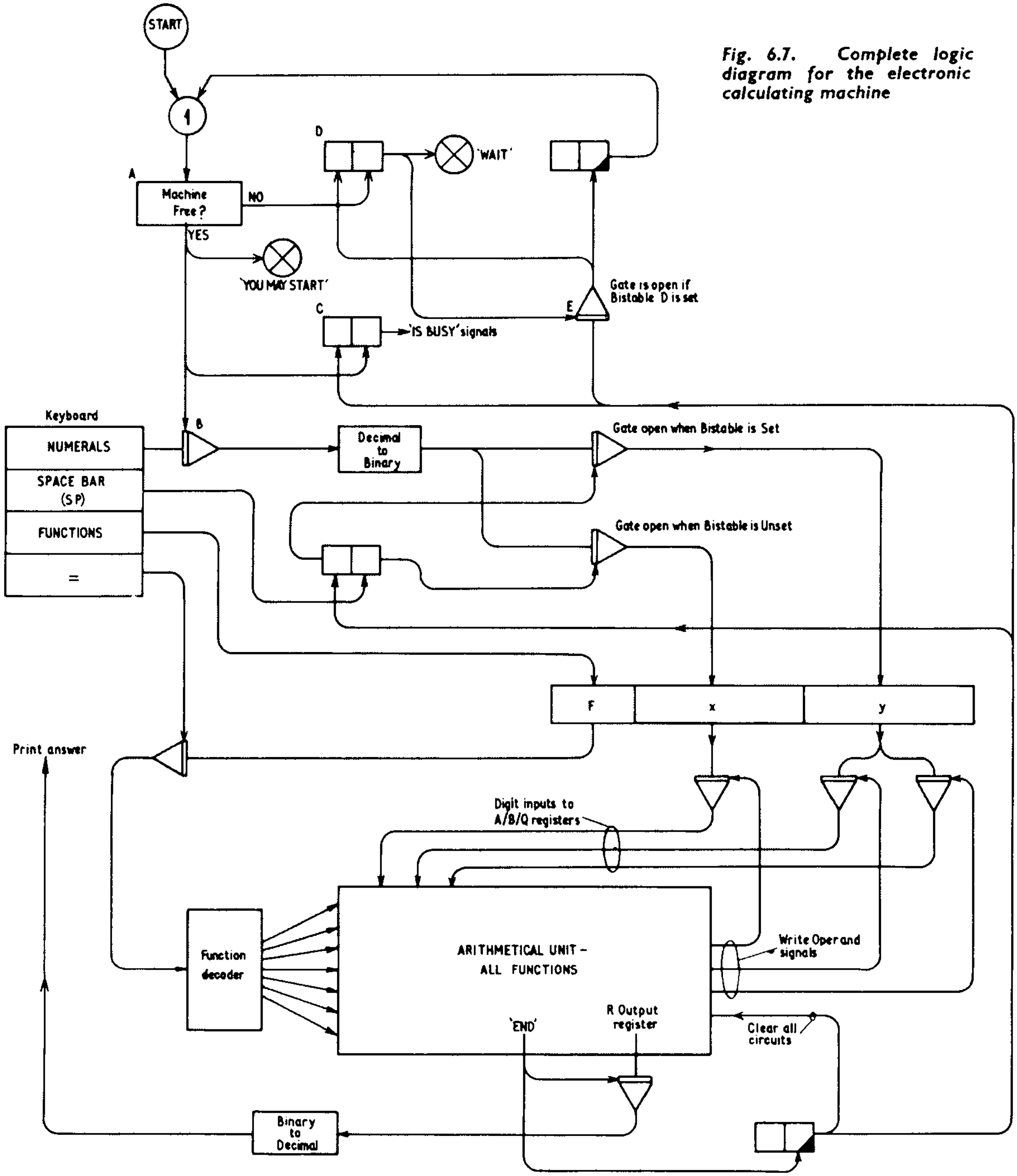


Fig. 6.7. Complete logic diagram for the electronic calculating machine

The circuitry discussed here is only one of the very many variations which can be used. Perhaps the most obvious feature of this sort of system is that the numbers in the machine are used in a "parallel" arrangement, all the bits of a given number passing simultaneously on separate wires. Another system called the "series" type represents numbers by trains of pulses following one another on a single wire; this increases the time taken to transfer a number from one part of the machine to another, but greatly reduces the amount of electronics required. Serial number systems are, in many ways, better than parallel ones and although the overall principles are the same, the detailed logic is somewhat different.

One last point must be made. Despite the comparative simplicity of the individual logic elements, the overall machine described in this series is extremely complex. Construction of the machine should be attempted only by those readers with a reasonable knowledge of electronic fundamentals. Although the logic diagrams published are accurate, adjustments will undoubtedly have to be made in some of the finer points of circuitry before the circuits will work to full efficiency. These adjustments cannot be performed without a complete understanding of all the principles involved. For those who succeed in an undertaking of this magnitude, however, the sense of achievement is considerable. ★

detached particles

JOHN VALENCE

TRANSISTORS FOR A SONG ?

The development of plastics is one of the key factors in modern life. So often the word is thought of as being synonymous with "cheap"—in not merely the economic sense, but as a term of disparagement. On the other hand a good example of plastics lowering the price of the commodity while at the same time enhancing its quality is to be found in transistor manufacture.

The familiar metal canned transistors seem likely to be superseded by plastic-capped types within a few years, according to a report issued by the General Electric Company of the U.S.A. It is stated that new processes enable micro-miniature high performance plastic-encapsulated transistors to be mass produced at low cost.

Apart from the cost aspect, it appears that the plastic encapsulation permits semiconductors to withstand pressures strong enough to crush conventional metal transistors. This feature is likely to be extremely useful in deep sea equipment and other arduous applications.

The low price will encourage the further use of electronic systems for such domestic appliances as washing machines, and of course one can expect the price of radio and audio equipment to be appreciably affected once these cheaper transistors get in circulation. As for the amateur constructor—well the price of an individual transistor may eventually be no more than that of a resistor!

This new trend in transistor fabrication is an interesting example of how the physical construction of many devices tends to become simpler and more basic as the state of the art progresses.

An almost parallel case exists in the development of the vacuum valve. The earlier types had glass envelopes of generous volume with substantial bases moulded on to carry the pins. As manufacturing techniques advanced and became more precise, electrode assemblies became more compact, the envelope reduced drastically in size, and the moulded base, eliminated altogether.

The latter was discarded not principally for cost reasons but to improve performance at high frequencies by reducing to the minimum the capacitance losses between pins.

By such evolutionary processes the electronics industry has proved itself an extremely economic consumer of raw materials—even as its products themselves increase spectacularly in performance and efficiency.

EASING THE TRAFFIC FLOW

The new Severn Bridge is equipped with what is claimed to be the first computer based toll registration system operating in Europe. Vehicles using the bridge are classified according to the number of axles, and these are counted by sensing devices in the road surface. Apart from recording the tolls paid by vehicles, the computer, an ARCH 1000, will keep an hourly log of the temperatures of the road surface. This data will be more grist to the mill for road designers and engineers as they plan more of Britain's new roads and motorways.

Another interesting application of electronics found on the Severn Bridge is a long-range fog warning device. A beam of modulated infra-red light is transmitted from a unit installed on one of the piers below the superstructure of the bridge, and is picked up by a receiver on another pier some 3,250ft distant. Fog of sufficient concentration will interrupt the beam and so trigger off warning devices. An internal process timer is included in the system to allow for breaking of the beam by ships passing under the bridge.

The increasing use of computers for road planning is further illustrated by Birmingham's new Five Ways Underpass Scheme. Detailed plans for this complex project have been calculated to one hundredth of an inch with the aid of a KDF9 computer. The more time consuming alternative would have been the employment of a team of mathematicians sweating it out over a vast number of simultaneous quadratic equations.

RADAR TRAP

Can't seem to get off the road this month. A news item concerning the prosecution of several people for betraying the presence of a police radar speed trap to approaching motorists reminds me of a rather wonderful story of the engineer "being hoist with his own petard".

The central figure in this case was none other than the Father of radar himself, Sir Robert Watson-Watt. While motoring in Canada some years ago, Sir Robert was stopped by the police and charged with exceeding the speed limit in a controlled area. A little mystified by this sudden appearance of the "law", he enquired if radar was responsible for his detection. "No", categorically asserted the police officer "—it was not radar, it was an electronic speed meter". Sir Robert's wife, who was accompanying him at the time, volunteered the information that her husband had been knighted for inventing radar. The officer remained strangely unmoved, and Sir Robert had to pay up!

IT'S THE TREND

The miniaturisation trend is not exclusive to electronics as anyone who takes the slightest heed of female fashions will confirm. After the reign of the mini skirt, we are promised the micro skirt. With the adoption of this terminology I am curious to know what follows—the *nano* or perhaps the *pico* skirt?

Readout—
A SELECTION FROM OUR POSTBAG

That car battery system

Sir—I was very pleased to note the appearance recently of several electronic projects which were designed for fitting to motor cars. Unfortunately, there is a certain lack of standardisation among motor manufacturers about battery voltage and polarity.

The six volt system has been almost completely superseded by the twelve volt system for private cars, twenty four volts being more normal with commercial vehicles.

The position with regard to polarity is somewhat more confused. The majority of British manufacturers have standardised, since before the war, on a positive earth system. One of the reasons for the adoption of this practice was the possibility of reduced contact breaker wear.

Now, however, the pattern is changing. The introduction of transistorised ignition equipment has called for very strict standardisation to prevent possible damage to expensive equipment. The negative earth system was adopted as from August 1965 and about 50 per cent of present vehicle production agrees with this. As new models are introduced they will automatically be fitted with the negative earth system.

Perhaps this variety will emphasize the need for alternative circuit details to be published whenever possible.

P. Harris,
The Volkswagen Owners' Club
(Great Britain),
Toddington,
Beds.

Correspondence please!

Sir—I would like to correspond with any of your readers who have or are at the moment constructing a radio telescope and/or auxilliary equipment.

G. D. Wilson, M.I.S.T.
17 Wensley Drive,
Withington,
Manchester, 20.

CAN YOU HELP?

Letters for inclusion under this heading should be as brief as possible. Replies should be made direct to the readers concerned.

Sir—I would be very grateful if any reader could sell or loan me the September 1965 issue containing details of the Echo Unit design.
R. G. Palmer, 78, Wakefords Way, Westleigh, Havant, Hants.

Sir—I am told that 5mA meters are available with 270 degree dials, which are very nice for visual display. If anyone knows where these can be obtained I would be very pleased to know.
H. A. Cook, 30, Wickfield Avenue, Christchurch, Hants.

Back numbers are usually very quickly exhausted. We strongly advise all our readers that a standing order be placed with their newsagent to avoid any future disappointment.

Cine/tape sync

Sir—May I suggest a practical problem which one of your readers or contributors might be able to solve. Namely, how to run a cine projector at constant speed? Many readers, like myself, have cine projectors and tape recorders. The tape recorders run at a remarkably constant speed. The 8mm cine projectors however do not run at anything even remotely approaching constant speed.

There are devices on the market for coupling the projector and tape recorder together but none of them, in my opinion, work very well. I achieved best results by using a stroboscope and holding the speed at 16⅔ frames per second. Although the nominal speed is 16 f.p.s. the slightly higher speed reduces flicker and as the shaft of the mechanism runs at three revolutions per frame change, i.e. $3 \times 16\frac{2}{3} = 50$ r.p.s. running it at this speed requires a stroboscope disc of very simple pattern.

However, to keep the speed constant by these means requires constant hunting with the speed control of the projector and requires an assistant during recording. Perhaps an electronic device could be constructed to make the adjustments automatically. I imagine that devices for keeping the speed of an electric motor constant under slight variation of loading probably already exist but are not well known.

I am certain that a solution to this problem exists, but where?

B. R. Flach,
B.Sc., A.M.I.C.E.,
London, N.2.

High Z "bootstrap"

Sir—Regarding the *A.C. Millivoltmeter* published in the August issue. I note that Mr. Hirst claims the input impedance (without the external probe) of this circuit is better than five megohms.

However, it will be easily seen from the circuit diagram on page 571, that the input impedance cannot be greater than the combined impedance of C1, R2, and R3, i.e. not greater than 700 kilohms.

I conclude that there is a printing error in the circuit published? As I am interested in this circuit I would be glad to know what it is.

P. M. Smith,
Carnforth,
Lancs.

You may notice in the text that the term "bootstrapping" is the operative word when describing the input impedance of the unit. This effect is too complex to be able to describe the action in this reply but, in fact, the feedback capacitor C2 promotes this condition in conjunction with R2 and for a.c. considerations the biasing may to all intents and purposes not be in circuit. Therefore the input impedance becomes a function of the combined collector resistances of the first two transistors and could, in an ideal condition, be something in the order of 10 megohms.—R.H.

Tacho for 6-volt "twin"

Sir—Could you please tell me what alterations are needed to convert the tachometer shown in the May 1966 issue so that it will fit a 6-volt supply on a twin cylinder engine.

P. J. Bush,
Cheshunt,
Herts.

To convert the tachometer for motorcycle use it is only necessary to delete R10 and substitute OC140 or OC139's for the OC71's. The transistor changes are necessary because of the polarity inversion of most motorcycle battery supplies.

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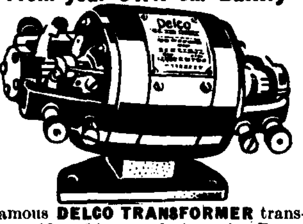

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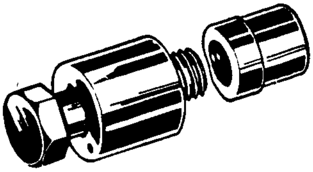

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⅞" ,, ...	10/8	,,
1" ,, ...	11/8	,,
1⅛" diameter Int. Octal	13/4	,,
1¼" ,, ...	16/2	,,
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