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Investing in the future

The prospects of the U.K. electronics industry, which is believed to be the fourth largest in the world (the U.S.A., Japan and Germany being the first three), have been assessed by the Electronics Economic Development Committee (Little Neddy) and a lengthy report has been issued by the National Economic Development Council. This report, which is primarily concerned with the industry's prospects during the next two years, draws a number of conclusions and makes several recommendations, the most far reaching being that concerning expenditure on research and development.

The committee considers that the most important immediately practicable step which could be taken to improve the flow of resources to the industry would be the recognition on the part of the government, that the industry's research and development expenditure fulfils the same economic function as its capital expenditure, namely a provision for the future out of current resources. In this connection the E.D.C. lays stress on the industry's development effort as distinct from its research effort. This is the vital link in translating the fruits of research into marketable products, and it is here where pressure on resources is greatest. It is already national policy to encourage industry to make adequate provision for the future in terms of production hardware, but since, as regards R & D, investment grants are confined to capital expenditure incurred in producing prototypes and in providing plant or machinery for use in scientific research, the effect is to discriminate in favour of industries whose R & D effort is relatively plant-intensive at the expense of industries like electronics whose R & D effort has a high labour content. The result is to exclude from grant the bulk of the R & D expenditure of the electronics industry. The E.D.C. therefore recommends that government should find some way of extending the coverage of the investment grant system to cover the whole of the industry's R & D expenditure, including that on software, even if this means some reduction in level of hardware grants.

There may be those, possibly of other industries, who will consider that electronics will be "feather-bedded" if Little Neddy's proposal is put into effect.

What are the facts therefore, that prompted the committee to suggest this fundamental change in the attitude towards the cost of R & D in a company's accounts? The R & D effort of the electronics industry is approximately five times as important in relation to capital expenditure as the national average for the country's manufacturing industry. With the exception of the chemical and aircraft industries electronics has a higher density of qualified manpower in R & D than any other industry. In a normal year the R & D expenditure of our industry is about twice its expenditure on capital investment, as normally defined, and currently exceeds £100m. In manufacturing industry as a whole the position is reversed—capital expenditure being about two and a half times that spent on R & D. Moreover, the technological advance and innovation in electronics results in very rapid obsolescence both of the end product and, not infrequently, the means of production.

Lest it should be thought that the committee which drew up the report is heavily biased it should be stated that of the 18 representatives of management, trade unions and government (under the chairmanship of Sir Eric Mensforth) only seven represent electronics companies: Plessey, Rank Bush Murphy, Wayne Kerr, International Computers, Ferranti, Mullard and Marconi.

One question which may justifiably be asked is "what of government financed research contracts?". How will the Treasury be able to differentiate between research for which government is paying and company research which could be claimed as "capital investment"? Despite this administrative problem we wholeheartedly agree with the committee's recommendation.

*Radio, radar and electronic capital goods; computers; instruments; radio and electronic components; domestic broadcast receiving and sound reproducing equipment; and telecommunications equipment.
Low-cost Horn Loudspeaker System

Details of successful experiments

by “Toneburst”

As far as the ear can tell, consistently clean and spacious bass can be reproduced only by a driver unit coupled to a horn-type acoustic transformer. This fact has, of course, been known for years and most of the credit must go to Paul Klipsch who in 1941 described a split folded bass horn which outperformed theoretical expectations, and set a performance standard that cannot be excelled. If there is any quibble about the performance of such a bass horn it can only be that ‘level’ response below about 35Hz is difficult to achieve.

In a sense it is unfortunate that Klipsch achieved what he did. Theoretical analysis of the performance of a corner horn has not advanced significantly since. Langford-Smith comments that “The only known method for handling frequencies below the flare cut-off frequency of an exponential horn, with good fidelity, is the use of an enclosed air chamber behind the diaphragm, resonant at a frequency in the vicinity of the flare cut-off frequency, as used with the Klipsch loudspeaker”. This is a very peculiar remark for it implicitly casts doubt on the exact nature and function of the horn mouth. In 1943 Klipsch had reported that “The improved horn has a cut-off due to flare of 50 cycles, but the impedance measurements and ear tests show that a strong fundamental is radiated down to 35 cycles. It must be concluded that the computed horn impedances are only qualitatively correct for frequencies within an octave of the low-frequency cut-off.”

No experiments seem to have been done since Klipsch’s design appeared, in a direct attempt to compromise horn theory without losing quality. Bearing in mind Langford-Smith’s condensation of Klipsch’s own experience there seems to be a good case for expecting to be able to simplify the design of a split folded corner horn whilst maintaining an acceptable low frequency performance.

Experimental work

The first necessary decisions were on size and shape. Klipsch himself gives some support in saying that “The front throat baffle may be rearranged for a simple flare rate working out of a larger cone, in which case the air chamber between the cone and throat may be eliminated.” A simple starting point was found in an adaptation of the Ambassador bass horn described by Briggs. There is no compression chamber behind the cone in this design, but after a slightly modified version had been constructed, employing a Fane 12/12 12-in driver, good response down to about 40Hz was heard. Unfortunately there were humps and bumps from about 320Hz upwards. Further modifications, to smooth the flaring rate, removed the trouble above 320Hz but also removed the bass below 100Hz. A compression chamber to Klipsch’s specification was constructed by filling up the corner space at the back of the enclosure. The result was, and is, clean bass with response down to below 30Hz.

A description of the final horn structure follows. It is recommended that all instructions are followed at least in spirit, if not to the letter, or significant resonances may be found rather late in the day.

Construction of bass horn

Raw materials required are lengths of 1 x ½ in or 1 x 1 in wood, ½ in nails, sand and cement, and pieces of plywood, blockboard, or chipboard. Most of the wood items can be bought as off-cuts and the sand and cement is available in a suitable mix in convenient 7-lb bags costing 2s 6d (Rustins).

Frame. The first step is to put together a rectangular framework into the front and sides of which will be cast concrete panels. Two side frames must be constructed as in Fig. 1, and ½-in keying nails knocked in as shown. Cutting the wood should present no problems even to those with no experience. An Eclipse No. 66 general purpose saw is recommended to anyone in doubt—it costs just less than £1. (After marking the wood to length remember to cut on the outside of the mark(s) and not to try to make two wood lengths out of a piece exactly the length of the two pieces finally required.)
Assembly should be on a flat surface, on a single layer of paper if need be. The recommended adhesive is Evostik Resin "W". The 4 fl.oz. 'oil can' dispenser is ideal for all the joining operations. This may be refilled from a 1-pt pack thus combining convenience with overall economy.

After one side frame is complete, and the resin set, four 13-in lengths are to be stood vertically at the correct positions on one of the frames and the adhesive left to dry. This is the one operation for which square-cut ends are essential.

After cutting each length of wood make sure that no saw-dust is left on the ends when the resin is applied. (A stiff wire brush is useful here.)

If 1 x ¾ in wood is used the joining should allow the 1-in face to set the depth for the concrete front panel.

**Concrete Panels.** The front and sides must next be fitted with concrete panels to the depth of the wood limiting each area.

The side panels are the smallest and thus the best place to start the concreting. Place about ten layers of newspaper on a flat surface—table or floor—and lay the frame with one of its sides down on the paper.

The cement may be used with or without gravel. If the average particle size of any gravel used is not less than ⅛ in, two or three pounds may be safely added to a 7-lb bag of sand and cement without significantly weakening the binding power. The complete contents of each bag of sand and cement should be used at once or some sandy results may be obtained due to separation of the mix during storage.

Start with 7 lb of cement mix (with or without a known amount of gravel) and fill up the panels. It is then just a question of doing some arithmetic to find out how much more concrete will be required to complete the paneling for one or two horn structures.

The mix should be fluid and can be spooned into the spaces. The newspaper will quickly absorb any excess water, and it should be possible to lift the frame after about 18 hours though it is better to leave it for 24 hours. (The concrete will take up to a week to dry out completely.)

The front panel should be cast next in exactly the same manner as described, but should not be lifted from the paper for about 48 hours. Finally the other side panels may be cast.

**Speaker Board.** The 16-in x 13-in panel carrying the bass driver should not less than ⅛ in thick and may be made of plywood, blockboard or chipboard. A 10-in diameter hole must be cut in the middle. It is quite easy to drill holes round the edge of a 10-in circle (as close together as possible) and then to drill round again in both directions at 45° to the surface. Finally, a sharp knock on the centre of the circle with a hammer should remove the disc and the edge of the hole can be cleaned up with a rasp or file.

The speaker board should be fitted into the concrete framework using Resin, as shown in Fig. 2. Once dry, wooden blocks should be glued as shown in Fig. 3. These blocks remove all significant resonance from the speaker mounting board.

**Top and bottom concrete flare-panels.** Using the same woodworking techniques as before two wooden frames should be made, using the main frame as a vice. When the joints are dry these frames should be removed and after positioning carefully on newspaper (with one wooden edge of each necessarily overhanging the table, if constructed as revealed in Fig. 4) concrete mix should be spooned in. Again, if 1 x ¾ in wood is used the 1-in face should give the thickness of the panel. When dry these panels can be glued into the main frame—which should be placed on its side. Next the speaker can be screwed down, as tightly as possible, using four 1-in screws. The terminals should face the middle of one side of the enclosure.

**Wooden flare-panels.** Simple rectangles of ½-in plywood will do for these—it does not matter at all that the junction with the speaker board is along a 'sharp' edge—a similar edge will also be 'flush' with the rear of the enclosure so far built. To fix these panels the enclosure should be turned on its side and each panel glued along the edges that will lie along the wood strips in the sides. When the joints are dry turn the enclosure on its front and glue along the junctions between the panels and the speaker mounting board.

**Back panels and duct.** The details of the remaining panels (⅛ in to ⅛ in thick) are deducible from Figs. 4 and 5. The angle pieces forming the 3-in high vent to the rear of the cone should be drilled so that they can be screwed down while the glue is still wet. The two panels completing the
compression chamber should be of 3/4-in ply. (The drive unit must be wired to external terminals before fitting the second panel.)

**Resonances.** Any concrete flanges that overlap the wood should be knocked off gently with a hammer. When satisfied that the concrete edges are clean, turn the enclosure on one side and run a stream of glue along all the wood-cement junctions. This procedure must be followed for each side, allowing each ‘run’ to dry while the enclosure is horizontal.

Now, standing the enclosure upright, tap the front panel with a finger. Note the dead sound—it is high-pitched, metallic and of no perceivable duration. Test each concrete panel in turn. The same should be done for the plywood panels.

If a resonance is found which suggests hollowness, then bracing must be fixed as in the case of the speaker mounting board. Such resonances, if left, will seriously colour upper bass frequencies.

Finally, the external concrete surfaces can be painted.

**Fitting against skirting boards.** There are four possibilities:

1. Cut out a suitable section from the back compression chamber.
2. Stand the enclosure on a triangular plinth raised above the skirting board.
3. Remove the skirting that is in the way.
4. Stand the enclosure against the skirting and fit wood strips in the gaps between the walls and horn.

The latter is the simplest way.

**Treble speaker**

In deciding what treble unit to use with the bass horn the main criteria for consideration are sensitivity, distortion, sound dispersion and frequency range.

Horn loading a treble driver raises its efficiency, linearizes its response, and allows the dispersion pattern to be controlled. Again I had recourse to the work of Klipsch. In 1963 Klipsch published details of a high-frequency horn with a cut-off below 300Hz, and off-axis response correct for good stereophony. This horn was driven by a pressure unit from a throat 1in or less diameter. The area doubled approximately every 2in and ended in a rectangular mouth 5in × 17in. Obviously if a suitable small cone speaker can be found the horn structure can be very simply shortened to match the cone diameter.

The Eagle FR4 driver, although sold as a full-range unit for use in a bookshelf enclosure, has excellent characteristics for use as a mid-range and treble speaker, with horn loading. The manufacturer’s frequency response chart shows a ±5dB variation in the range 100Hz to 9kHz, and a steady decay out to about 17kHz. A concrete horn was therefore designed to match this drive unit.

**Construction of treble horn**

**Cardboard mould.** The horn has flat top and bottom, and curved sides. The diagrams of Fig. 6 show the exact shape and dimensions of the four cardboard pieces required. The templates may conveniently be drawn on thin card—only one of each shape being required. These can be drawn round to transfer the shape to the thick cardboard needed to make the mould. The best cardboard for the mould is the 3/4-in thick “grocery box” stuff with a corrugated middle layer sandwiched between two thin flat sheets. In preparing the sides of the mould it is helpful to ensure that the corrugations assist rather than hinder the folding. The dimensions given allow for the thickness of the concrete layer and the thickness of the cardboard where the joints are made.

Once the pieces are cut gluing can begin. Epo-Stik “impact” adhesive is best for this, the sides being stuck between the top and bottom. Although the mould can be used as it stands, it is recommended that the inside be given a layer of varnish so that the wet cement does not cause deformation.

**Casting.** Concreting is in four stages using a gravel-free mix. The mould should be placed on a flat surface and the bottom surfaced with a 3/4-in layer of cement. It is a good idea to mark a small screwdriver 3in up the blade and use this as a probe to ensure a more or less uniform layer. The work must now be left to dry out completely. Next, one of the curved sides can be cemented, in exactly the same manner, but first a layer of Epo-Stik Resin ‘W’ should be applied to the side of the dried concrete to help bond the new to the old. The mould should be turned on its side while the side piece dries out. Do the other side piece and then the remaining flat piece, applying the wood resin as each new section is formed. Finally, the cardboard may be stripped off.

**Throat section.** Stand the horn throat down on a piece of 3/4-in blockboard 6in square and draw round the edge. Drill out the middle section (as specified for the bass speaker board) and fit it like a collar round the throat—a hammer can help if used with due care. When the throat opening is flush with the top of the collar, wood resin should be run round the joint and left to dry. A 6-in square of 3/4-in plywood, with a 3-in-diameter hole in the centre (again drilled out) can be screwed or glued down over the throat opening. When dry (if glued) the inside of the throat must be concreted to give a proper exponential transition from circular to rectangular cross-section. Wet cement can be applied with an old knife, the four cement “fingers” stopping about 3in from the now circular throat. A file can be used to remove roughness on the inside of the horn. One or two coats of paint can be applied to give better smoothness. The FR4 unit can now be screwed on to the horn, and the final assembly is shown in Fig. 7. Sound absorbent material must be fixed over the back of the speaker chassis to prevent unwanted wall reflections.

**Crossing over between drivers**

The treble horn loads its drive unit quite satisfactorily down to about 300Hz. The bass horn delivers its output with an increasing amount of distortion as the frequency rises above about 500Hz. It seems correct therefore to cross over at about 400Hz and at a rate of not less than 12dB/octave.

In constructing a crossover network of the constant resistance variety (where the impedance seen by the amplifier remains more or less constant right through the crossover point) there are four variables to

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Fig. 5. Two panels of 3/4-in ply complete the compression chamber. The angle formed by the apex of the triangle must be 180° and the sides wide panels were satisfactory. When one panel has been screwed and glued to the remaining sides can be cemented, in exactly the same manner, but first a layer of Epo-Stik Resin ‘W’ should be applied to the side of the dried concrete to help bond the new to the old. The mould should be turned on its side while the side piece dries out. Do the other side piece and then the remaining flat piece, applying the wood resin as each new section is formed. Finally, the cardboard may be stripped off.

**Fig. 6.** Dimensions of templates for constructing treble horn cardboard mould.
consider—the crossover frequency, the load impedance, and values of $L$ and $C$.

The most difficult component to obtain is a suitable capacitor. Non-polarized electrolytic types specially made for crossover networks come in a very limited range—at the large value end of the scale the choice is either 60μF or 100μF. If these capacitors are not used the alternative is a monstrous parallel-array of ex-W.D. paper types which will at the same time be quite expensive. To cut a long story short values of 60μF and about 31mH give a network which in theory crosses over symmetrically at about 430Hz with load impedances of 12Ω or 6Ω depending on whether a series or a parallel 4-section network is employed. The capacitor on the treble side was reduced to 48μF (3×16μF) to reduce a slight peak in the treble-horn response at the crossover point. Resistors across the driver voice coils, whilst reducing the overall impedance, also reduce the significance of changes in voice coil impedance from the point of view of the crossover network.

Three crossover circuits are shown in Fig. 8. These allow different impedance treble units to be used—I have 8Ω in one channel and 16Ω in the other. Crossover circuits (a) and (b), which I use, may be doctored further still. A small choke—say 250μH—placed in series with the 10Ω resistor across the treble unit will remove the shunting effect at high frequencies, thus extending the top. In circuit (b) the 2Ω series element can be bypassed by a 2.4μF capacitor as well.

Winding the chokes. A 2-in piece of 3/4-inch diameter ferrite rod (with cardboard discs glued on at the ends) can be wound with 37ft 6in 24 s.w.g. enameled copper wire to give an inductance of about 3μH. The turns must be close and the layers neat. Careless winding will give a sadly low value. The treble boost choke can be wound similarly—about 10ft close wound will give 30μH.

Notes of the final assembly

Fig. 9 shows the composite horn in its corner—the total cost of materials, including that of the two driver units, amounted to about £17. The bass enclosure is properly called a driver, the bass horn being formed in conjunction with the walls and the floor.

Three points are worth making in conclusion.

1. The most striking characteristic of the treble unit is a reduction in background noise, for example when playing worn discs, compared with direct radiator treble units. Where there is a significant background noise level this seems to separate out from the music, and any odd clicks are peripheral to the sound image.

2. Provided the bass-horn driver makes fair contact with the corner walls the bass performance is not affected by the hardboard guides which theoretically define the horn mouth and the final flare rate. Considering the size of the enclosure this is an inducement to further experiment. The question remains—"What defines the actual lower limit of the bass response?"

3. If the bass enclosure is constructed to the width of the treble horn the whole system can be "cased" to give a very acceptable rectangular structure.

Crossover components

Ferrite rod of 3/4-inch is available from G. W. Smith (Radio) Ltd. Four-inch lengths cost 1s 3d, and six-inch lengths 1s 6d each. To break the rod, first file a shallow notch 2in from one end. Place a pin on a hard surface, such as a metal ruler, and with the notch facing upwards press the ends of the rod downwards with the pin lying exactly below the notch. This should result in a clean break.

If choke-winding is considered tiresome, 5mH chokes are available from K.E.F. Electronics Ltd, Tovil, Maidstone, Kent, for 9s 6d each. Removing 8ft of wire will reduce inductance to about 2μH.

60μF and 16μF non-polarized 50V capacitors are also available from K.E.F. for 4s and 2s 6d each respectively.

REFERENCES

4. Ref. 1, p. 144.

FIG. 7. Completed treble horn.

FIG. 8. Crossover circuits: (a) 1-section parallel network arranged for 16Ω treble driver; (b) 1-section parallel network arranged for 8Ω treble driver; (c) 1-section series network that can be used with 16Ω treble driver—this is the most efficient circuit but unfortunately the FR4 is no longer being produced in the 16Ω version. Resistors can all be 1/2W.

FIG. 9. A speaker in its corner showing hardboard guides fixed with hinges—shown from the side in Fig. 5.
Circuit Ideas

Multivibrator timing control

The timing of any multivibrator can be controlled very simply, over a wide frequency range, and without risk to the transistors, by use of a diode and resistor combination as shown below. With reference to Fig. 1 it can be seen that in the idle condition the monostable is unaffected since the diode is reverse biased. When triggered, the base of Tr2 approaches -Vcc volts and diode D1 conducts, thus providing an additional discharge path for C1. If RV is large, the circuit is unaffected. As RV approaches zero, so the discharge time is shortened. Fig. 2 shows how the frequency of an astable multivibrator may be varied without altering the mark/space ratio. If RV is large, the circuit is not affected as the diodes are back to back. As RV is reduced capacitors C1 and C2 alternately discharge through RV thereby increasing the frequency. If desired RV may readily be replaced by a p-n-p type transistor, or other active device.

L. V. GIBBS,
Wellington,
New Zealand.

Measuring zero drain-current coefficient in f.e.ts

It is well known that f.e.ts exhibit a zero drain current coefficient at some particular quiescent drain current. This is known as \( I_{ddo} \) but it is not specified by manufacturers for a particular device and the standard method of temperature cycling each device in order to find its \( I_{ddo} \) is long, expensive and laborious. The following method is a simple alternative. The f.e.t. to be tested is put in the test rig shown. A 5ms wide positive going pulse, with a baseline at -10V is applied to A. The differential inputs of an oscilloscope are connected between points B and C. The pulse on the gate of the f.e.t. turns it on, the drain current being determined by \( R_1 \) and the pulse amplitude developed across it, and it heats up. Any undershoot or overshoot on the source, compared with that on the gate is due to heating of the f.e.t. junction and corresponding changes in drain current. Therefore to find \( I_{ddo} \) the input amplitude is adjusted until a flat top waveform is obtained on the source. \( R_1 \) is adjusted to give the minimum difference between the two input settings to the oscilloscope and therefore prevent overload conditions. The drain current at which this \( I_{ddo} \) is obtained is then calculated from the peak voltage across \( R_1 \).

P. R. THRIPE,
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Comparator for small sine-wave voltages

This circuit, used in a production test, was designed for determining accurately the percentage difference in the output voltages (nominally 150mV r.m.s.) of two sine-wave LC oscillators operating at 1kHz and 100kHz respectively. In use, the input leads are first connected to the 1kHz oscillator, \( RV_2 \) and \( RV_1 \) then being adjusted for half-scale reading on the meter with \( RV_1 \) set to the "0%" mark. The leads are then transferred to the 100kHz oscillator and \( RV_1 \) moved until half-scale reading is again obtained. The percentage by which the 100kHz amplitude differs from the 1kHz amplitude is then read directly off a calibrated scale associated with \( RV_2 \). With values as shown, the model built has a frequency response level from 20Hz to 200kHz within \pm 0.1%, i.e. approximately \pm 0.01dB. It may thus also be used for making very accurate frequency-response determinations. \( TR_1 \) and \( TR_2 \) conduct current in pulses only, at the positive-going peaks of the input signal. The mean value of these pulses, which is registered by the meter, increases very rapidly with signal input voltage, once this voltage exceeds a threshold value. The circuit thus provides very good resolution of small input changes.

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Simple Audio Pre-amplifier

Design with high input impedance for use with radio tuner and ceramic pickup

by J. L. Linsley Hood

The circuit to be described was developed, in response to requests from friends and correspondents, in order to provide, with the minimum of trouble and complexity, a pre-amplifier suitable for use with a radio tuner and ceramic pickup. It was required that this unit should have low distortion and noise level, and should provide the facilities normally expected in a good quality pre-amplifier stage—bass and treble lift and cut controls, input selector switching, a switched frequency steep cut low-pass filter, and a rumble filter giving rapid attenuation below 30Hz. Also, for convenience in use with a variety of inputs, it was required that the input impedance should be at least 2MΩ.

Ceramic pickup cartridge matching requirements

Although there can be little doubt that for the perfectionist there is no real substitute for the velocity sensitive (e.g. electromagnetic) pickup transducer, many of the better ceramic cartridges can give extremely pleasing results when suitably matched to a good amplifier and loudspeaker system, and such an arrangement fully satisfies the requirements of a large number of users.

In connection with the use of relatively low input-impedance transistor amplifiers, it has been suggested by a number of workers that a satisfactory performance can be obtained from such piezo-electric transducers if they are connected to the normal 47—100kΩ magnetic cartridge input of a pre-amplifier circuit, and then treated as if they were velocity sensitive units, with the normal recording characteristic compensation. However, while this may work with some cartridge designs, in many cases the manufacturers of the transducer have taken some care in the design to provide a proper frequency response characteristic, by electromechanical techniques, on the assumption that a high impedance load (≈2MΩ) will be used, and, in these cases, a better performance is obtained if the manufacturers' intentions are realised.

Although the provision of adequately high input impedances has been difficult in the past with transistor amplifiers, the growing availability of inexpensive junction field-effect devices has removed this problem, and it is now fully practicable, even without recourse to insulated gate devices, to design systems with input impedances as high as 10^11 Ω, and the provision of a suitable load impedance for a ceramic cartridge is now quite a straightforward design exercise.

Filter characteristics

Unfortunately, the use of piezo-electric gramophone pickup systems, though convenient in terms of the large voltage output and the avoidance, by and large, of the need for relatively complex recording, characteristic equalization networks, leads to other problems in use. In particular, because they are displacement sensitive devices, such pickups are inconveniently sensitive to the almost unavoidable low-amplitude and low-velocity vertical and lateral irregularities in the motion of the turntable, and unless an effective high-pass 'rumble' filter is

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Fig. 1. Active filter circuits: (a) low-pass bridged T; (b) high-pass bridged T; (c) and (d) unity-gain arrangements of (a) and (b).

Fig. 2. Rearrangements of Fig. 1(d): (a) output to filter network taken from tap on output load resistor at point where input-output gain is unity; (b) low-pass filter incorporated in loop of Fig. 2(a).

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employed, the reproduction of the recorded signal on an amplifier and speaker system with a good low frequency response is likely to be marred by the presence of a continuous low-pitched background rumble. Also, the mass of the piezo-electric ceramic elements is prone to cause mechanical resonance effects in the region 6–12kHz, which can exaggerate the record surface noise, and a steep-cut low-pass filter can then be very valuable in reducing this background. This type of filter can also be very helpful in a.m. radio reception to minimize sideband 'splash'.

Development of filter design
The use of a bridged T RC configuration, as shown in Fig. 1 (a), in an amplifier feedback path, to provide an active low-pass filter circuit, was described in Wireless World in July 1969. The complement of this, shown in Fig. 1 (b), is an equivalent high-pass filter circuit. However, both of these circuits can be rearranged in unity gain form, as shown in Figs. 1 (c) and (d), and this last arrangement was used in the previous article in a rumble filter circuit. Both of these unity gain transformations have an important advantage over the circuit due to Sallen and Key in that they will operate satisfactorily with a high source impedance, whereas the Sallen and Key filter requires a very low generator impedance for proper operation. It should be noted, however, in passing, that the signal should ideally be applied between the two inputs of the amplifier, whereas, in this transformation, it must be applied between one input and the common earth line. The error in function due to this cause can be ignored provided that the impedance of \( R_1, R_2 \) and \( C_1 \) is very much less than that of \( R_1 \) and \( C_1 \). (component nomenclature of Figs. 1 (c) and 1 (d).

Although the configuration shown in Fig. 1 (d) is that for a unity gain system, such as a cathode- or emitter-follower, it can be employed with any non-inverting amplifier, provided that the output connection to the filter network is taken from a tapping point on the output load resistor at which the input-output gain is unity. This arrangement is shown in Fig. 2 (a), and has the incidental attraction that in addition to the input high-pass filter stage, an independently operating, switched frequency, low-pass filter can be incorporated within the same loop, as shown in Fig. 2 (b).

In both cases the circuit will require to be preceded or followed by a simple RC filter to provide the desired 18dB/octave attenuation slope. The gain/frequency characteristics of this part of the circuit arrangement are shown in Fig. 3.

Complete pre-amplifier
The circuit of a practical pre-amplifier unit, incorporating this type of input filter, and employing an inexpensive epoxy-resin encapsulated junction field effect transistor in the input stage, is shown in Fig. 4.

The preferred rating for this unit is 15 V. This is not critical within a volt or two either way, except that a lower voltage will restrict somewhat the magnitude of the output signal at the quoted distortion level, and rail voltages of 20 or above would exceed the safe working ratings of the transistors in the event of a circuit fault. The few shillings cost of a zener diode to limit the maximum voltage on this line may be a wise expenditure.

Large capacitance electrolytics are employed in the source and emitter bypass networks of the first two stages to avoid unwanted phase-shift errors in the high-pass filter loop. Their presence also ensures that both the two input stages are 'bottomed' at the instant of switching on, to avoid

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**Fig. 3.** Frequency response characteristics of pre-amplifier's low-pass and high-pass filters.

**Fig. 4.** Complete pre-amplifier circuit. The 4.7k\( \Omega \) input resistors prevent short-circuit damage when unwanted sources are earthed.
the inadvertent application of excess voltage to the f.e.t.

Although the d.c. working point of both the input stages is stabilized by d.c. negative feedback loops; from the collector of $T_2$, to the source of $T_1$, through $R_4$ to $R_3$ and $V_T$, and from the emitter of $T_2$, to the gate of $T_1$, via $R_4$ to $R_3$ and $R_1$, it is also necessary to provide some manual adjustment to the working potentials of the circuit, to allow for the unfortunately wide spread in the slope and gate cut-off point of any f.e.t. used. Any n-channel f.e.t. with a negative gate cut-off voltage in the range 0.75-1.5 V can be employed provided that it has a sufficiently low noise figure. This adjustment is provided by the preset potentiometer $V R_s$ across $C_s$, and this should be used, on initial setting up, to fix the voltage on the collector of $T_2$ to 8 V. Once this voltage has been set for the particular f.e.t. in use, the constructor may replace the preset-set with a fixed resistor of approximately the same value (within 5%).

The gain of the pre-amplifier, at the flat settings of the tone control potentiometers, is entirely determined by the ratio $(R_s + R_2)/R_2$, at frequencies within the filter pass-band. With the values chosen this gives an overall gain of 10, which is thought to be adequate for most pickup cartridges and power amplifier input sensitivities. The system can, however, be modified to give an overall gain of 20, and details of the necessary modifications are given in Appendix 1.

Adjustment to the setting of the volume control alters somewhat the input conditions to the high-pass filter and this produces a very slight change in the slope of the low-frequency roll off. This effect is also caused at maximum gain settings by the use of low impedance inputs, and the extent of this is indicated on the frequency response graph of Fig. 3. This can safely be ignored.

Tone control stage

This is largely based on the modification of the original Baxandall design due to Bailey, and the description of the operation of this given in Wireless World in December 1966 applies to the present design also, the only differences being that a higher loop feedback factor is employed, by the use of a higher gain transistor, and the utilization in the feedback path of the whole of the collector output voltage. This allows the rated distortion figure to be obtained at an output signal level of 1 V r.m.s., over the whole pass-band from 100 Hz to 10 kHz. The gain/frequency characteristics of the tone control stage are shown in Fig. 5.

The output circuit in Fig. 4 is shown for stereo operation. For mono use, the balance control $V R_s$ is omitted and the value of $R_2$, reduced to 47 ohms.

Hum and noise

One of the unfortunate snags in using amplifier systems with high input impedance connections is that they are extremely sensitive to hum pick-up from stray a.c. fields, and great care is necessary in screening the input leads and in earthing the associated metalwork to the correct points. The use of television-type coaxial cable, plugs and sockets helps to keep the hum pick-up to a low level, and the construction of the whole pre-amp except for its power supply, within a single die cast aluminium box (such as those marketed by Eddystone and S.T.C.) is strongly recommended.

The background noise level (noticeable as hiss) of this circuit is dependent to a large extent upon the noise figure of the f.e.t. Since these devices are, in principle, extremely low noise components, the pre-amplifier background level should be very low. Unfortunately, in the experience of the author, some of the inexpensive plastic encapsulated f.e.t.s do not come up to the specifications of their manufacturers in this respect, and it cannot, therefore, be guaranteed that units of different vintages and different origins will always be as noise-free as one would wish. The f.e.t. specified, the Amelco 2N4302, has a very low noise figure, and should not give any trouble in this respect. (A 100pF capacitor can be connected across the feedback resistor $R_s$ to reduce the noise output from a less satisfactory component.)

Construcional notes

Several units of this design have now been built by different constructors and no problems have been encountered. However, since the amplified signal at the tone-control network is in phase with the (high impedance) input circuit with its associated switching, care should be taken to keep the stray capacitances between these two parts of the circuit as low as possible, to avoid high-frequency oscillation.

The preferred layout, in the view of the author, is in a similar form to that of the theoretical circuit, and this can be built, for a single channel, on a single "Lektrokit" 4.0in x 4.75in pin board. Two such panels, with the associated potentiometers and switches, can easily be accommodated in an 8.75in x 5.75in x 4.2in diecast box (available from G. W. Smith (Radio), Ltd.) which can then be mounted in a more elegant housing.

Appendix 1

Modification to give an overall gain of 20

The rearrangement of the circuit of $T_2$, and $T_3$ to give 20 gain is shown in Fig. 6. This involves reducing the value of the lower feedback resistor $R_2$, to 470Ω, altering the values of the low-pass filter capacitors $C_1$, $C_2$, $C_3$, and the arrangement of the collector load of $T_2$. The circuit then gives an identical response to that shown in Fig. 3, but at a higher gain.

Appendix 2

Use of the pre-amp circuit with a magnetic cartridge

Although this circuit was specifically
designed for the user of a piezo-electric ceramic pickup cartridge, it is expected that circumstances may arise in which it is desired to change over to a magnetic pickup head, and it would be convenient if this modification could be done without major alteration to the remainder of the pre-amplifier circuit.

Since additional amplification will be required, for the typical 5mV output from the magnetic head, as well as recording characteristic compensation, the most convenient way of doing this is by the use of a linear integrated circuit, with a suitable passive network. Although almost any operational amplifier type of linear i.e. can be used, with suitable phase correction, two particularly suitable types are the Motorola MC1435P and MC1303P, which are electrically almost identical and contain two, independent, amplifier units in a 0.1-in, centre dual-in-line package which can be mounted on either 0.1-in matrix pinboard or printed circuit stripboard. The MC1303P is specifically intended for use as a stereo pre-amplifier and requires a +15V and -15V supply. The +15V can be obtained from the existing supply line, but an additional -15V line will be required.

The MC1435P i.e. requires supply lines of only +6V and -6V, and these can be obtained from the existing rail through an appropriate resistive dropper network. A suitable circuit is shown in Fig. 7. The decoupling resistor $R_{12}$ should, in this latter case, be adjusted in value to compensate for the additional current drain. The performance which can be obtained from a linear integrated circuit of this type in an input recording correction network is fully equal to that which can be obtained by alternative means. The resistor and capacitor values quoted give a fit to within 1dB of the required R.I.A.A. curve, with an overall gain of 10 at 1kHz.

Fig. 6. Rearrangement of input circuit to give ×20 gain. Only the amended component values are given.

![Diagram of input circuit](image)

Fig. 7. Linear integrated circuit amplifier stage for magnetic pickup. Gain is 10 at 1kHz. (Numbers in brackets on MC1435P refer to pin connections for the other stereo channel. Circuit arrangement identical. Power supply to pins 14 and 7 feeds both channels.)

References
3. ibid. p.308, Fig. 4.

In response to requests from readers who missed one or more parts of the series of articles on the *Wireless World* Colour Television Receiver we have produced a reprint of the 13 articles which appeared in 1968-69. It is obtainable, as are the other booklets listed below, from the Trade Counter, Dorset House, Stamford Street, London S.E.1. Prices include postage and packing.


No. 2. Stereo Decoder and Simulator by D. E. O'N. Waddington (Jan. and Oct. 1967). Describes the construction of a stereo decoder for positive or negative power supplies and an instrument for producing a stereo multiplex signal. Price 3s.


No. 4. Wide range General Purpose Signal Generator by L. Nelson-Jones (April 1968). Range 15kHz to 120MHz in five bands; output attenuator range 100dB in 20dB steps (+0.5dB); modulation depth 0 to 50% (can be set to within ±5% of meter indication); max. output 100mV (from 75Ω). Price 3s.

No. 5. Low-cost High-quality Loudspeaker by P. J. Baxandall (Aug. and Sept. 1968). Can be built for a few pounds! Excellent performance above 100kHz but is improved if used with a woofer for the low frequencies. Price 5s.


In addition, the following reprints from earlier issues are still available:

*Wireless World Oscilloscope: Main frame, X amplifier, E.H.T. unit (March, June, July and August 1963), price 5s; No. 1 (audio) Y amplifier (April 1963), price 2s 6d; No. 1 (audio) Timebase Unit (May 1963), price 2s 6d; Calibration—Alternative E.H.T. Unit (Feb. and Oct. 1964), price 2s 6d; and Wide-band Amplifier (March and April 1964), price 2s 6d.*


Plotting Semiconductor Characteristics

Using an analogue computer and curve tracer to plot transistor and diode characteristics

by W. G. Allen*

In an article by J. B. Swainston* it was shown that rectifier action can be conveniently demonstrated in slow motion by incorporating a diode into an analogue circuit. In the present article it will be shown that, not only can the characteristic of a diode be exploited in this type of analogue circuitry, but the analogue computer can actually be used to obtain diode and transistor characteristic curves. The method is not without limitations, but it is found that the characteristics can be obtained over a useful range using a modest size transistorized computer of the type widely used for educational purposes. When compared with the alternative methods of obtaining characteristics, it will be seen that the present method has the advantages of the high accuracy of point-by-point plotting, together with the speed of the commercial curve tracer.

Diode characteristics
Transistor analogue computers are usually based on a low voltage reference. In case of the machine used in the present investigation (an Electronics Associates Limited TR20) this value was 10 V. The simplest technique

for applying a potential difference to the diode is to connect it between a computing potentiometer and the base of a high gain amplifier with a feedback resistor, Rf in circuit. This arrangement is shown in Fig. 1. Under normal conditions as an operational amplifier, the base B is a virtual earth, and so the p.d. applied to the diode is directly related to the potentiometer setting. This p.d. is also connected to the arm input of an X-Y plotter. Since B is a virtual earth, the diode current i passes through the feedback resistor Rf, and gives rise to a voltage

\[ V_{\text{out}} = i \cdot R_f \]

in the amplifier output O. In view of the inherent phase reversal occurring in this amplifier, it is convenient to add a further inverting amplifier before connecting to the plotter pen input.

An alternative viewpoint is to regard the diode simply as a variable resistor of value

\[ R = V/I, \]

where V refers to the p.d. across the diode. With a feedback resistor Rf, the effective voltage gain becomes

\[ G = R_f/R, \]

and so the output voltage is

\[ V_{\text{out}} = G \cdot V = (R_f/R) \cdot (i \cdot R) = i \cdot R_f, \]

as before. The choice of value for Rf is to a certain extent determined by the maximum diode current required. In order to avoid overload of the high gain amplifier, it must be ensured that i \( R_f \) is less than 10 V for a computer with a 10 V reference. In the case of Swainston's simulation of a rectifier circuit, a value Rf = 10 k\( \Omega \) was used. This limits the maximum current to about 1 mA, which is perhaps an unrealistically low value.

It has already been stated that the high gain amplifier will overload when a certain maximum input voltage is exceeded. Another factor that can cause overload is too high a current i; this can cause the point B to no longer be a virtual earth. It is thus wise to monitor the potential at B, and to stop increasing the diode p.d. as soon as the potential at B increases from zero. Although the amplifiers are usually overload protected, the output voltage V_{out} is no longer proportional to the diode current beyond this point.

Thus, a certain amount of trial-and-error is involved with the choice of Rf, and the range of diode currents that can be accommodated by a given computer. In the present experiments performed on the TR20, it was found convenient to adopt Rf = 100 \( \Omega \) for most diode forward characteristics, so that an output voltage of 1 V represents 10 mA diode current. This would be expected to allow currents of up to 100 mA, but in practice the virtual earth condition was no longer satisfied at currents above about 60 mA. By using Rf = 10 \( \Omega \), a value of about 75 mA can be attained. It was thus considered satisfactory to run the current up to 50 mA, which is a sufficiently high value for most applications.

Automatic voltage sweep

The disadvantage of using the circuit of Fig. 1 is that it is difficult to increase the diode p.d. smoothly by the potentiometer, even though the latter is usually of the ten-turn variety. This is slightly offset by the advantage that a good degree of control is available of the p.d. applied to the diode.

A suitable circuit for automatic voltage sweep is shown in Fig. 2. With a voltage of -10 k volts (k being the potentiometer setting) into a unit gain on the integrator (that is, an integrator time constant of one second), a ramp of +10 k volts/sec is produced at its output. This is shared between the limiting resistor \( R_{\text{lim}} \) and the diode, since \( B \) is at virtual earth. In the initial section of the diode characteristic, the resistance is very high and so practically all the ramp voltage is dropped across the diode. On the other hand, when the diode starts conducting and its resistance decreases, a proportionately smaller fraction of the ramp voltage is applied. The overall effect is that the rate at which the characteristic is traced is to

a certain extent self-adjusting. This refinement is particularly important in the case of zener diode characteristics.

The maximum value of $R_{\text{min}}$ is determined by the maximum value to which the diode current is to be taken. This is because the maximum ramp voltage is of the order of 10 V before overload occurs. On the other hand, there is little advantage to be gained by a large $R_{\text{min}}$ value, since the plot would then become very slow as the diode resistance decreased. This could, of course, be compensated by increasing the ramp speed, but the flat regions of the characteristic would then be traversed too quickly. For most of the characteristics plotted, the potentiometer was set at $k = 0.04$, giving a ramp of 0.4 volt/sec, and a limiting resistor of $R_{\text{min}} = 30 \Omega$ was used. These values were found to be satisfactory for a wide range of diode types.

The reverse characteristic can easily be obtained by changing the polarity of the input to the integrator. At the same time it is usually necessary to increase the value of $R_p$ so that reasonable voltages are produced by the very small reverse leakage currents commonly found. For many germanium diodes, a value $R_p = 100 \Omega$ is convenient.

Fig. 3 shows a reproduction of the characteristics obtained for three common diodes. Since the same scales are used for each, the reverse current of the OA202 is too small to be represented (being of the order $10^{-7} \mu A$).

Transistor characteristics

The present technique has been applied to produce the common emitter output characteristic for several types of transistor, using the circuit shown in Fig. 4.

As in the case of the diode characteristics, the voltage ramp is applied by means of an integrator. This is the voltage $V_{CE}$. The base bias current $I_B$ is produced by applying a known potential difference to a large base resistor $R$, the p.d. being obtained from a computing potentiometer connected to the appropriate reference voltage. A convenient value of $R$ is 100 kΩ, since this means that base currents up to 100 µA are then available. The actual resistor used was of the precision wirewound variety ($\pm 0.1 \%$). Since the potentiometer can be accurately set under load by a null method, there is no need for an ammeter to monitor the base current.

It will be noticed that the limiting resistor $R_{\text{min}}$ has been omitted. The reason for this is twofold. Firstly, the presence of this component can produce a zero error on the plotter arm due to the base current in the transistor.

Secondly, it will be recalled that $R_{\text{min}}$ was added to prevent the characteristic from being plotted too rapidly during the low resistance regions. This is not an inconvenience for most applications, as this region is at the limit of the active region and not usually of interest to the designer of linear circuits. For switching circuits, the saturation region is of interest and this is usually plotted on an enlarged scale. When plotting this region using the circuit of Fig. 4, the ramp speed would be appreciably reduced.

Fig. 5 shows a transistor characteristic as obtained on the $X$–$Y$ plotter. It was found satisfactory to use $R_p = 100 \Omega$, together with a gain of 20 on the following inverting amplifier. When using a recorder pen scale of one volt per inch, one inch then represents a collector current of 0.5 mA.

It has been demonstrated that a small transistor analogue computer affords a convenient method of obtaining some diode and transistor characteristics. Many common types of diodes have been studied with great success, but it must be pointed out that a satisfactory characteristic for a tunnel diode is very difficult to obtain in the negative resistance region, and the value of $R_{\text{min}}$ appears to be very critical. The common emitter output characteristic has been obtained for several transistors and the only difficulty was that, in the case of germanium transistors, adequate time must be allowed for the transistor to cool after plotting each characteristic.

This method may be of applicability to other characteristics, but it is felt that the scope of the present investigations (in which I was assisted by G. H. Olsen and E. A. Burrell) is sufficient to demonstrate the online possibilities of the analogue computer in this field.

Announcements

The Council of Engineering Institutions announces that the London Engineering Congress, LECO '70, to be held from May 4th to 7th has been cancelled.

"Principles of Colour Television" is the title of two 3-week full-time courses to be held at Leeds Polytechnic commencing May 4th and June 8th. Application forms are available from The Registrar, Faculty of Technology, Leeds Polytechnic, Calverley Street, Leeds LS1 3HE. Fec £50.

BM Marketing International Ltd, Gaydon House, Thriplow, Royston, Herts, have been appointed sole U.K. agents for the C.G.S. Scientific Corporation, of America, manufacturers of a range of dynamic and fatigue materials testing equipment and vibration generating equipment.

Pye T.V.T. Ltd. has received an order from the Post Office for the supply of 12 closed-circuit television cameras, six monitors and control equipment to be used in Manchester's new £2M parcels sorting office.
Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents.

C-D ignition

I was delighted to read Mr. Bolton's letter in the March issue in praise of the C-D ignition circuit described by R. M. Marston in January. Like Mr. Bolton, I had a great deal of difficulty trying to construct a reliable system and I am pleased to report that Mr. Marston's really works. I too have used the Repanco TT51a transformer but wonder whether the circuit will fully realise the claims made for it—after all, at some 300 volts h.t., the charge stored in C is only just over one half that at 400 volts.

The point regarding possible failure of Tr is indeed a valid one—it has already happened to me! A common method of protecting a transistor against excessive reverse bias is to connect a diode between base and emitter. I am not however too sure whether this expedient can be adopted in this case.

I would be most grateful if Mr. Marston would comment on these points.

D. BURN, Blackheath, London S.E.3.

The author replies

I have not tried a Repanco TT51a transformer in my version of the converter circuit, and can not therefore make a positive evaluation. My general impression, however, is that it will work perfectly well on a 4-cylinder vehicle, but will give unsatisfactory operation (because of its limited power capabilities) in vehicles with six or more cylinders. The output voltage from the TT51a circuit is substantially lower than that of my original circuit, and its cold-start characteristics will not be as good as those of the original design; these characteristics should still, however, be better than those obtainable from conventional ignition systems.

As Mr. I. M. Shaw pointed out in the March issue (page 109), and as Mr. Burn now confirms, the design of the trigger circuitry is such that excessive emitter-base breakdown currents may result in the destruction of Tr. I believe there is also a possibility of damage due to excessive transient forward currents in this transistor. This is clearly a bad design fault on my part, and I apologise to any reader who may have suffered inconvenience as a result of it. The design fault can, however, be readily overcome by simply wiring a 180-ohm limiting resistor in series with Tr base. This modification, which I first mentioned in the March issue (page 111) in replying to letters, should be regarded as a standard design change.

I have received several letters from readers complaining of mistiming with the C-D system. Unfortunately, these letters give little clue as to the actual cause of the trouble. It is probable, however, that it is caused by excessive resistance between terminal 0 of the unit and the 'hot' terminal of the car battery. If this resistance exceeds half an ohm or so, it is possible for the s.c.r. to be triggered by the switching pulses of the converter circuitry, as well as from the normal C-B pulses, so that mistiming and power loss takes place in the ignition circuit.

To find out if this is in fact the cause of the troubles, proceed as follows.

Disconnect from the distributor cap the e.h.t. lead (i.e., the heavy cable connecting the coil to the distributor cap) and place its free end roughly 1 in from the chassis (to form a spark gap). Turn on the ignition, and slowly turn the engine through one complete revolution by hand. If the above fault is present, heavy and continuous arcing will occur across the spark gap when the C-B is in the open position.

If the fault is present, thoroughly check the wiring between terminal 0 of the unit and 'hot' terminal of the battery, looking for the cause of the high resistance. The voltage measured between these two points (with the ignition turned on) should not normally exceed a couple of hundred millivolts, and must in no circumstances be permitted to exceed 0.5 volt.

If, after the wiring has been thoroughly checked, the voltage between terminal 0 and the battery can still not be reduced to negligible proportions, and the self-triggering still continues, the fault can be cured by connecting a 250mA silicon diode in series with the s.c.r. gate, to reduce the s.c.r. sensitivity. Fig. 1 shows how to connect the diode in the positive and negative earth versions of the unit.

R. M. MARSTON

Amateurs and television interference

Reference the comments in "World of Amateur Radio" (April) about amateurs tackling their own interference problems, it might not be generally realized that the terms of the licence excludes anyone other than the licensed operator, or another licensed operator, from speaking into the microphone on an amateur station. This is a tremendous handicap when it comes to tackling one's own television interference problems.

I have so far managed to cure most of my own TV interference problems, but one has to fit filters and then ask the television receiver owner to listen or view while one puts out a test call. Often the result is very misleading and not at all like being able to check for oneself.

You will probably say "why not ask another amateur?" and this would most likely be economical because amateurs are very co-operative. However, if one had to pay for this person's time the cost would be still somewhere in the region of £2 per hour.

I would like to suggest that the time has come to end this rather peculiar rule and allow other people to speak but not to operate the station.

H. S. WOOD, G85X, Allerton, Bradford.

Words, pictures and customs

To quote S. W. Amos from his article on Graphical Symbols (Wireless World February 1970) "... a good diagram is worth hundreds of words... ."

The quotation in its original form did not qualify the type of diagram. Good or bad any diagram is worth a lot of words, as anyone who has had to cause puzzle over the maze of connections that is the average car wiring diagram will know. As bad as these are, they are never readily swapped for good prose.

Obviously a good diagram is better than a bad one, but in an industry that too often recognizes custom before truth, who will judge good from bad? The British Standards Institution? Wireless World?

Fig. 1. Compare this with Fig. 5 on p.55 of the February issue.

Fig. 1 is a simple circuit diagram showing the function of a changeover switch. Is the non (British) standard but conventional symbol of Fig. 5, Wireless World Feb. 1970 p.55, preferred? In the same issue, Fig. 8...
p.65 poorly serves an article which actually proclaims the fundamental importance of careful symbol selection and correct diagrammatic form. Does the 'OFF' press button really lock ON? Rather than list faults, Fig. 2—which is thought would serve this article better than the original—is submitted for comparison.

Lastly Fig. 3 is a re-draw of the "Audio Switch" circuit diagram p.73, Wireless World Feb. 1970 which contained three full-wave rectifiers drawn in a manner which illustrates connection rather than function, but which are customary and standardized.

With a national standards institution that defines this particular circuit form out of existence (See B.S.204 for "Electrical Bridge" and "Bridge Rectifier" and B.S. 3939 for circuit diagram definitions), then advocates its use in the "Guiding Principles" and justifies this anomaly by reference to custom, it seems we have little hope of improving the low standard of circuit delineation that prevails in industry today. Unless that international institution, the Wireless World, periodically publishes some draughting howlers in order to encourage a competitive reaction and hence an interest in the subject among its readers. A good example to start with would be to extract the perfectly ordinary power supply components from Fig. 3 p.100 Wireless World Mar. 1970. W. W. MARTIN. London S.E.9.

The problem of dynamic range

I was interested to read Mr. O'Veering's article* in the April issue of Wireless World since I too have evolved a practical solution to the problem of dynamic range, but have approached the problem from a different angle.

I have developed the 'Ultimate Fidelity Listening Chair'. The basic chassis on which ten loudspeakers are mounted is conveniently provided by a heavy oak-framed wing-arm chair. Mounted on each wing are five units, two 15in bass units, two 5in mid-range units and one 2in high-flux tweeter, together capable of handling 120 watts r.m.s. per channel. A special steel framework supports the pre-stressed concrete baffles from within the heavily upholstered armchair wings, since each baffle complete with units weighs just over 1 cwt.

The amplifiers are commercially available 150-watt laboratory units fed from equally conventional sound sources.

Initial experiments showed that nylon reinforced seat belts were necessary to prevent the listener's nervous reflexes propelling him from the chair under heavy transients, and missing the most exciting musical passages.

On the advice of the local family doctor, however, I have now replaced them with an ex-R.A.F. ejector seat, triggered by electrodes placed on the listener's temples. Although the listener is restrained during normal nervous spasms, when the sound pressure approaches that considered to be detrimental to the brain, the rocket propelled ejector seat is triggered by the induced skin potentials, propelling the listener from the listening area and out of danger through a specially constructed roof trap within 10ms. This arrangement has proved most effective, in fact during the Prom season last year, and as a result of the excellent transmissions from the Albert Hall, I was ejected no less than eight times to the great amusement of my children and the annoyance of my neighbour on whose greenhouse I landed on one occasion, on re-entry.

The big drawback of this method of musical enjoyment however is that, like headphones, full benefit can be experienced by only one person at a time. It is for this reason that I am busy developing the 'Ultimate Fidelity Settee' which I hope to report on in due course.

IVOR NEDAKE
Beaconsfield, Bucks.

F.E.T. modulators

I read with interest the article on f.e.t. modulators in the February 1970 issue. However, one statement made in the first paragraph bothers me. Here it says: "the relationship between r ds and V gs is parabolic". I agree that many things in f.e.t.s relate to one another in a parabolic way but the parameters mentioned above do not.

To substantiate my objection I refer to "Field-Effect Transistors" by L. J. Sevin, page 41, eq.(2,30) and in all modesty to my own paper "The F.E.T as a Voltage-Controlled Resistor" which appeared in the Jan. 1970 issue of EEE, Eq.(2,30) in the first reference states that the channel conductance is roughly a linear function of V gs and on this property I elaborated in my paper. It is obvious that converting conductance to resistance does not produce a parabolic relationship.

T. MOLLINGA,
Hengelo, Netherlands.

*Our hard-of-hearing contributor's April article brought forth a number of suggestions similar to this one—Ed.
Microcircuits seen at this year's Salon des Composants Electroniques were all the result of evolution and not revolution and there were no outstanding products employing new technologies. Most manufacturers are increasing the size of their standard ranges, particularly in the m.s.i. field, and there was evidence of the slow permeation of microelectronics into new fields. It was interesting to see that some of the major (i.e. manufacturers are combining monolithic and thick and thin-film practices to produce complete sub-systems and were not leaving it to firms which specialize in this process. This is only a step away from their producing complete equipments and one is bound to ask how long it will be before all that is left for the equipment manufacturer to do is to add the cabinet and knobs. Even the readout can be integrated if the display is to be in alpha-numerical form.

The Russians were exhibiting again this year and they displayed a full range of linear and digital microcircuits including m.o.s. and hybrid devices. They claim that in some other fields they are ahead of the West, particularly in capacitor manufacture and in c.r.t.s for data displays. They exhibited 80mm (3.2in) diameter slices of silicon which they are using for microcircuit manufacture. Since manufacturers in the West have only fairly recently gone over to using 2-inch slices, and in some cases 3-inch slices, the Russians are advanced in this respect. Also of great interest was a multi-element 1-GHz 10W transistor they had on show. It is very probable that the devices displayed represented the Russian production achievement of a year or two ago.

Microelectronics for consumers

More firms are introducing devices for the consumer industry. For instance both Texas Instruments and Fairchild have agreements with Philips which will enable them to cash in on Philips' experience in this field.

Ferranti are now in the consumer microelectronics business although one of their latest products for this market still has strong avionic connections! A German firm commissioned Ferranti to design and produce a microcircuit for servo motor control in model aircraft. It is the type ZN430E which combines the functions of pulse width discriminator, comparator, and servo amplifier. The position of the servo motor is determined by the mark-space ratio of the incoming control signal, as is standard practice now in model aircraft control. The circuit measures the mean level of the input signal and compares it with a voltage proportional to the servo motor position. This voltage is derived from a potentiometer mechanically coupled to the motor shaft. Any difference is used as an error signal which is applied to the servo amplifier, and this in turn drives the motor, via an external output stage, in such a direction as to reduce the error voltage to zero. Part of Ferranti's agreement with their German customer states that Ferranti may not sell this product to other users for model control purposes for one year.

The vital statistics of the ZN430E are: a supply voltage of plus and minus 2.5 V and a maximum output current of 30mA. The "dead band" corresponds to about one degree in 100 degrees of rotation.

Last year a number of microcircuits were introduced for cars and although no new ones were seen this year Marconi-Elliott had an m.o.s. circuit designed for a toy manufacturer who produces model cars. The circuit enables the car to respond to a command produced by blowing a whistle capable of producing four tones. The tones could, of course, be generated in many other ways. One tone is used for steer left, one for steer right and one each for forward and reverse traction. The incoming signal is amplified and squared and measured using a reference oscillator and counter combination in a similar manner to the 20MHz counter/timer described on page 237 of this issue. At the end of each sampling period the contents of the counter are inspected by four gates, one for each channel. If the counter holds a number appropriate to a particular channel the correct control is actuated. The control system is activated by the output of an integrator which ensures that the input signal must be present for a predetermined time before a command is obeyed, thereby rendering the system insensitive to impulsive noises.

Other safeguards ensure that input overtones cannot overflow the counter, causing a motor to be instructed to turn in both directions at the same time. A circuit to do the same job built in d.t.l. would require about 25 packages.

A problem with the design was to keep the frequency of the reference oscillator stable as the voltage of the two 9V batteries fell. Marconi-Elliott say that it would not have been possible to do this three months earlier because the necessary computer programmes were not then available.

The computer is certainly a very important tool in microcircuit design and it is of particular value in custom designed i.c.s. Our front cover this month shows a typical situation in which an engineer uses a computer and a graphic display with light pen to produce a complete microcircuit design.

Another consumer i.c. from Marconi-Elliott is intended for use in electronic organs. It provides a divide by $12/2$ function so that the twelve basic tones required in an electronic organ can be synthesized from a single oscillator instead of the twelve required before. The company were also showing how standard m.o.s. circuits could be used to make a digital clock.

Texas Instruments are working on a whole range of i.c.s for the consumer industry although they were still in the design stage. Fairchild say that they will soon be announcing a high quality stereo amplifier on a single chip intended for use with a separate class A or B output stage.

Ates (Italy) were showing quite a range of microcircuits for the consumer industry. Among these was the TBA381, a 5-W r.m.s. audio amplifier intended for use with a 24-V supply and an 8-$\Omega$ loudspeaker Total harmonic distortion is 2% and voltage gain is 26dB. Another i.c. shown by this company was the TBA365 intended for a.f.c. purposes in television receivers. The chip contains an i.f. amplifier, detector, d.c. amplifier, a.g.c. amplifier and a zener voltage regulator.
For the sound section of TV receivers Ates have the TAA591, consisting of a wideband amplifier, f.m. detector and a.f. processing amplifier and driver.

A video processing circuit, type TAA 700, was shown by Radiotechnique-Compelec (R.T.C.). This is a Philips design which, incidentally, will also be manufactured in this country by Plessey. The chip contains a video pre-amplifier, i.f./a.g.c. detector, r.f./a.g.c. amplifier, noise detector and gate, phase comparator and sync separator, using over 40 transistors—explaining why the circuit is known as the "jungle chip".

SCS showed two microcircuits for television applications; the first, the TAA261, is an audio amplifier with a 4-W output into 16Ω with total harmonic distortion of 10%. The second circuit, TBA271, is a voltage regulator for variable capacitance tuning of TV receivers. Output voltage is between 30 and 36V with a temperature coefficient of −3.3 to +1.66mV/°C.

There were more basically similar circuits for radio and television applications on show some being slight improvements on those mentioned last year.

**Microelectronics for Industry**

Motorola announced a hybrid 8,192-bit memory at the exhibition although there was not much in the way of technical information available on it. The memory consists of four substrates on which are mounted a total of 36 monolithic chips. Each substrate is identical and contains eight 256-bit read/write memory chips and an e.c.i. address decoding chip. Each of the four substrates was individually packaged and mounted one above the other. Access time is 120ns and power consumption is 6W.

Another microelectronics company about to introduce standard hybrids is Fairchild who will soon be announcing a v.h.f. frequency synthesizer contained in four packages and a 10-bit digital-to-analogue converter. This latter device employs m.s.i. bipolar chips with both thick and thin film circuitry although here again there is no technical information available as yet.

Still looking at products which are just around the corner Signetics will soon be announcing a range of monolithic active filters and Intel (U.S.A.) will also shortly announce an m.s.o. dynamic read/write memory organized as 512-words of 2-bits with a cycle time of 100ns. In this type of circuit information is stored as a charge on the gate capacitance of the m.s.o. storage elements. This information has to be periodically refreshed, not rewritten, but this is a fairly simple matter. Refresh time is 1 or 2% of the total time.

Marconi-Elliott were showing what they can do in the way of customer-designed hybrid circuits. They displayed a thick film circuit employing 26-beam-lead monolithic chips on a 3 × 1 inch substrate. A five-bit binary word at the input was converted to a two-bit octal readout and also used to select one of 32 equals control lines. Lamps connected to the output lines were driven directly by the circuit.

R.T.C. showed an interesting m.o.s. dynamic shift register which could be electrically varied in length from 1 to 64 bits by means of a 6-bit control word. The register, type FDN126, requires a 2-phase clock and is compatible with d.t.l. and t.t.l. integrated circuits. Operating frequency is between 10kHz and 3MHz.

A bipolar monolithic 64-bit memory with Schottky diodes connected between the base/collector junctions of the transistors in order to reduce charge storage effect and increase speed was to be seen at the Intel display. The Schottky diode is made by depositing aluminium from the base region to the n region of the collector of each transistor where it forms the metal-semiconductor junction of the Schottky diode. Since the Schottky diode has a lower forward voltage compared to the collector/base junction of the transistor the diode clamps the transistor and diverts most of the excess base current, preventing the transistor from saturating. There is therefore no stored charge in the transistor or the diode, so speed is increased for a given power dissipation. The memory using this process was the type 3101 from Intel which had an access time of 60ns and a power dissipation of 6mW/bit.

The Schottky diode is also used in the Texas Instruments range 54/74S which is a high-speed version of the well-known 54/74 series of t.t.l. A typical gate propagation delay of 3.5ns is quoted for the new range.

An alternative to the shift register for high-speed shifting was shown by Signetics. This is a version that will shift an 8-bit word in 20ns. Also shown was a decoder/driver for Nixe tubes with 180V output transistors.

Apart from the servo amplifier mentioned earlier other new devices on the Ferranti stand were t.t.l. monostables (ZN1010 E and F) which have an optional lock-out facility. This inhibits the inputs after the monostable has triggered so that the timing period cannot be affected by spurious noise pulses. A gated operational amplifier (ZN402E) with a performance a little better than the 709 but with an extra input which results in the output being clamped to zero was also shown. Finally by way of adding to the monolithic "ring-of-two" voltage reference element which could be used as a constant current source for zener diodes etc. is this type ZN401T.

Secosem (France) had on display a modified version of the 709 operational amplifier which featured built-in frequency compensation and output short-circuit protection. ITT were showing a similar circuit, the MIC741.

A voltage-to-frequency converter in hybrid form was announced by Prana (France) with a conversion ratio of 5Hz/mV. The converter has an input impedance of 100MΩ and an output of 6V from 1kHz, the type number is CM-ADS.

On the Russian stand among the many items on display was a range of hybrid circuits employing m.o.s. transistors. One type contained 13 four-input NAND gates, another an eight-bit shift register. A three-bit reversible shift register is also available. The typical gate propagation delay of these is 45ns and a noise immunity of 0.4V is specified. Also to be seen was a number of m.o.s. circuits. Among these was the K160 series consisting of gates and flipflops with propagation delays of 0.4μs.

Monsanto were showing a monolithic seven-segment alpha-numeric display using light emitting diodes Power consumption is only 8mW (1.6V at 5mA) per segment. Each package measures about 6 × 4mm and is potted in clear epoxy resin. It is understood that the display, called MAN-3, costs about £3 per character.

Microsystems International (Canada) had on display a push-button, or touch-tone, telephone system which used a circuit designated QGL4B which combines tandem thin film wiring, resistors and capacitors with monolithic silicon beam and chips. In order to describe the circuit it is necessary to know something of the touch-tone telephone system. There are 16 push-buttons arranged in a four-by-four matrix and there is a separate frequency assigned to each row and each column of buttons. The row frequencies fall in a low band 697, 770, 852 and 941Hz and the column frequencies are in a higher band, 1209, 1336, 1477 and 1633Hz. Pressing any button causes the frequencies associated with that button's row and column to be transmitted.

The QGL4B has two monolithic amplifiers with twin-tee feedback networks that cause the frequencies in the two frequencies to be shifted by a frequency determined by the value of components in the twin-tee filter. One amplifier and filter combination provides the low-band, and the other amplifier the high-band, of frequencies. The push buttons select different resistor values in the twin-tee filters to cause the necessary frequency shift. The circuit drives its output along the same two wires which are providing the power supply for the circuit and it is arranged, using a diode bridge, that it does not matter which way round the two wires are connected. Because of varying line lengths the impedance into which the amplifier has to work varies enormously, as seen by the variations in the output of the unit is maintained to within 0.2dB and the frequency held to much better than 5% of the desired value.

If the gain of the amplifiers in the QGL4B is lowered by altering internal resistor values the amplifiers instead of being oscillators become active filters. The circuit can then be used to demultiplex signals from touch-tone telephones.

For those interested in statistics: of the 784 companies exhibiting at the Salon (about 5% more than last year) 364 were French, 120 American, 108 German, and 64 British.
News of the Month

Displays—the answer?

Colour change displays using liquid crystal have been made in the Marconi research laboratories. (We reported work done by R.C.A. in using liquid crystal for information displays and detecting temperature changes on page 222 of the July 1968 issue.) Liquid crystal is a transparent liquid with a regular crystal-like structure in that all the molecules “point” the same way (nematic structure). When a voltage is applied across the liquid ions move through it and disrupt the regular structure causing a colour change from transparent to white. When the voltage is removed the liquid returns to its transparent state.

Displays have been made by sandwiching a very thin layer of liquid crystal between sheets of glass. The patterns to be displayed can then be held as an invisible conductive pattern on the glass and is made visible when a voltage is applied to the pattern.

The voltage requirement of liquid crystal is low and is compatible with standard logic levels. Bright ambient lighting does not affect the clarity of the display.

The work at Marconi has resulted in a liquid crystal which changes from green to blue when a voltage is applied; no dyes are used. Marconi say that other colour displays should result from the work being carried out although more research is needed to increase the speed for some applications.

Nuclear-powered heart pacemakers

Trials of nuclear-powered heart pacemakers have now started in the U.K. and two successful animal implants have taken place. The animals concerned, both dogs, have so far responded well. These implant experiments are an essential part of an exhaustive joint technical development programme by the Department of Health & Social Security and the Atomic Energy Authority. If successful, the programme will permit patients suffering from “heart block” to be fitted with pacemakers powered by nuclear batteries having a design life exceeding ten years, in place of the short life (approximately one to two years) chemical batteries that are currently used.

Heart pacemakers have been used for over ten years to maintain the heartbeat of patients suffering from “heart-block”. This disease, the failure of a bundle of nerves in the heart, can be overcome by using a pacemaker to provide the minute rhythmic electrical pulses normally transmitted through the nerve bundle.

The nuclear battery, which was developed at Harwell, utilizes the heat from the radioactive decay of a small quantity of platinum-238 to generate power from a miniature semiconductor thermo-electric converter. The complete battery is two inches long and about half an inch across. It weighs about an ounce. There is no radiation hazard to the patient, or to anyone else, from the small quantity of plutonium used and the battery is fully encapsulated to prevent the escape of radioactive material or attack from body fluids. The pacemakers used in the trials are special units coupled to the Harwell battery through a voltage changing circuit developed at Aldermaston.

The nuclear battery was developed at Harwell in close collaboration with the Institute of Cardiology and the National Heart Hospital.

GEE chain to close

The famous GEE navigation system which was developed to get bombers safely and accurately to the target and back again during World War II was taken out of service on March 26th, ending a 28-year chapter in aviation history.

The system consisted of ten transmitting stations which operated in pairs providing accurately timed radio pulses. The receiver in the aircraft measured the time of arrival of the pulses enabling the aircraft’s position to be quickly determined by referring to GEE charts.

New master for B.C.S.

J. D. Platt has succeeded H. E. Barnett, who has retired from public service, as director of the British Calibration Service. Mr. Platt, who was born in 1916 at Newcastle-on-Tyne, received his early engineering training at Siemens Bros., Woolwich, and at the Woolwich Polytechnic. He has been in the Civil Service since 1939 on inspection and quality assurance of electrical and electronic equipment. Mr. Platt spent eleven years at the Harwell Laboratory of the Aeronautical Quality Assurance Directorate specializing in electrical measurements and testing. He has been with the Electrical Quality Assurance Directorate (formerly E.I.D.) since 1958. Latterly, as Head of the Components Department of E.Q.D., he has been closely associated with the B.S.I. in the implementation of the Burghard Report with responsibility for the overall inspection surveillance arrangements for BS 9000 in the electronic components industry.

To date thirty laboratories, covering measurements in many fields, have received approval. Laboratories for d.c. and i.f. measurements are: Ferranti Ltd., Wythenshawe; G.E.C. Measurements Ltd., Stafford; Marconi Instruments Ltd., St. Albans; Mann Components Ltd., Wymondham; The Solartron Electronic Group Ltd., Farnborough; Atomic Energy Research Establishment, Harwell; University of Leeds; G. & E. Bradley Ltd., London N.W.10; H. W. Sullivan Ltd., Orpington; Welwyn Electric Ltd., Bedlington.

For h.f. electrical measurements the approved laboratories are: G. & E. Bradley Ltd., London N.W.10; Aveloe Electric Ltd., South Ockendon; Electrical Quality Assurance Directorate, Bromley; Marconi Instruments Ltd., St. Albans.

Other approved laboratories carry out optical, fluidic and mechanical measurements.

Thermionic products still hold sway at E.E.V.

In an age when it is generally assumed that semiconductors are rapidly taking over electronic control in industry, the English Electric Valve Company is trying to cope with increasing demands for more thermionic devices. At their Lincoln works, where 336 operatives are employed, there is scant regard for semiconductors and even their own process control equipment is based on a well tried method of mechanical sequence switching. Despite this, turnover for the

High frequency processing of a magnetron cathode at E.E.V.'s works.
last financial year reached an all-time record of over £1M.

Bulk of the orders comes from areas where heavy current control is required, in car factory spot welding equipment and traction motor speed control. These are mainly for the E.E.V. ignitron, a high-current rectifier with a mercury pool cathode, usually in a water-cooled envelope. E.E.V. claim to have 80% of the ignitron market in this country.

The operating gap between the low-current end of the ignitron range and the point where high-power thyristors take over is where the thratron, a gas-filled glass rectifier, still finds a place. There has been no decline in the call for thratrons over the past ten years, mostly as replacements in existing equipment.

E.E.V.’s Lincoln factory is also producing magnetrons up to 2MW peak for ground radar, an “S” band 2.5kW magnetron and a linear accelerator with an 8MHz tuning range. Also a 40W magnetron and duplexers for use in “X” band marine radar.

A new development by E.E.V. is a 1kW c.w. magnetron for r.f. cooking. This features a cathode with a 5-second warm-up time. Some have already been incorporated in commercial cooker designs.

Telecommunications development plan

Over £4M is the contribution being made by the National Research Development Corporation for research into a system which “will radically alter telecommunications manufacturing methods”.

Total cost of the project is nearly £9M

A printed circuit layout aid is shown below which was developed by Alfred Clark of the Aeronautical Division of Marconi at Basildon. It enables a positional accuracy of about 0.1mm to be consistently maintained. The aid, which employs a nickel, reference grid, is available from Chartpak-Rölex.

and the remaining £4M or so is being provided by the Plessey Company. Work on the system in Plessey’s laboratories envisages the use of advanced stored programme control principles (SPC) in future telephone exchanges. The first full-scale model of an SPC exchange now being started at the group headquarters in Liverpool will demonstrate the interdependence of data processing technology and electronic switching.

Research studies, begun in 1964, led to a new overall approach to systems and control involving new techniques in real-time software programming, in processor design and in telecommunications switching practice. Stored programme control is the use of software and processors for the control of automatic exchanges. It is thought that SPC will be used increasingly from 1975 onwards.

Colour TV tube patent extension refused

Mullard’s level of investment in TV colour tube production stood at £10M according to J. C. Akerman, head of Consumer Electronics Division, and the break even point had not yet been reached. He was giving evidence in the High Court last month in the petition by Philips Electrical, of London, and N.V. Philips Gloeilampenfabrieken, of Eindhoven, for a second extension of their patent for colour television tubes, Philips were making application for a second extension because since the first was granted in 1965 for four years, the expected number of 1.35M colour sets had not been sold and the patentees pleaded therefore that they had not received sufficient recompense. They were seeking an extension of the period by another two-and-a-half to three years. Opponents of the petition were Asahi Glass Company of Tokyo. The application was rejected by the Court but Philips intend making a fresh application on different grounds. It is understood that supporting evidence for the Asahi Glass Co. was given by the Radio & Television Retailers’ Association.

Shipboard Skynet terminal

GEC-AEI (Electronics) have been awarded a contract by the Ministry of Defence, for the development of a small shipborne satellite communications terminal (SCOT) to operate in the Skynet system*, and provide secure communication links between small ocean-going warships and the U.K. The paraboloid aerials, will be only 3.5ft in diameter, and, while designed as part of the Skynet system, will be capable of operation through the American Defence Communication Satellite system should the need arise.

SCOT consists of two stabilized and fully-steerable dish aerials to be mounted on each side of a ship’s mast. No active communications equipment will be mounted on the aerials, but will instead be located in an unmanned engineering cabin at deck level, and connected to the dishes by a low-loss waveguide run. This arrangement should lead to high reliability and will make all elements of the system readily accessible for maintenance.

The aerials, each protected by a double skinned radome, will be stabilized against ship motion by a modified version of the inertial unit devised for the Black Arrow rocket.

All operational controls will be provided on a control console in the ship’s main communications office, from which an operator will be able to acquire the satellite and select the correct receive frequency. He will also be able to switch on the transmitter and spot any faults without needing to visit the equipment cabin.

The original concept of SCOT was formulated in the Admiralty Surface Weapons Establishment, Porisdown, and an experimental model to prove the feasibility of a miniaturized terminal has been operating through geo-stationary satellites for the last twelve months. This experimental work has been so successful as to justify embarking on a programme leading into full development and production with the minimum of delay.

Domestic radio / TV show

Running concurrently with the annual conference of the Radio and Television Retailers’ Association held in London last month at Grosvenor House, Park Lane, was a three-day exhibition of radio, television and electrical appliances for the domestic market. This was the first occasion for a number of years that the six major manufacturing groups, B.R.C., Decca, G.E.C., ITT/KB, Philips and Pye, representing a dozen or more brand
names, had exhibited under one roof. Perhaps they had taken heart from the theme of the conference, “Unity for the 70s”.

The total number of exhibitors was over forty and there was some speculation that this show could be the forerunner of an annual spring event which would replace the fragmented autumn trade show. This idea was hotly denied by the major manufacturers who have already laid plans for this year’s trade shows. While most makers were unenthusiastic over the amount of business the exhibition brought them, there could have been little joy for the retailer either, since all the attractive colour sets on view are still strictly on ration.

**Electron microscope views moving subjects**

Recent developments at the National Physical Laboratory, Teddington, have extended the use of the scanning electron microscope, making it possible to observe dynamic phenomena at high magnification. The Laboratory can now observe continuously the changes taking place in materials subjected to stress. Carbon fibre composites are among the materials to have been observed in this way.

In the scanning electron microscope an electron beam scans the surface of the specimen in synchronism with the spot on a r.f. Electrons leaving the specimen are collected and the resultant current is amplified and used to control the brightness of the spot. Since the number of electrons leaving the specimen is dependent on its topography, an image of the surface is displayed on the tube. Hitherto, the electron image display has had to be built up slowly, like a radar display, on a long persistence screen. In the new N.P.L. system a high-speed scanning system is used which produces a bright, flicker-free image on a television monitor tube. The advance has been made possible by improvements in the electron detection system and in the performance of the scanning amplifiers. These improvements can be added without modification to the basic instrument which was a “stereoscan” microscope made by Cambridge Instruments.

**Sound in vision**

Pye T.V.T. Ltd has reached an agreement with the B.B.C. which will permit them to manufacture the p.c.m. television sound system “Sound in Vision” (See *Wireless World* January 1969, p.38 and April 1970, p.167).

**Groovy senescence**

“The electric guitar is one primrose path to the hearing aid.” Quote from the leader article “Yet More Noise” in the April issue of *Hearing*.

**BBC test tones for stereo receivers**

To help with channel identification and the adjustment of cross-talk in stereo receivers, each day (except Wednesday and Saturday) the BBC transmits a 250Hz signal in the left hand channel from about four minutes after the end of Radio-3 programme until 23.55.

On Wednesday and Saturday each week, a sequence of tone transmissions during a period of approximately thirteen minutes is transmitted to allow specific checks to be made on receivers. Details of these are given below.

<table>
<thead>
<tr>
<th>time</th>
<th>left channel (a)</th>
<th>right channel (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23.42</td>
<td>250Hz at zero level</td>
</tr>
<tr>
<td>2</td>
<td>23.44</td>
<td>900Hz at +7dB</td>
</tr>
<tr>
<td>3</td>
<td>23.48</td>
<td>900Hz at +7dB</td>
</tr>
<tr>
<td>4</td>
<td>23.49</td>
<td>900Hz at +7dB</td>
</tr>
<tr>
<td>5</td>
<td>23.50</td>
<td>No modulation</td>
</tr>
<tr>
<td>6</td>
<td>23.51.20</td>
<td>Tone sequence at –4dB: 60Hz, 900Hz, 5kHz, 10kHz. This sequence is repeated</td>
</tr>
<tr>
<td>7</td>
<td>23.52.20</td>
<td>No modulation</td>
</tr>
<tr>
<td>8</td>
<td>23.53.20</td>
<td>No modulation</td>
</tr>
</tbody>
</table>

**Notes**

The tests will normally start at 23.42 hours, or 2 minutes after the end of programme if this is later.

The schedule is subject to variation to accord with programme requirements and essential transmission tests.

The zero level reference corresponds to 40% of the maximum level of modulation applied to either stereophonic channel before pre-emphasis. All tests are transmitted with pre-emphasis.

Periods of tone lasting several minutes are interrupted momentarily at one-minute intervals.

The following table indicates the type of check or adjustment for which each test transmission is primarily intended.

1. Identification of left and right channels and setting of reference level.
2. Check of distortion with signal wholly in the \((A-B)\), i.e. S, channel.
3. Check of distortion with signal wholly in the \((A+B)\), i.e. M, channel.
4. Check of \(A\) to \(B\) cross-talk.
5. Check of \(B\) to \(A\) cross-talk.
6. Check of \(A\)-channel frequency response and \(A\) to \(B\) cross-talk at high and low frequencies.
7. Check of \(B\)-channel frequency response and \(B\) to \(A\) cross-talk at high and low frequencies.
8. Check of noise level in the presence of pilot tone.

**Notes**

With receivers having separate controls of sub-carrier phase and cross-talk, the correct order of alignment is to adjust first the sub-carrier phase to produce maximum output from either the \(A\) or the \(B\) channel and then to adjust the cross-talk (or ‘separation’) control on tests four and five for minimum cross-talk between channels.

With receivers in which the only control of cross-talk is by adjustment of sub-carrier phase, this adjustment should be made on tests four and five.

Adjustment of the “balance” control to produce equal loudness from the \(A\) and \(B\) loudspeakers, is best carried out when listening to the announcements during a stereophonic transmission, which are always made from a centre-stage position. If this adjustment is attempted during the tone transmissions, the results may be confused because of the occurrence of standing-wave patterns in the listening room.

www.americanradiohistory.com
Exhibitors at the I.E.A. Show

Instruments, electronics and automation exhibition at Olympia

The biennial I.E.A. exhibition opens at Olympia, London, on May 11th for six days. Below are listed the 420 or more exhibitions. Many of them will be displaying equipment from companies for whom they are agents and composite exhibits are being staged by several countries so that the products of some 950 manufacturers (20% from abroad) will be on show. Organized by Industrial Exhiions Ltd. the show is sponsored by five trade associations: Scientific

A.B. Electronic Components
A & E Electronics
AEG (Great Britain)
A.P. Publications
A.P.T. Electronic Industries
Acbars-Meter
Accumulatorfabrik Sonnenschein Addo
Aga (UK)
Air Control Installations
Airex
Aladdin Components
Albany Components
Almagerm Company
American Embassy
Amplex Great Britain
Annapol
Anlitz Group of Companies
Apollo Electronics
Appliance Components
Aronoidic Switches
Ariel Pressings
Aizu Werke
Aikon Instruments
Arrow Electric Switches
Associated Automation
Astralux Dynamics
Atex Components Electronics
Austen, Charles, Pumps
Automatic Control Engineering

Automation
Autometrics
Avdel
Avetchup Electric
Avery, W. & T.
B & K Laboratories
B & R Relays
Bailley Metros & Controls
Baird & Tatlock
Bakelite Xylophone
Barten Corporation (UK)
Bar & Stroud
Batley Valve Company
Bell & Howell
Bellinger & Lee
Benney Electronics
Blackbournagh, J. & Sons
Blundell Harling
Bonnattl, D. M. & Son
Boons (Triumph)
Bowthorpe-Hellermann
Bibmond Printed Circuits
Biscott
Britimpex
British Aircraft Corp.
British Hovercraft Corp.
British Insulated Callender's Cables
British Physical Labs
British Rototherm Company
British Sonctobol Company
British Steam Specialties
Brookdeal Electronics

Brooks Instrument
Bryans
Budenberg Gauge Company
Burgess Micro Switch Co.
Burgess & Signer Bayley
C.G.S. Resistance Co.
Cadmium Nickel Batteries
Cambion Electronic Products
Cambridge Consultants
Canada
Carbonized Company
Carlingswitch
Chance Pilkington Optical Works
Channel Electric Equipment
Chart-Pak Rotex
Ciba (A.R.L.)
Circuit Integration
Clark Electronics
Clemac
Colvern
Cole Electronics
Coromark Electronics
Computer Instrumentation
Computer Memory Systems
Computer Technology
Computing Techniques
Contraves AG
Control Instruments
Controls & Automation
Cornerstone Hawthorn Baker
Coulor Electronics

Counting Instruments
Courant Electronics
Cranefone
C revisions
Dansk Industri Syndikat
Data Dynamics
Davy Wire & Cables
Davy & United Instruments
Dawe Instrument
Daystrom
Deak (Great Britain)
Digital Printing Machines
Delta Controls
Deutsche Export
Diamond H Controls
Digital Equipment Company
Digital Systems
Doubler, B. & Son
Drewer Manufacturing
Dubliar Condenser Co.
Dyna Electronics
Dynamico
EMI
East Gristead Electronic Components
E.F.C.O.
Elco
Electrical & Electronics Trades Directory
Electricity Council

One of the Levell TG200 series of RC oscillators covering 1Hz to 1MHz in 12 ranges.

Six digit counter timer type TSA6636/3 from Venners covering frequencies up to 40MHz.
Solartron digital multimeter, type LM1240, which has 26 ranges.

This carrier servo generator introduced by Prosser Scientific Instruments has a frequency range of 0.0008Hz to 200kHz and provides a two phase modulated output.

Dymar modulation meter, type 785, for narrow deviation mobile v.h.f. and u.h.f. radio telephone transmissions.

A new digital frequency meter, type 801M, introduced by Racial Instruments capable of direct gating throughout the range 10Hz to 125MHz.
Sound '70

A.P.A.E. Show in new surroundings

For the first time since it began 22 years ago the exhibition of equipment organized under the auspices of the Association of Public Address Engineers was held in a different, more central venue, and something should be said first about the effect of the change.

Camden Town Hall, situated in Euston Road adjacent to several main line stations, was much more accessible than was the previous location.

There was a serious attempt to match this exhibition, the only one of its kind in Europe, with those held by larger sections of the radio manufacturing industry. It even had an official opening by Ray Mawby, M.P., Opposition spokesman on telecommunication subjects.

Looking at the products on view confirmed the impression that public address engineering nowadays is hardly likely to be a temporarily installed "lash-up" with plenty of power output to enable the people at the back to hear.

Increasingly the p.a. engineer becomes the sound consultant and the equipment he seeks is required to be an integral part of the building construction, be it a new hotel or sports stadium. We were told that where architectural and acoustical interests conflict the architectural design need no longer be a compromise. The acoustic deficiencies can be easily and unobtrusively corrected by using the wide range of sound reinforcement equipment at the modern sound engineer's disposal.

The main p.a. system is often linked with other major facilities such as private intercom systems, tone signal paging,

density TV, and even coupling to a Post Office telephone line.

Something like 50% of the equipment on display was there to satisfy the demands of the king of musical money spinners—Pop. Large amplifiers of 150W r.m.s. output, or more, were shown with companion mixer units sporting half-a-dozen inputs each with an array of polished metal controls, some with tell-tale legends such as "Reverb", "Tremolo" and "Echo". Matching loudspeakers had special transducers for bass and organ effects. These carried brand names like Impact and Orange, newcomers to the public address show.

One piece of useful equipment not seen before was the Phaserite phase tester shown by Keith Monks (Audio) Ltd. It was a two-unit device (transmitter and receiver) constructed in two Ever-Ready heavy duty torch cases.

The transmitter emits a train of specially shaped positive-going pulses which, when picked-up by the p.a. system microphone, can be heard in the loudspeakers. If the receiver transducer is pointed towards each loudspeaker in turn the in-phase or out-of-phase condition is indicated visually by a green or red light at the rear of the unit. Both units were battery-operated and used i.c.s. In the receiver, the sense of the acoustic signal is detected by two parallel inhibit gates followed by two monostable multivibrators which operate the lamps.
World of Amateur Radio

Intrusion and interference

For many years amateurs have been concerned about the intrusion of broadcast and commercial services into bands allotted exclusively to amateur radio. In particular, the 7-MHz band has given rise to two main complaints. British and European amateurs have long resented unauthorized operation of broadcasting stations in the segment 7000 to 7100 kHz, while American and other Region 2 amateurs have complained about the high-power Region 1 broadcast stations in the segment 7100 to 7300 kHz beaming signals into North America.

Partly as a result of the R.S.G.B. Intruder Watch (honorary organizer C. J. Thomas, GW3PSM) a number of broadcast and point-to-point stations have been moved out of the 7000 to 7100 kHz band. The Intruder Watch passes information to Minpostel* which in turn advises the administration concerned, or, if this fails, notifies the International Frequency Registration Board of an infringement. Attempts are being made to streamline the procedure so that action can be taken more quickly.

Alleviation of interference to Region 2 operators should also result from recent pressure on broadcasters by the I.F.R.B. In a circular letter (No. 229) this body recently officially drew the attention of broadcasters to harmful interference caused to Region 2 amateur operation in the band 7100 to 7300 kHz, stressing that this contravenes Radio Regulation No. 117 (equality of rights of different services). The F.R.B. has also established a procedure which provides administrations with a basis for action in specific cases of actual harmful interference. All future broadcasting schedules for this band will include a note from the Board specifically reminding the stations of the possibility of causing harmful interference to amateurs.

Aurora and sunspots

That one amateur's meat is another's poison was seldom better illustrated than on March 8th when the B.E.R.U. h.f. contest and a 144 MHz v.h.f. contest were running simultaneously. The highly disturbed radio conditions that weekend, culminating in widespread auroral conditions on the Sunday afternoon and evening, meant tough going for the h.f. operators, and the virtual closing of the North Atlantic path into central Canada. But on 144 MHz the aurora produced an "opening" which permitted many contacts. With the characteristic buzz on all signals, over distances up to about 750 miles including contacts with Czech, Swedish and Swiss stations. During such conditions, the 144 MHz signals arrive from, and should be beamed towards, the North.

March 8th was considered one of the longest duration auroral openings recorded in recent years and the R.S.G.B. scientific studies committee is making a special study of contacts made that day (reports to G. M. C. Stone, G3FZL, 11 Liphook Crescent, London S.E.23).

Despite the poor h.f. conditions, some British Commonwealth stations in the B.E.R.U. contest were heard exchanging contact serial numbers between 300 and about 500. This represents a marked decline on the 1969 event, but this is also to be expected from the gradual decline in sunspot numbers from the peak of the present cycle in September, 1968.

Top-Band season

Those enthusiasts who, each winter, seek to overcome the formidable problems in long-distance communication on the 1.8-MHz band, appear well satisfied with the results of the 1969-70 season. According to the latest DX Bulletins issued by Stewart Perry, W1BB, many unusual countries have been heard or worked. Among those contacted by British amateurs have been 9X5SP (Rawanda), 5Z4LE/HZ (Saudi Arabia), VS9OC (Oman), and VK6NK (Western Australia). During the transatlantic tests on February 1st, ten British stations were among those who "got across". An American amateur reports "sunset" band opening conditions during the noon eclipse on March 7th.

A feature of recent operation on Top Band has been the revival of interest in Beverage receiving aerials using extremely long, but quite low, aerials pointing in the direction from which it is desired to receive stations. At the far end the aerial is usually terminated through a resistor to earth and extensive radial counterpoise wires, or efficient earths are desirable. Aerials up to 2600ft long have been used, but about 1100ft is more common. A 600 to 700ft Beverage aerial has been used effectively by (R. F. McLachlan, G3QCT, and J. P. Rogers, G3PQA.

I.E.C. station WF3IEC

During the 35th general meeting of the International Electrotechnical Commission—the oldest international standards organization in the world—in Washington D.C. from May 17th to 30th, a special amateur station, WF3IEC, will be operating from Suite 9101 in the Washington Hilton. More than 1400 delegates from 41 countries will be participating in these meetings. The amateur station will be under the supervision of Ed Redington, assisted by members of the Foundation for Amateur Radio. Operation, on a round-the-clock basis, will include s.s.b. and c.w. operation on all h.f. bands except 1.8 MHz. (QSL cards to L. M. Rundlett, W3ZA, Electronic Industries Association. 2001 Eye St., N.W., Washington, D.C.)

In Brief: Prof. Franco Fanti, III/EC, one of Europe's keenest slow-scan TV enthusiasts, recently made contact with a New Zealand station for what is believed to be the longest-distance S.S.T.V. contact yet achieved—he has also recently exchanged pictures with two stations in Alaska... The Bedford Amateur Radio Club is to operate a three-transmitter station (3.5 and 144 MHz), G81BS, at the Scout Rally Camp at Ampthill Park, Bedfordshire, on May 10th... The GB3GEC 70-cm beacon in West London now operates on 433.45 MHz... Northern Amateur Radio Mobile Society is holding a mobile rally on May 17th (details D. Binns, G3MGI. 80 Gipton Wood Road, Leeds 8)... Thetan Radio Society has a mobile rally at the King George VI Park, Ramsgate, on May 3rd... Monday evenings are being established as 70 MHz "activity nights" in the Yorkshire region... The annual commemoration of the 1897 Marconi-Kemp tests between Lavernock Point, Glamorgan, Flatholm Island in the Bristol Channel and Brean Down, Somerset, will take place on May 17th when the Barry College of Further Education will establish GB3P1 on Flatholm and GW3VKL/P at Lavernock Point Holiday Camp operating on all bands from 1.8 to 28 MHz (s.s.b. and c.w.) and 144 MHz (a.m.). A special QSL card containing many details of the 1897 event and five historic illustrations will be sent to all stations contacted... An Irish VHF/UHF convention and mobile rally will be held on May 24th at the County Arms Hotel, Brr. Details from R. Williams (E17AF/G3JUIJ), 31 Main Street, Birr, Co. Offaly.

PAT HAWKER, G3VA

* Abbreviation for Ministry of Posts & Telecommunications suggested by the Minister, Mr. John Stonehouse.
A unique receiving aerial which provides optimum directional and performance characteristics over a frequency range of four octaves (2-32 MHz, typically) has been developed by E.M.I. Electronics Canada. It consists of eight double one-metre diameter loops spaced 13 feet apart, and each loop has a transistor amplifier fitted in the base. This particular combination results in a constant effective height over the full four-octave frequency range, that is, the pre-amplifier output voltage is constant over the complete frequency range for a fixed incident field strength. Because of the flat frequency response, the aerial has well defined phase characteristics and is particularly suited for a phased aerial system. The aperiodic configuration comprises loop/pre-amplifier elements in an "end fire" array with an inter-connecting transmission line coupling each element. Outputs at both ends enable the array to "look" both ways simultaneously, if required, or the system can be rapidly switched through 180° with a coaxial relay.

**Design philosophy**

At frequencies above 100MHz the problems inherent to receiving and transmitting aerial designs are generally inter-changeable except that, perhaps, the radiating element operates with a voltage stress. Below 100MHz, and to a much greater extent below 30MHz, this is no longer true because of the effects of atmosphere and galactic noise sources. Although a requirement for free space coupling efficiency remains for the transmitting aerial, it does not for the receiving aerial. For example, at V.F. a large copper curtain is necessary for the transmitting array, but a small whip aerial having negligible free space coupling is adequate for receiving purposes.

At frequencies below 30MHz it is possible to employ a receiving aerial which is electrically small and has a poor free space coupling efficiency, without prejudicing the overall system noise factor. The aerial output noise comes primarily from atmospheric and galactic sources, hence the thermal noise introduced by the aerial radiation resistance is insignificant by comparison, provided the resistance is assumed to be at ambient temperature.

The aerial system noise factor is defined as

<table>
<thead>
<tr>
<th>incoming atmospheric s/n ratio</th>
<th>aerial output s/n ratio</th>
</tr>
</thead>
</table>

Tabulated values of the noise factor for six different geographic locations are given below for a single loop element. The atmospheric background noise values for these calculations were taken from the contours given in C.C.I.R. Report No. 65 (Atmospheric Radio Noise Data) and averaged over all four seasons. The two lower frequencies (2 and 4MHz) were calculated on the basis of night-time interference levels only, since long-haul communications using these frequencies are normally practical only at this time. For similar reasons, the two higher frequencies (16 and 32MHz) were computed for daytime only. The 8MHz frequency was taken over a full 24-hour period.

Two immediate conclusions may be drawn from these tests: that optimum directional characteristics for both long- and short-haul, point-to-point h.f. communication via the ionosphere are feasible with the E.M.I. loop system, and that the small size of the aerial does not prejudice its performance to any practical extent in most world locations.

With n loop elements arranged in an array the signal amplitude is increased n times, but the pre-amplifier noise only increases by \( \sqrt{n} \), giving further improvement in the signal-to-noise ratio.

### Aerial noise factor (single loop)

<table>
<thead>
<tr>
<th>Location</th>
<th>2MHz</th>
<th>4MHz</th>
<th>8MHz</th>
<th>16MHz</th>
<th>32MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>&lt;1.0</td>
<td>1.0</td>
<td>2.3</td>
<td>5.5</td>
<td>6.9</td>
</tr>
<tr>
<td>North America</td>
<td>&lt;1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>5.5</td>
<td>6.9</td>
</tr>
<tr>
<td>South America</td>
<td>&lt;1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>4.2</td>
<td>6.9</td>
</tr>
<tr>
<td>Hawaii</td>
<td>&lt;1.0</td>
<td>1.0</td>
<td>2.3</td>
<td>5.5</td>
<td>6.9</td>
</tr>
<tr>
<td>South East Asia</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>4.2</td>
<td>6.9</td>
</tr>
<tr>
<td>Africa</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>4.2</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Each loop is supported by an aluminium tube in which the pre-amplifier is housed.

---

by Philip G. Baker

**Receiving array for h.f. communications over four octaves**

Aperiodic Loop Aerial

Wireless World, May 1970
The polar diagrams (Fig. 1) illustrate the directional characteristics of the loop array, the elevation pattern being shown as a broken line and the azimuth as a solid line.

The polar diagrams show further that aperiodic loop arrays provide directional characteristics for both long- and short-haul communications using ionospheric reflection. Long-distance reception at higher frequencies in the 2-32MHz band benefits from the narrow beamwidth and corresponding higher aerial gain. Short-haul communications, which depend upon acute reflection angles, are generally possible only at the lower part of the frequency range because of the nature of the reflecting characteristics of the ionized layers. The wider elevation beamwidth of the aerial at these frequencies allows signals arriving at near vertical incidence to be received with substantial aerial gain.

Operation in the presence of strong unwanted signals

Each pre-amplifier is designed to handle a peak signal strength in excess of 2V/m without overloading. In the h.f. band this is greater than the signal from a 10-kW transmitter at a distance of one mile over land. Aperiodic aerial arrays yield second-order inter-modulation products down more than 70dB, and third-order down more than 100dB, below two signals of 10mV/m. This performance compares well with active multicouplers found at most receiving sites.

D.C. power is fed to the loop pre-amplifiers by the coaxial cable which connects the array to the receiver building, and no other cables are necessary. The pre-amplifiers are designed to operate over external environmental temperatures of from -40° to +70° C. They are contained in a sealed unit which plugs into the central tube of the loop from underneath, thus providing double protection from the weather.

The aperiodic loop aerial system is largely unaffected by ground conductivity and nearby objects, and, as a result, negligible site preparation is necessary. The system requires under 100 square metres of ground area and is easily erected in half an hour. The loops should be located close to the ground (in terms of wavelength) where direct and reflected signals will add in phase.

The low mutual interference between the untuned loop/pre-amplifier elements permits multiple cross array systems to be constructed. Six 8-loop arrays can be arranged radially through a common centre point in increments of 30° to provide omni-directional coverage without mutual interference. Both ends of each array can be fed to the receiving building, enabling all 12 outputs to be used simultaneously by numerous receivers. This particular configuration would require a circular site only 30 metres in diameter, and would replace an entire rhombic farm. There is virtually no restriction on the length of the aerial feeder cable, and steerable arrays are easily constructed.

Painless Electronics (we hope)

Occasionally readers say to us “I can't understand a lot of what’s in Wireless World”, perhaps adding, if they are getting on in years, “... any more.” The fact is, if all articles had to be simplified to a standard level they would become excessively long, the technical content of each issue of the journal would be less varied and the more advanced readers would be irritated. In practice we try to steer a middle course. We do, however, recognize that we have many readers, not formally trained in electronics, who would like to be able to get a better mental grip on the technical articles published or on the technology as a whole. We have therefore asked our contributor James Franklin to write a series of short introductory articles on electronics—one page in each issue—on the principle that this could be a gradual, painless way of absorbing knowledge, in contrast to, say, a “crash” course.

This series, “Electronic Building Bricks”, begins next month. It does not follow a conventional text-book approach, but emphasizes the functions of electronic units—as “black boxes”—rather than the circuitry and hardware from which they are constructed. Some fundamental theory comes in, but only where it is strictly necessary for this approach. Circuitry is described in a manner that should be understandable by the average electrical handyman.

But do not think Wireless World intends to “write down” to any of its readers. The author treats his readers as intelligent people who simply do not want to be “blinded by science”.

Fig. 1. Directional characteristics of the E.M.I. loop array. Broken lines show elevation patterns and solid lines the azimuth.
Once upon a time there was a lot of simple books on what was always a joint subject, Electricity and Magnetism. Electricity was described in many of these books in terms of water pipes and tanks. The child, an old-fashioned way of describing the sub-teenager or mini-dropout, cannot see electricity once it gets inside wires; masculine will only be things that you can touch and see: therefore if he is to understand electricity his feet must be firmly set in water. Educationalists were not so thick on the ground in those days and, just as now, some students learned something, some did not. Those were, of course, Imperial days, and, as both Joyce and Wells have pointed out, imperial powers have a cloacal obsession. The Romans built baths and the aqueducts to fill them: in every corner of the globe you can still pull a British chain—the British are a contemplative race. The Americans, always impatient, demand shower-baths wherever they go. In the gracious days, now past, every decent schoolmaster had studied Latin. The philosophy of the Latin grammar demanded water-pipes as the model, even if running water was as remote to the child as electricity.

Water only really works for direct current. Guillemin, in the opening chapter of Communication Networks, published (Vol. 1) in 1931, starts off by saying "The engineer likes to be able to visualize the mechanism of his investigations." His first figure and his first equation are for a mechanical system, not an electrical one. My own feeling, having been around with inductance and capacitance for so long, is that if there is a need for analogues it is a need to be able to draw an electrical circuit to help to understand a mechanical one. However, when I was explaining to one of the handsome and talented people whose names appear on the masthead of this journal that I thought that simple theory deserved a rest, I was assured that spring-heal Jack is a regular reader. Some of you, apparently, would rather watch an elephant sliding down hill than connect a coil across a battery.

Analogue models, and they can be dangerous. In any model-making operation you can hardly avoid leaving out some features of the original and adding some new characteristics. Unless you are careful to stick to the rules of the modelling process you may come to some quite erroneous conclusions. This would not surprise you. The same is true of our everyday components. A resistor is a resistor. A wire-wound resistor has some inductance, which we can measure to improve our "model"; in this case the drawing we put on our circuit for calculation purposes. But the manufacturer does not usually specify the inductance and he may change his construction, giving us the same resistance with a different behaviour at high frequencies. Clever circuits, which use unspecified characteristics of practical components, live, and often die, under the shadow of this refusal to stick to the rules.

The use of analogy between electrical systems and mechanical systems is normally developed along one particular path, and is brought sharply to a full stop before the main difficulties arise. I am going to follow this path, but in such a way that the difficulties shed new light on the whole problem. At least I hope so.

The two equations we need are:

Newton’s Third Law, \( F = ma \), in which \( F \) is the force, \( m \) the mass and \( a \) the acceleration; and

Hooke’s Law.

Hooke’s Law applies to springs, or any material which is stretched or compressed by force. For small displacements this is usually a linear elastic deformation. If it is not, Hooke’s Law does not apply. The difficulty is that different sources arrange the equation of stress is proportional to
strain in rather different ways. If we have a displacement \( x \) we can write

\[
F = S_a x,
\]

in which \( S_a \) is the stiffness, or

\[
F = x/C_a,
\]

in which \( C_a \) is the compliance. \( S_a \) is the material characteristic which appears in the expression for Young's Modulus.

We need also to notice that

\[
a = dv/dt = d^2x/dt^2
\]

and \( v = dx/dt \). Here \( v \) is the velocity.

The traditional approach is to write down

\[
F = ma = m dv/dt = m d^2x/dt^2.
\]

Below this

\[
V = L dI/dt = L d^2Q/dt^2.
\]

Contemplation of these two results suggests that if we represent force by voltage, velocity by current, displacement by charge, we can represent inductance by mass.

With an ideal spring, and writing Hooke's Law as

\[
F = kx
\]

we put below it

\[
V = Q/C
\]

and this suggests that capacitance can be represented by a spring, with capacitance inversely proportional to the stiffness.

Resistance is not quite so easy as you think. At least, as I think. My first reaction is to say that it is just the ordinary friction, but the experiment we do to find the coefficient of friction gives us a force which depends only on the loading. A given pressure on a car foot brake produces roughly the same deceleration at any speed. It is viscous drag we must consider, the plunger in the bowl of treacle. Modern practice uses silicone treacle, but it must be a dash-pot, not a slide, to get the essential equation

\[
F = pg \quad \text{which we compare with} \quad V = RI.
\]

Everything in the garden is lovely: a period phrase, well suited to the stage we have reached. Let us look now at Fig. 1, which is taken direct from Guillemin and is, indeed, his Fig. 1. Notice that the mechanical force is shown as applied at a single point and that the electrical circuit has two terminals. The reader may feel that I am being a bit persnickety about this. After all, anyone can see that the other mechanical terminal is earth, the framework. If you really feel that this is a sufficient answer, write down the electrical equivalent of Fig. 2.

![Fig. 2. If you know where earth is in Fig. 1(b), draw the electrical version of this.](image)

If the analogue technique is any good it should be possible to write down the circuit by a simple inspection operation. This just does not work with the results we have at this stage. The elementary analogue users work on the principle that you should get away from analogues as fast as you can. Get the feel of an LCR circuit from Fig. 1 and then get stuck into the circuit theory. The only trouble is with those of us who want to make electrical models of mechanical systems so that we can connect an oscilloscope to study the behaviour, or who want to build mechanical filters. We cannot escape. Anyway, if the analogue technique is worth attempting at all, it is worth treating properly.

A sound self-consistent approach is to treat all the systems as four-terminal networks or, more strictly, two-terminal pairs. This sounds clausy, but it simply means remembering that each bit has two ends and that the good earth is there below. Let us start off with the mass, drawn now as in Fig. 3. The little rods sticking out at the ends of the circuit form a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, a', b', c', d', e', f', g', h', i', j', k', l', m', n', o', p', q', r', s', t', u', v', w', x', y', z', A', B', C', D', E', F', G', H', I', J', K', L', M', N', O', P', Q', R', S', T', U', V', W', X', Y', Z'.

\[
V = \frac{dx}{dt} + v_2.
\]

Our final set of equations is:

\[
\begin{align*}
F_1 &= F_2, \\
v_1 &= \frac{dF_1}{dt} + v_2.
\end{align*}
\]

Now let us look at the circuit of Fig. 5(a). For this circuit we obviously have \( V_1 = V_2 \).

We also can see that

\[
I_1 = C \frac{dV_1}{dt} + I_2
\]

We get the relationship that \( C = 1/k \).

For the restoring spring shown as Fig. 5(b) the equations are quite different. The light stiff rod is only there to separate the input and output terminals and its two ends move at the same velocity. The spring alters the force relationships, so that

\[
F_1 = F_2 + kx,
\]

which gives us

\[
F_1 = F_2 + k \int v_2 dt.
\]

Consider the circuit of Fig. 6(b). In this circuit the current which flows in at one terminal flows out at the other. I am not sure whether this is obvious, but if you consider a battery connected at the left-hand end you will see that the capacitor will not charge until you short-circuit the right-hand
There is a difference between the two voltages, which is given by

\[ V_1 = V_2 + \frac{1}{C} \int I_2 \, dt \]

\[ I_1 = \frac{V_2}{R} \]

Comparing this with the force-velocity equations we see again that

\[ C = \frac{1}{k} \]

but we see the important difference in the method of connection. It is the first reward of our rather pedantic approach.

It is fairly easy to see that friction, the viscous friction we are concerned with, can also appear in two ways. On a level road, at constant speed, the engine of a motor car is simply providing the force needed to balance the various friction loads, drag, internal losses, the cooling fan. Bang the accelerator down on an icy road and you are aware that you rely on force transmitted through a frictional coupling. The same is true when the clutch is slipping, either of intent or age.

We can draw these two forms of frictional element in the forms of Fig. 7. Fig. 7(a)

\[ F_1 = F_2 + \rho v_2 \]

\[ v_1 = v_2 \]

The equations for these are similar in pattern to the equations we can write down for the electrical circuit of Fig. 8(a):

\[ V_1 = V_2 + R I_2 \]

\[ I_1 = I_2 \]

We see that \( \rho \propto R \).

For the circuit of Fig. 7(b) we have rather different equations. This dash-pot coupling is assumed to be without mass. Any mass which is found in a real dash-pot appears as a separate circuit element, just as the inductance, and for that matter the capacitance, of a real resistor is not included in resistance equations. No mass, no net force.

We get the equations:

\[ F_1 = F_2 \]

\[ v_1 = \frac{F_2}{\rho} + v_2 \]

The circuit of Fig. 8(b) gives us

\[ V_1 = V_2 \]

\[ I_1 = V_2/R + I_2 \]

Again \( R \propto \rho \), but the method of connection is different.

Before we can apply this collection of analogues to mechanical systems of the kind shown in Fig. 1 we need to be able to convert to a two-terminal network. At the end of an analysis we finish up by either short-circuiting or open-circuiting the terminals at the extreme right-hand end. Open-circuiting a mechanical terminal means simply pretending it is not there: short-circuiting it means clamping it to earth. We can clamp the rod in Fig. 7(a) by allowing the frictional force to become very large, so that \( F \) is finite as \( v \) goes to zero. This makes \( R \) in Fig. 8(a) go off towards infinity, leaving the left-hand terminals as good as open. A clamped rod appears as an electrical open circuit, with \( I \), \( v \) both zero.

A free mechanical terminal is obtained if we let \( \rho \to 0 \) in Fig. 8(b). If the left-hand end can slide freely, it does not matter what we do about \( F_1 \) and \( F_2 \). We get the same conditions as we get if \( R \to 0 \) in Fig. 8(b). \( V \) and \( F \) must always be zero.

Now we can draw out Fig. 1 again. I have done this in two different ways. In Fig. 9(a) the spring is shown as a restoring spring, with the right-hand end left free. In Fig. 9(b) it is a spring coupling, connected to a clamp. Building up term by term we get the two circuits of Fig. 10.

The actual end result is the same, but it is obtained in two slightly different ways.

At last, however, we can look at Fig. 2. For convenience the electrical equivalent is drawn from left to right, corresponding to reading the mechanical circuit from right to left. We get the result shown in Fig. 11.

Because of this clarification between shunt and series arms the network is very easy to determine. There is, of course, the possibility of introducing a restoring spring somewhere in the middle, to provide us with a capacitance in a series arm. And this raises a rather embarrassing question. Analogues, we said at the beginning, are to give us something mechanical to look at when we cannot picture the flow of electricity in a network. What are we to do if we have a shunt inductance in the electric circuit?

Questions like this explain why in the elementary books the use of analogues is allowed to fade away quietly. *Wireless World* authors, however, are not such mugs as to raise questions they cannot answer: at least not without laying a careful smoke-screen. We want the mechanical analogue for the circuit of Fig. 12, which satisfies the equations:

\[ V_1 = V_2 \]

\[ I_1 = \frac{1}{L} \int V_2 \, dt + I_2 \]

The second equation of this pair can be differentiated, to give

\[ \frac{dl_1}{dt} = \frac{V_2}{L} + \frac{dl_2}{dt} \]

We now consider, because I know it leads to the right answer, a bar, of length \( 2l \), mass \( m \), with all the mass concentrated at the centre of gravity, which is also the middle of the rod. This is shown in Fig. 13. If we waggle one end the other end will move. Rather inconveniently the two ends move in opposite directions, so I have drawn \( F_3 \) and \( V_2 \) in the common-sense way rather than the formal way. The moment of inertia about the centre of the rod is zero, and if it

Fig. 7. Frictional mechanical elements.

Fig. 11. Electrical equivalent of Fig. 2.

Fig. 12. Shunt inductance.

Fig. 9. The Fig. 1 mechanical circuit redrawn.

Fig. 10. The electrical forms of Fig. 9.
is not to have infinite angular acceleration
\[ F_1 l - F_2 l = m \ddot{\theta} dt^2 = 0 \]

Thus \( F_1 = F_2 \).
The net force acting on the rod is,
\[ F_1 + F_2, \]
and this will accelerate the central mass, which is assumed to have velocity \( v_0 \), giving
\[ (F_1 + F_2) = m(\frac{dv_0}{dt}) \]
The rod does not come apart, so that we must have
\[ v_0 = (v_1 - v_2)/2 \]
Hence \( F_1 + F_2 = 2F_2 = \frac{1}{2}(m \frac{dv_1}{dt} - m \frac{dv_2}{dt}) \)

Rearranging this:
\[ \frac{dv_1}{dt} = \frac{4}{m} F_2 + \frac{dv_2}{dt} \]

Compare this with the equation
\[ \frac{dI_1}{dt} = \frac{1}{L} V_2 + \frac{dI_2}{dt} \]
We see that this weighted bar gives us the right shape of equation, with \( L \) appearing as \( m/4 \). In order to keep things in line we

![Fig. 13. A bar with its weight concentrated at the centre of gravity.](image)

![Fig. 14. To get the senses lined up we add a lever.](image)

...can add a lever, as shown in Fig. 14. This makes no difference to the analysis.

At this stage we have the complete set of elementary text-book equivalents. Sheer idleness makes me omit the proof that a pivoted lever is in fact an ideal transformer, provided that it is infinitely light. The equations are so simple that they are not worth writing down. We are all ready to take a mechanical system and draw the corresponding circuit. If the mechanical circuit is a rotary motion system we need some minor changes. We use angular velocity, not linear velocity: we use moment of inertia, not mass; torque, not force. It is much of a muchness, though. There comes, however, one difficult moment. Suppose that the mechanical circuit is not a thing by

...itself, but is being driven by, or is driving an electric circuit. At one end we have a transformer—it may be a loudspeaker coil—which is fed from an electrical network. Two networks in tandem will be fine, we think, until we notice that for the transformer we have the equation
\[ F = \mu I \]
and working the other way round
\[ V = \mu v \]
The ideal transformer will have \( VI = FR \), so that \( \mu = \mu'/V \) and
\[ F = \mu I \]
\[ v = \frac{1}{\mu} V \]
the equations of an ideal transformer, if only we could take \( I \) as equivalent to \( F \), and \( V \) equivalent to \( v \). We can, and somewhere at the beginning of this article I said we had to choose in a rather arbitrary way whether to take \( E \rightarrow V \) or \( F \rightarrow I \). If only I had not been so stupid, and had made the other choice. Then, I hasten to explain, I would have considered at this stage the piezo-electric transformer, with \( F \propto V \). More tears and gnashing of teeth.

It is clear that we need to have two sets of equivalents available if the mechanical system is to be interconnected with an electrical one. If it is not connected to an electrical circuit there is nothing to choose between the two sets, in spite of some writers who have claimed that one or the other is right. A text-book writer can find some systems which are a little easier his way, just as it is sometimes easier to work with conductance instead of resistance: he

leaves out the systems which are just a little harder his way.

The other set of equivalents is derived in exactly the same way as before, except that now we compare the two sets of equations:
\[ V_1 = AV_2 + BI_2 \]
\[ I_1 = CV_2 + DI_2 \]
and
\[ v_1 = xv_2 + BF_2 \]
\[ F_1 = yv_2 + BF_2 \]
When we find a set in which the two patterns:
\[ A \quad B \quad \alpha \quad \beta \]
\[ C \quad D \quad \gamma \quad \delta \]
look alike except that one contains \( m \) or \( \mu \) and the other \( C \) or \( L \), we can trace the equivalence. We do not need any more figures: we have all the network elements we need. For Fig. 3, for example
\[ v_1 = v_2 \]
\[ F_1 = m \frac{dv_2}{dt} + F_2 \]
and for Fig. 6(a)
\[ V_1 = V_2 \]
\[ I_1 = C \frac{dv_2}{dt} + I_2 \]
In this set of equivalents, then, the mass is no longer the series inductance: it is a shunt capacitance.

The restoring spring of Fig. 7(b) gives us
\[ v_1 = v_2 \]
\[ F_1 = k \int v_2 dt + F_2, \]
\[ \frac{dF_1}{dt} = k \frac{dv_2}{dt} + F_2 \]
This is the equation, in equivalent terms, for the shunt inductance of Fig. 12
\[ \frac{dI_1}{dt} = \frac{V}{L + \frac{dI_2}{dt}} \]
The spring has become a shunt inductance, and the relationship is that \( L \propto 1/k \). For the spring of Fig. 5 (a)
\[ v_1 = v_2 + \frac{1}{k} \frac{dF_2}{dt} \]
\[ F_1 = F_2 \]
This we compare with
\[ V_1 = V_2 + L \frac{dI_2}{dt} \]
\[ I_1 = I_2 \]
which are the equations for the series inductance in Fig. 4. Again \( L \) and \( 1/k \) appear as equivalents. We are left with Fig. 6(b) and Fig. 14. I propose to take it for granted that \( C \) turns into \( m/4 \).

Some readers may have recognized that this treatment has led us to a set of dual circuits. Duality is a topic which is always of academic importance but which has ups and downs in its value to the practical man. When the triode valve was the normal active element in circuits we did our sums with amplification factor and anode impedance. The valve became a Thévenin generator. When the pentode became the common device we threw out the anode impedance as being too high to worry.

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The transducers are assumed to be ideal. Real transducers have mass, and resistance, and are not infinitely stiff, so we get inductance and resistance and capacitance in the network. We are accustomed to the idea of sorting out the properties of the ideal element, however, and here is a system which, in ideal form in a black box, has electrical properties that, one might say, never were on land or sea.

On sea, especially, there was, in the long distant days when this was first noted, a mechanical system with just the equivalent properties. It is applied to a gyroscope: the shafts move with an angular velocity proportional to the torque. You need to support the whole thing in such a way that you can take off two shafts, but the equations are:

\[ T = g \theta \]

\[ \theta = \frac{1}{g} T \]

in which \( T \) is the torque for the two shafts and \( \theta = d\theta/dt \), the angular velocity.

The black box with the crystal pickup driven by a moving-coil loudspeaker inside is, or would be if it were perfect, the electrical equivalent of the gyroscope in a mechanical system. A gyroscopic equivalent is the idea of a gyro-stator, or a wheel shaped with its L, C, R, transformer and the gyroscope, the set was complete. There is not another one waiting to be found, named, studied.

One feature of the gyroscope is that it throws the Reciprocity Theorem out of the window, though not out of the books. With no gyrostats in a circuit you know that if a signal will go through it from left to right it will equal well right from left to left. This only applies, of course, to linear passive networks. With gyrostats in the circuit this is no longer true.

An immediate result was to clean up a rather untidy situation in a theoretical area where lumped circuit theorists had rather come to grief. If you transmit a signal by way of the ionosphere you find that in some conditions the signal will reach a distant station, but that their signal at the same frequency will not reach you. Working away with Maxwell’s equations and the equations for free electrons in a magnetic field this is perfectly reasonable. To a circuit man, with two pairs of aerial terminals and some passive system in between, it seemed again nature. The clue lies in those electrons, spinning in small circles. The gyro-coupling in the ionosphere provides the essential circuit element for making the transmission path non-reciprocal.

Here, in turn, is the key to the practical passive gyrostabilizer. We can put a lump of condensed ionosphere into a circuit. We do not, of course, bring down real ionosphere with specially built rockets. We use ferrites: the spin associated with the magnetic characteristic of a ferrite provides us with the gyro-coupling we need to produce a gyrostablizer in a waveguide at microwave frequencies.

It may appear that Roman aqueducts have nothing to do with microwave equipment but yet, as we have seen in this article, there is a continuous line of reasoning from the water flowing in pipes which we are given as an analogue of a direct-current circuit through to the gyrostabilizer used to sort out whether the signals are coming or going.

Pneumatic and hydraulic systems can equally well be treated, at a low level, in terms of electrical equivalents, and vice versa. At a low level, only, because we find that these are not really linear in normal working situations. A diode pump is not the same as a bicycle pump, because the rise in air temperature cannot be described in terms of simple circuit resistances. You can still get a good idea of what is happening, for example why you have a water hammer in your home plumbing, but it is not wise to rely too closely on the calculated results. The solution is qualitative, not quantitative. For engineers who want to understand designs in another discipline analogues are fine: a heating problem becomes just a matter of voltages (temperatures) and currents (heat) in a network of capacitances (thermal insulation) resistances (heat loss).

If you do want to design a silencer for your car you may prefer to think of it as a low-pass filter—with some simple sections if you like—before you take up the tin-snips.

Remember, always, that though analogues are useful, they are only models, and it is quite a step from piloting your radio-controlled boat on the Round Pond to commanding the Q.E.2. You get worse pay in Kensington Gardens.
Active Filters

10. Uses of the parallel-T network

by F. E. J. Girling* and E. F. Good*

The balanced parallel-T network offers convenience and versatility, and makes less demand on amplifier gain than the two-lag loop and related circuits. It is, however, sensitive to errors that cause unbalance in the two tees, increasingly so as the Q factor is raised. It is most useful, therefore, in circuits of moderate Q in which economy in amplifier gain and in number of amplifiers is desired.

In principle the Q factor of a parallel-tee network can be increased in direct proportion to the available loop gain, Part 4, equin. (32). This is apparently a much more powerful law than the square-root relationship that applies to the two-lag loop and related circuits. The potential performance can, however, be exploited only to a degree depending on how closely equal the time constants of the two tees can be held, since the effects of any inequality increase as the required Q factor increases. Nevertheless, parallel-T circuits may be considered a practical possibility for moderate Q factors (say from 2 to 10), and may on occasion be preferred because of the economy in amplifier gain.

The particular arrangement of active parallel-tee filter to which most attention is given in this article (Fig. 10(b)) is one which the present authors have found useful from time to time, and one which is easily adapted to give any 2nd-order transfer function. It can therefore be used to build higher-order filters by the method of synthesis by factors.

The parallel-T network

The basic characteristics of the balanced parallel-T network were discussed in Part 3. Its special feature is that at a certain frequency it gives zero transmission, and the necessary condition for the existence of the zero is that the short-circuited-output time constants of the two tees should be equal. Thus in Fig. 1(a) C2 multiplied by the resistance of R and R in parallel must equal R multiplied by the sum of C and C, i.e. for a zero

\[ T_2 = T_2^* \]  

where \[ T_2 = \frac{C_2 R R^*}{R^* + R} \]

and \[ T_2^* = \frac{(C + C^*)}{R_2} \]  

(See the analysis given next month.)

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Fig. 1. (a) Parallel-T network. (b) LCR network giving symmetrical notch response.

If now \( T_1 \) is the time constant of the mesh formed by the upper four components when the lower two are removed, i.e.

\[ T_1 = \frac{C^* (R + R^*)}{C + C^*}, \]  

the transfer function for the input \( V_1 \) may be written

\[ V_0 = \frac{1 + p^2 T_1^2}{1 + pT/q_0 + p^2 T_1^2} V_1 \]  

and for \( V_2 \) (see Fig. 21, Part 3)

\[ V_2 = \frac{1 + pT/q_0}{1 + pT/q_0 + p^2 T_1^2} V_0 \]  

where \( T_1 = T_1 T_2 \). These transfer functions are of the same form as those for the LCR network of Fig. 1(b), though, of course, for the CR network \( q_0 \leq \frac{1}{4} \), but there the similarity between the two networks ends, since there is no direct correspondence between the currents or the internal voltages. As shown in Part 3, \( q_0 \rightarrow \frac{1}{4} \) only when \( T_1 = T_2 \) and both \( R / R^* \) and \( C / C^* \rightarrow 0 \); and it is usual to accept a lower value in exchange for the convenience of using sets of components with more equal values. Thus in most of what follows \( R = R^* \) and \( C = C^* \). The maximum value of \( q_0 \) obtained when \( T_1 = T_2 \) is then

\[ q_0 = \frac{1}{4}. \]  

(7)

This set of relative component values is shown in Fig. 2(a) and will be represented when convenient in the shorthand form shown in Fig. 2(b).

A practical problem in using the parallel-tee network is finding from the standard ranges of values sets of components which give balance (i.e. a null) at, within allowable tolerance, the required frequency, and some suggestions made at the end of the article (next month) may be of help.

The parallel-T network with gain and feedback

As shown in Part 4 the Q factor of an (accurately balanced) parallel-tee network is magnified according to the relationship

\[ q = (A + 1) q_0 \approx A q_0 \]  

(8)

This result is most easily obtained by considering a system with 100% feedback, Fig. 3, in which the input voltage is applied in series with the output voltage. This gives

\[ V_1 = V_{in} + V_0 \]  

\[ V_0 = -V_{out}/A \]  

(9)

(10)

whence by substitution from equin. (5)

\[ V_{out} = \frac{A}{A + 1} \frac{1 + p^2 T_2^2}{1 + p T/q_0 + p^2 T_2^2} V_{in} \]  

(11)

with \( q \) as given by equin. (8).

Theory of circuits with ideal amplifiers

Practical circuits must be arranged so that the input voltage can be applied with one side grounded, and in addition it should be possible to enter the circuit at different places so that a variety of 2nd-order responses can be obtained, I, p, b, p (tuned-circuit), etc. To obtain accurate values of Q factor (and to ensure low output impedance) the effective value of A should be stabilised by feedback; and, as usual, the easiest and most effective approach to all these problems is by considering idealised arrange-

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ments using amplifiers which are assumed to have infinite internal gain.

A convenient starting point is the circuit arrangement shown in Fig. 4(a), in which the rejection characteristic of the parallel-T network is employed in a feedback path to give the arrangement an approximate tuned-circuit response. At the rejection frequency of the network there is no feedback via this path, and (with $A = \infty$)

$$V_{in}/V_{out} = -R_{L}/R_{in}.$$  \hfill (12)

At high frequencies the feedback network approximates to a single capacitor of value $C$, which in conjunction with $R_n$ causes the amplitude response $|G(o)|$ to fall indefinitely as frequency increases. At low frequencies, however, the combined feedback network becomes equivalent to a single resistor ($R$ in parallel with $R_{L}$), and so $|G(o)|$ falls to a constant value. Less obviously, the maximum in the amplitude response is not at the null of the parallel-tee network (Ref. 1).

A simple modification to obtain exact tuned-circuit response was invented by S. W. Noble and F. C. Williams at the Telecommunications Research Establishment during the last war (Ref. 2). It still does not seem to be widely known. The purely resistive branches, $R_{L}$ and $R_{in}$ are replaced by $CR$ branches with time constants equal to the time constant ($T_1 = T_2$) of the tees, i.e. the time constant that appears in the denominators of the expressions for the short-circuit output currents, eqns. (42) and (44). This is shown in Fig. 4(b). The magnitudes of the impedances of these branches can (in principle) have any values as long as the $CR$ products equal $T_2$ (which is $T$ when $T_1 = T_2 = T = 1/\omega_n$, as for the circuit shown).

By inspection:

$$I_1 = V_{out} \times \frac{1}{R} \times \frac{1}{1 + pt}$$  \hfill (12)

$$I_2 = V_{out} \times \frac{pT}{qR} \times \frac{1}{1 + pt}$$  \hfill (13)

$$I_3 = V_{out} \times \frac{pT}{R} \times \frac{1}{1 + pt}$$  \hfill (14)

$$I_{in} = V_{out} \times \frac{pT}{nR} \times \frac{1}{1 + pt}$$  \hfill (15)

and hence

$$V_{out}(1 + pt)(q + p^2T^2) = -V_{in}pt/n$$  \hfill (16)

i.e.

$$\frac{V_{out}}{V_{in}} = \frac{1}{n + pt/q + p^2T^2}.$$  \hfill (17)

So true tuned-circuit response is obtained with $Q$ factor $= q$. If $n = 1$ the gain at resonance is $q$; if $n = q$ the whole curve is depressed so that at the peak $V_{out} = V_{in}$.

Putting $p = jo\omega$ turns the numerators of the transfer functions of eqns. (12) to (14) into $1, jo\omega, (jo\omega)^2$. Hence, since the denominators are alike, the feedback currents $I_1, I_2, I_3, I_4$ have successive constant phase differences of $90^\circ$. At the null frequency $I_1$ and $I_2$ are equal in magnitude as well as opposite in phase. Consequently, since the sum of the currents converging on the virtual earth must be zero, $I_4$ and $I_2$ must also be equal and opposite. It follows therefore that at the null frequency of the parallel-tee network, which is also the peak or resonant frequency, the vectors representing the four currents form a figure with four right angles, Fig. 5, and for the relative component values of Figs. 2(a) and 2(b) the currents are at $45^\circ$ and $135^\circ$ to $V_1$ and $V_{out}$.

For the arrangement without the additional Cs. Fig. 4(a), $I_4$ and $I_{in}$ are in phase with $V_{in}$ and $V_{out}$, and so not in quadrature with $I_1$ and $I_2$. The independence of tuning and damping is then lost, and the behaviour of the circuit is more complex.

Any arrangement which gives the same flow of currents to the virtual earth gives the same response. Hence a considerable number of variations of the circuit are possible, and a selection are shown in Fig. 6. At (a) the number of capacitances is reduced by amalgamating those of the input and damping arms. At (b) one of the tees is made to serve also as the input arm (either or both tees may be so used); and at (c) the damping arm is eliminated by feeding to the bottom of one of the tees a fraction of $V_{out}$. It is necessary, of course, that in all variations the effective $Ts$ (time constants) of the current paths are unaltered. This means, for example, since $V_{in}$ represents an effectively zero-impedance source, that sometimes when $V_{in}$ is introduced into a branch carrying relatively heavy current a buffer amplifier of low output impedance is needed.

**Effect on Q factor of unbalance in the tees**

Suppose the capacitance which ideally has the value $4C$ (Fig. 4) is slightly increased. Then at the frequency $\omega_n$ which was the frequency of balance the magnitude of $I_1$ is slightly reduced and the phase angle it makes with $V_{out}$ is slightly increased. At a certain slightly lower frequency the phase angle of $I_1$ will move back by an amount equal to about half the increase just mentioned and the phase angle of $I_2$ will move forward to give a figure as shown in Fig. 7. $I_1$ and $I_2$ are again equal in magnitude, and have a resultant OP which is in phase with $I_{in}$ (Fig. 5).

![Fig. 6. Some alternative methods of applying damping.](image)

![Fig. 7. Phase-angle relationships when $T_3 > T_2'$.](image)

If at the frequency $\omega_n = 1/\omega$ the time constant of a simple-lag network is increased by a small fraction $x$, the increase in phase angle is $x/2$ radians. Hence in Fig. 7 $\Delta \phi = x/4$ radians and the length of OP (if $I_1 = I_2$ lengths $= 1$) is $x/2$.

Since OP is in phase with $I_{in}$ for constant $I_3$ (and hence for constant $V_{out}$) a smaller $I_{in}$ is required. Hence at this frequency $\omega_n$ approx, the gain of the system is increased. At frequencies well removed from $\omega_n$, where there was already a considerable unbalance between $I_1$ and $I_3$, the unbalance is not significantly altered. Hence it is only near the peak of the response that the gain of the system is increased, and the increase can be expressed as an increase in $Q$ factor. Therefore, since with ideal values $|I_3|/|I_1| = 1/q$, the increase in the time constant of the low-pass tee has effectively increased the $Q$.
factor according to the equation
\[ \frac{1}{q} = \frac{1}{q_i} \frac{x}{q_i - \frac{1}{2}}. \] 
(18)

This shows that when \( q_i > 2 \) the fractional change in \( Q \) factor is \( > x \), and that if \( x \to \frac{1}{2q_i}, q \to \infty \).

Similarly if the value of the resistance of the high-pass tee (nominally \( R/4 \)) is reduced by a fraction \( x \), the same change in \( q \) is found, though the frequency of the peak moves upwards. And in the same way the effect of changes in the horizontal elements of the tees can be estimated. In general if \( T_1 > T_2 \) [see eqns. (2) and (3)] \( q \) is increased; if \( T_1 < T_2 \), \( q \) is reduced. The change in the frequency of the peak depends both on the change in short-circuit time constant and on whether \( T_1 \) [eqn. (4)] is changed.

A fractional change in only one of the horizontal elements has only half the effect on \( T_1 \) or \( T_2 \) as the same fractional change in the vertical elements (when the two horizontal elements are approximately equal), and therefore the \( q \) sensitivity to changes in only one horizontal element is also only half as great.

Series feedback

Consider the circuit arrangement shown in Fig. 8(a). For the input \( V_{in}^2 \) applied between terminals 1 and 2, this is the same as that already considered except that the damping arm is missing (the amplifier is shown as a valve, as in Part 6, in order to make clear graphically the steps which follow). Consequently if \( A = \infty \) the response shows infinite \( q \) and infinite gain at the tuned frequency, i.e.,
\[ G(p) = \frac{V_{out}}{V_{in}} = -\frac{1}{n} \frac{pT}{1 + p^2 T^2}. \] 
(20)

To add 100% feedback we must include the whole of the output voltage in series with the input, and this is done by applying the input, \( V_{in}^1 \), between terminals 1 and 3. The gain \( A \) found in eqn. (20) is now the forward gain \( \mu \), and as \( \beta = 1 \), Black's formula reduces to \( G = 1/(1 - A/\mu) \), and the gain with the loop closed becomes
\[ \frac{V_{out}}{V_{in}} = n \frac{1 + pT + p^2 T^2}{1 + n pT + n p^2 T^2} \] 
(21)

Thus the series feedback connection has produced a response with \( q = n \), a result which might have been expected since the input branch is now in a feedback path and takes the place of the damping branch of the previous circuit arrangement.

Now that the anode (node 3) is common to input and output it is convenient to have this point earthed (as indicated by the arrowhead), after breaking the original earth connection at \( x \). Fig. 8(b) is the same circuit redrawn with the earth line conventionally at the bottom, and shows that the value in eqn. (21) is the same as the cathode follower. It follows (or see Part 6) that an amplifier with gain \(-A\) in Fig. 8(a) converts to a cathode follower with gain \( K = A/(A+1) \) in Fig. 8(b), and that \( K \to 1 \) only as \( A \to \infty \). It is important to remember this when considering the effect of finite gain. Because the output terminals have been inverted, the minus sign is removed from eqn. (21) for Fig. 8(b).

It does not require much practice to be able to make the step from one of these types of circuit to the other without drawing in a representative three-terminal amplifier as has been done above. For example, with the parallel-tee in the forward path, Fig. 9(a), and with \( A = \infty \),
\[ \mu = \frac{-n}{n} \frac{pT}{1 + p^2 T^2} \] 
(22)

and hence
\[ \frac{V_{out}}{V_{in}} = \frac{1 + p^2 T^2}{1 + n pT + n p^2 T^2}. \] 
(23)

which is symmetrical notch response with
\[ q = n. \]

This result should be compared with the comparable result for the ordinary Sallen- and-Key circuit [Part 6, eqn. (8), with \( b = 1 \)].

The effect of finite gain

Looking again at Fig. 9(a), it is clear that removing the damping arm, by breaking the circuit at \( x \), will give \( q = \infty \) when \( A = \infty \). But now the circuit is identical to that shown in Fig. 3, so with \( A \) finite \( q \) will be as given by eqn. (8). This value of \( q \) may be identified with a residual value \( q_e \) (the value obtained when all intentional damping is removed and the \( Q \) factor is limited only by the value of \( A \)). Thus we may write
\[ q_e = (A+1) q_0 \approx A q_0 \] 
(24)

From the rule that, since losses add, \( q \) as add as their reciprocals, it follows that \( q \) with \( A \) finite will be given by
\[ \frac{1}{q} = \frac{1}{q_0} + \frac{1}{q_1} + \frac{1}{q_2} \] 
(25)

that is to say: the actual loss factor is the sum of the ideal loss factor (the loss factor calculated on the assumption of infinite gain) and the residual loss factor,
\[ \frac{1}{q} = \frac{1}{q_0} + \frac{1}{q_1} \] 
(26)

When the parallel-tee network has the usual set of values (Fig. 2) \( q_0 = \frac{1}{2} \) and hence
\[ \frac{1}{q} = \frac{1}{q_1} + \frac{1}{A} \] 
(27)

Only when \( q_i > 2 \) does the parallel-tee filter show an advantage in performance, although there may be other reasons for choosing it. However, with increasing \( q_i \) the advantage grows rapidly. The residual loss factor \( 4A \) in eqn. (27) may, indeed, be compared with the residual loss factor \( 2A \) for the two-integrator loop—but only so far as the accuracy of balance of the parallel-tee network allows.

In the virtual-earth or shunt-feedback arrangement of the circuit the presence of both input and feedback arms causes some loss of effective internal gain. This does not show in the ideal design equations as they are based on \( A = \infty \). For Fig. 4(b) with the amplifier gain set at \(-A\), and writing \( q_i \) instead of \( q \),
\[ \frac{V_{out}}{V_{in}} = \frac{A}{n(A+1)} \] 
(29)

\[ 1 + \frac{1}{(A+1) n q_i} \] 
(30)

which shows that
\[ \frac{1}{q} \approx \frac{1}{q_1} + \frac{4}{A} \] 
(31)

which confirms several results already derived: finite \( A \) leaves the response

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*Also we neglect practical points such as correct biasing and the position of the h.t. battery.
of the correct form; the resonant frequency is unaltered; and for \( n > 1 \), \( q_{max} = A/4 \) approx.

**"Universal" 2nd-order filter**

With the above particular examples in mind, it is not difficult to take the next step to the general situation shown in Fig. 10(a),

![Image](https://www.americanradiohistory.com/graphics/fig10.png)

**Fig. 10.** Circuit of "universal" 2nd-order filter: (a) with amplifier in high-gain, sign-reversing mode; (b) with amplifier in voltage-follower mode.

in which a separate series feedback connection is made for each of the three branches. Assuming \( A \to \infty \), the currents \( I_1 \), \( I_2 \), and \( I_3 \) are now given by

\[
I_1 = \frac{V_1 + V_2}{R} \times \frac{1}{1 + pT} (31)
\]

\[
I_2 = \frac{V_2 + V_3}{qR} \times \frac{pT}{1 + pT} (32)
\]

\[
I_3 = \frac{V_3 + V_1}{p^2 T^2} \times \frac{1}{R} \times \frac{1 + pT}{1 + pT} (33)
\]

and since \( I_1 + I_2 + I_3 = 0 \)

\[
V_{out} = -\frac{V_1 + V_2 + V_3}{q} \times \frac{1 + pT}{1 + pT} + \frac{V_3}{p^2 T^2} (34)
\]

Moving the earth point in the now familiar way leads to the practical arrangement Fig. 10(b), in which each of the three generators has one side earthed (and for which, because the other output terminal is now earthed, the minus sign is removed from eqn. (34)).

The two examples already considered are covered by making \( V_2 = V_3 = V_1 = 0 \) for tuned circuit response, and \( V_1 = V_2 = V_3 = V_1^* \), \( V_2 = 0 \) for the symmetrical notch. [Note: putting a particular generator voltage \( 0 \) is equivalent to replacing it by a short circuit.]

**Unsymmetrical notch response**

\( V_1 = V_2 = V_3 = 0, V_4 = aV_1^* (a<1) \), Fig. 11(a), gives the low-pass unsymmetrical notch. Making \( V_1 \), a fraction of \( V_1^* (V_1^* = aV_1^*) \) gives the corresponding high-pass response. In this case it is possible, as shown in Fig. 11(b), to obtain the required fraction of the input voltage by using a simple potential divider. Apart from the possibility for higher \( Q \) factors compared with the circuits offered in Part 6, there is also the useful feature that \( q \) may be adjusted independently of \( T \). Applications to high-order filters are similar to those suggested in Part 9.

**Simple low-pass and high-pass**

\( V_1 = V_2 = V_3 = V_4 = 0 \), Fig. 12(a) gives simple (i.e. all-pole) low-pass response, and \( V_5 = V_1^*, V_2 = V_3 = 0 \), Fig. 12(b), gives high-pass. These circuits have a somewhat strange appearance in this simple role. This is because we know that two capacitances are in principle sufficient for simple 2nd-order response. It is worth remembering, however, that they retain the same potential for higher \( Q \) factor as the other circuits (for unexcited the circuit is unchanged and hence the natural motion, i.e. the decay of transients, is unaltered), and also that it is not necessary to increase the size of any \( C \) when \( q \) is increased. An obvious application is for the synthesis of the highest-\( q \)-quadratic factor in a high order Butterworth series (see Part 9). There is also some attraction in a Butterworth filter composed entirely from these circuits, since the parallel-T networks are the same for every factor and only the values of the components in the damping branches differ (and even these can be alike if potential dividers are used, Fig. 14). There is no advantage in performance for the lower \( q \) factors however.

**All-pass**

If \(-V_s\) is made available (by using an inverting amplifier) it is possible to set \( V_1 = V_4 = V_5 \), and \( V_2 = V_3 = -V_s \), Fig. 13. This gives the all-pass transfer ratio

\[
\frac{V_{out}}{V_{in}} = \frac{1 - pT/q + p^2 T^2}{1 + pT/q + p^2 T^2},
\]

which has a flat amplitude vs. frequency response with phase going from \( 0^\circ \) to \( 360^\circ \) as \( \omega \) goes from 0 to \( \infty \).

**Variable \( q \)**

If \( V_1 = (1-x)V_{out} \), controlled by a potentiometer, Fig. 14, the \( q \) of any low-pass, high-pass or notch response can be con-

![Image](https://www.americanradiohistory.com/graphics/fig13.png)

**Fig. 13.** Circuits for all-pass response — (b) shows possible economical alternative to (a).

![Image](https://www.americanradiohistory.com/graphics/fig14.png)

**Fig. 14.** Variable damping with a potentiometer.

The subject of the uses of the parallel-T network will be concluded in Part 11 next month. The article will deal with: variable tuning with constant bandwidth, third-order systems, an analysis of the parallel-T circuit, dependence of \( q_0 \) on the ratio \( T_1/T_2 \), and the eight-component parallel-T network.)

References


Active Fillers 4
Aerospace Instrumentation

New devices for detecting and recording physical variables described at Cranfield symposium

by R. Gregory

A prominent feature of aerospace engineering for some years has been the increasing use of the digital computer. Considering, for example, that the cost of flight testing a new aircraft such as the Boeing 747 "jumbo jet" is over £8,000 per hour, it is easy to see the justification for computers—and they are in fact used not only for data processing but also to store calibrations, to present results in appropriate engineering units and even for "file keeping". Current techniques in this field were described at an international symposium on aerospace instrumentation held at the Cranfield Institute of Technology (formerly College of Aeronautics) from 23rd to 26th March. The symposium is a regular event and in the past has been jointly sponsored by Cranfield and the Institute Society of America. On this occasion the Royal Aeronautical Society was also a sponsor.

Transducers

The use of digital information processing techniques implies the availability of data in digital form, but the transducer which will provide a pure digital output has yet to be conceived. A near approach to this has been a number of designs based upon change of resonant frequency of mechanical elements in sympathy with the measured parameter, thus giving an output in terms of frequency or period. A development of this was explained by members of the Kollman Instrument Corporation. The company's long experience and detailed research into precision altimeters led them to the understanding that the limit of accuracy for an aneroid altimeter was within the instrumentation rather than in the aneroid capsule itself. From this they have developed an altimeter relying upon the change of mechanical resonance of the capsule, Fig. 1, thus giving a change of natural frequency with pressure.

Advances in semiconductor technique have brought the semiconductor strain gauge forward to become a reliable and useful element in transducer design. There were several interesting contributions on this subject and one, from the Kulite Corporation, explained how a 300-kHz response pressure transducer has been developed using silicon as the diaphragm material with the gauges diffused into this base material. Further developments of this type of transducer included putting signal conditioning circuitry into the diffusion. Ether Ltd presented a design for a low-range pressure transducer constructed in a similar manner but operating on magnetostrictive principle (Ref. 1).

The force balance technique, Fig. 2, in wide environmental ranges is now readily available and are physically only about the size of a cigarette packet.

Three papers dealt specifically with force balance transducers. A N.A.S.A. paper explained a triaxial angular accelerometer involving three servo loops, Fig. 3. As with all accelerometers, the device relies upon a spring restrained mass, the mass in this case being a sphere suspended within a fluid-filled cavity. There is a servo loop to control the temperature of the fluid so that its density is always that of the sphere, another, an electrostatic forcing system, to keep the sphere centrally suspended, and the third, an electro-magnetic servo to force the sphere to zero rotational displacement during parameter inputs. A very typical side study of this transducer was the necessity to develop a special rate table for test purposes.

Another paper from United Controls Corporation described a force balance multi-axis accelerometer system or "cluster" in which, by the use of cunning design, the effective centres of mass are all at a common point. Progressing towards better reliability from the more conventional transducers, a paper from Vibrometer described how co-operation with European airlines, to develop vibration-measuring devices, resulted in a synthetic quartz accelerometer capable of operation at temperatures beyond 600°C. Endevco demonstrated their expertise in this field by exhibiting an accelerometer working

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Fig.1. Basic structure of the vibrating capsule loop.

Fig.2. Sketch of a typical force-balance transducer system.

Fig.3. Triaxial accelerometer with three separate control loops.
within the flame of a blowlamp at some 630°C.

**Tape recorders**

Magnetic tape is likely to remain a major recording medium for many years to come. This opinion was substantiated by the nine tape recorder companies represented at the exhibition. Much of the R & D of the '50s and '60s was put to developing precise analogue recorders, but latterly greater interest has been shown in digital recording, not only for direct computer memory use, but also for recording digital data. This has changed many of the philosophies in transport design, particularly in the field of accident recorders where extremely simple transports suffice, some of them completely lacking fly wheels and belts and relying solely upon the speed control achieved from the use of an hysteresis motor.

A contribution from S.E. Laboratories gave a review of present precision instrumentation recorder design. Who would have thought a few years ago that the tape drive capstan would be mounted directly onto the motor shaft? Low inertia printed-circuit motors are being increasingly used with tight servo speed control, giving an overall response into the 200-300 Hz range; thus problems of wow and even flutter are becoming less of a design problem. Both analogue and logic I.C.s are being used extensively. Tape speed change, for example, is now only a matter of electrical switching (Fig. 4)—there is no belt or pulley changing nor any filter or centre frequency changing, this all being accomplished by logic frequency division.

**REFERENCE**


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**More Circuit Ideas (see also page 206)**

**Level-sensitive battery switch**

Many present-day instruments are battery powered and not infrequently are inadvertently left switched on when not in use, resulting either in damage to the instrument through chemical leakage from Leclanche type cells or the destruction of the more expensive mercury or nickel-cadmium types. The circuit shows a method of automatically switching off when the battery voltage falls below a predetermined level. So long as the supply voltage is sufficient to cause the zener diode to conduct, transistors $T_r$ and $T_l$ are switched on and the instrument functions normally. Conversely, when the supply voltage drops below the diode breakdown level, $T_r$ and $T_l$ switch off. Transistor and diode leakage current still flows, but with good silicon types this will amount to only a few micro-amps which is insufficient to cause damage, except perhaps over a very prolonged period. The price paid for this protection, apart from the cost of the components, is the zener diode current and the voltage drop across $T_r$, which will be virtually constant provided it is bottomed. The circuit shown is suitable for a nominal 12V battery, and switches off when the voltage drops below 9V.

N. L. BOLLAND, Farnham Common, Bucks.

**150mW General Purpose Audio Amplifier**

The design given here is straightforward and is suitable for intercom and many other uses. Prior to switch on $VR$, should be set to zero and then subsequently set to give 1mA quiescent current through $T_r$ and $T_l$. The input impedance is 850Ω and 2mV input is required for full output. This circuit was extracted from the Ferranti "E-Line Transistor Applications" handbook.
20-MHz Counter Timer

The information given here was extracted from a Motorola application note

The functional blocks of the system are shown in Fig. 1. In the frequency mode of operation, the incoming signal is amplified or limited, as required. It is then conditioned by the pulse shaper in order to meet the constraints imposed by Motorola r.t.l. devices. The resulting pulse train, the frequency of which is directly dependent on the incoming frequency, is one of the inputs of the count gate.

The 1-MHz oscillator signal is appropriately divided down, depending on the position of the frequency multiplier switch, and routed through the period selector to the second input of the count gate. This results in turning the count gate on for a specific "gate time". The output of the count gate is then a burst of pulses, the number of which is directly proportional to the original input frequency. These pulses are then counted by the decade counting units (d.c.u.s), each of which contains a b.c.d. decade counter, b.c.d.-to-decimal converter and produces one digit of the readout. The count is retained in the readout until the system is reset.

Resetting is accomplished by applying a "high", or logical one, to all direct clear (C_D) inputs of the flip-flops and decade counters. In the manual reset mode, this is done by a momentary push button switch.

In the automatic reset mode, and in all but the number five multiplier switch position, the output of the seventh decade divider from the oscillator is used to do the resetting. This particular output goes high during the eighth and ninth second from zero time (that time immediately following the previous reset cycle). Once this high signal is applied to the C_D inputs, the devices are reset, therefore they are effectively reset at the beginning of the eighth second. In the number five multiplier switch position, since the gate time is ten seconds, it is necessary to take the auto reset signal from the third flip-flop output of the eighth decade divider and reset occurs at the 40 second point. Since it is necessary to hold each C_D high for a minimum of 100ns to ensure resetting of all flip-flops, a one-shot multivibrator is used. The signal triggers the one shot, which holds the reset signal high for approximately 5ms. The 5ms value is strictly arbitrary; however, consideration should be given to various propagation delays due to stray line capacitances and inductances, etc., throughout the system. The output of the one-shot is buffered to provide sufficient drive for all C_D inputs.

The operation in the period mode is essentially the same with one major exception. The incoming signal is routed through

**Specification**

- **Waveforms handled:** sine, square, or negative pulses with greater than 30ns duration.
- **Type of measurement:** frequency; period: random pulse counting with selected gate times.
- **Input impedance:** 10kΩ typical, 75Ω minimum
- **Input protection:** DC-c.: 1 watt peak in the unattenuated position; conservatively up to 200 watts peak in the attenuated position.
- **Input sensitivity:** 50mV r.m.s. guaranteed.
- **Readout:** 4-digit decimal; fixed decimal point location; ranging accomplished by rotary switch.
- **Accuracy:** ±0.05% ±1 count with self-calibration using line frequency, to ±0.1%
- **Resetting:** manual or automatic

**Fig. 1. Block diagram of the instrument.**
the period selector and is used as the gate time of the count gate, whereas the oscillator signal is used as the events counted.

The self-contained calibration feature is obtained by simply counting the frequency or period of the 100-Hz signal. For more accurate calibration an external signal is recommended. A calibration adjustment is provided in the oscillator section.

**Pre-amplifier and pre-scaler**

The pre-amplifier of Fig. 2 uses the MC1552G video amplifier. Two input amplitude ranges are provided, 50-300mV r.m.s. and >300mV r.m.s. The 3dB down points of the pre-amp. circuit only, in the unattenuated position as shown, are 4Hz and 42MHz for small signal applications. Input impedance is typically 10kΩ.

Since Motorola r.t.I. devices are guaranteed to only 4MHz, a Motorola d.t.I. decade counter (MC838P) is utilized to extend the frequency range to 20MHz.

Note that the $V_{CC} + 5V$ for the decade counter is derived from the +6V supply by placing a silicon diode in the line. This places $V_{CC}$ well within the supply tolerances of the d.t.I. In order to attain the high frequencies specified care must be taken in constructing the pre-amp. Of prime importance is the shielding between input and output circuitry and for this reason double clad printed circuit board should be used, with the input and output components located on different sides of the board. In the prototype the pre-amp. was constructed in a separate box within the chassis.

**Pulse shaper**

As mentioned earlier, the pulse shaper's function is to condition the incoming signal to meet the input constraints of r.t.I., J-K flip-flops. The primary requirement is for the fall time of a flip-flop's clock pulse inputs to be within the range of 10 to 100ns. (Not applicable to the MC778P). This is accomplished by using one-half of a hex inverter, connected in a Schmitt trigger configuration as shown in Fig. 3. Under worse case conditions (15°C and 4MHz) input hysteresis is about 2V. Inputs to the pulse shaper can be periodic waves of any form or random pulses. The one constraint is a minimum input pulse duration of 30ns.

**Crystal controlled oscillator**

In the oscillator of Fig. 4 two gates are cross-coupled to form a free-running multivibrator whose square-wave output frequency is locked by the crystal. The resistors serve as biasing elements, in addition to being a part of the circuit time constants. With the crystal placed as shown, however, $R_1$ and $C_1$ determine the period. Since $R_1$ also establishes the bias of the gate input, and must be fixed for a given $V_{CC}$, $C_1$, and the crystal, of course, would be changed if another frequency is desired. Typical values of $C_1$ for other frequencies are 430pF for 500kHz and 0.001μF for 100kHz.

The trimmer capacitor permits exact adjustment of the frequency, which is stable to within ±0.01% from +15°C to 55°C, without a crystal oven.

**Period selector**

The function of the period selector is to accurately select one, and only one, period of either the incoming signal to the counter, with the counter in the period mode, or of the oscillator, with the counter in the frequency mode. The period selection, in the form of a low or logical zero, is then used as the gate time for the NOR logic count gate. In the period mode, the count gate allows passage of the oscillator signal for one period of the incoming signal. In the frequency mode, the count gate passes the incoming signal for one period of the oscillator signal.

The period selection is accomplished by using a dual J-K flip-flop connected as shown in Fig. 5. The initial state is preset.
(during the reset cycle) so that the Q outputs of both devices are in the low state. The first negative transition of the incoming signal causes Q_A to go high. The second negative transition causes Q_B to go low, which in turn causes Q_A to go high. The high output of Q_B is passed by the two series connected NOR gates to the direct clear of A (C_DA), which inhibits any further transitions until the devices are reset. As can be observed, the high condition of the Q output of flip-flop A exists only during one complete period of the input to the period selector. This high state is inverted and becomes the gate timing signal.

During the normal operating sequence of the period selector, C_DB must be kept low and C_DA must be connected to Q_B. In order to reset the selector, both C_DA and C_DB must go high. A d.p.d.t. switch could perform this function, were it not for contact bounce. This problem is further discussed in the manual reset section. The use of the gating arrangement rather than a switch will then become clear.

Manual reset
The counter is reset by setting the Q outputs of all flip-flops to the low state. This is accomplished by making all direct clears high.

The circuit used is independent of the duration of contact bounce, and meets all constraints of the devices being used. It is, in essence, a bistable multivibrator. Fig. 6 with its accompanying table, illustrates the various high and low states of the possible switch conditions. As the table shows, once the switch arm makes contact with either the normally closed (N.C.) contact, or the normally open (N.O.) contact, no amount of bounce can change the state of the output. The only restriction for the switch arm is that it cannot rebound completely between the N.C. and N.O. contact. (Switches of this variety could be called choppers or vibrators.) As in a true switch action, this arrangement yields the complimentary output, either a momentary ON or OFF condition. In this system, unused sections of quad gates are used in the switch to perform the necessary inversion. For this purpose, gates, buffers, or inverters can be used.

One-shot multivibrator
As explained earlier the one-shot maintains the reset pulse for 5μs to insure complete reset. Fig. 7 illustrates the one shot configuration of two r.i.l. NOR gates and only one resistor and capacitor. In a quiescent condition, prior to an input pulse, a steady current flows through R appling a high voltage level or logical “1” to B1. This results in a logical “0” at B3 which is fed back to input A2. Since both A inputs are at a logical “0” at this time, A3 is at a logical “1” level. There is little charge stored in C since both plates are at about the same potential.

If a positive going pulse (logical “0” to logical “1”) is now applied to input A1, A3 goes low and C begins to charge. The high initial charging current through R drops the voltage at B1 to a logical “0” that, together with the permanent “0” at B2, switches output B3 to a logical “1”. This “1” is fed back to input A2 and maintains A3 at a low level until C charges to the point where B1 reaches the logical “1” threshold level. Then output B3 is switched to a “0” completing the generation of the monopulse. The “0” at B3 is fed back to A2 and the one-shot has returned to its original quiescent state. The presence of this feedback loop makes the duration of the one-shot output relatively independent from the duration of the trigger input. It insures that the output of gate A will remain a “0” after the trigger input has reverted to a “0”. Thus the duration of the “1” output from the one-shot is determined by the value of R and C, not the time duration of the trigger.

Decade counting unit
In this counter a decade counting unit is a device which contains a divide by ten counter, a b.c.d.-to-decimal decoder and a numerical readout. As shown in Fig. 8, the divide-by-ten function is accomplished very simply by using the Motorola MC780P decade counter.

The most inexpensive way of performing the decoding and readout function is by using the current summing technique. Here, the outputs of the MC780P are used to control the on-off condition of four
transistors. The values of the collector resistors form a sequence in which each is twice the preceding, resulting in binary weighted collector currents. The currents are brought to a summing junction and since the aggregate current can be in only one of ten discrete states, it is readily displayed on a current meter with a zero to nine scale. An accumulative error of even ±0.25 mA still allows plainly discernable readings. For best results, however, 1% precision resistors are recommended. The resistor values chosen provide more than 10 mA to the meter. This allows shunting of the movement to compensate for meter variations.

Switch functions
The input sensitivity switch (50–300 mV or >300 mV) selects the most beneficial input impedance and protection for the two positions provided.

The input frequency range switch has two ranges: the f position permits measurement over the 10 Hz to 4 MHz range and the f/10 position causes the input frequency to be divided by ten, extending the range by almost an order of magnitude up to 20 MHz.

An MC838P d.l. decade counter is used to divide the input frequency by ten, as shown in Fig. 11, and imposes the requirement of a 1 μs input fall time for toggle operation. This constraint and input signal rise time determine the minimum operating frequency of the counter. The maximum operating frequency is also determined by the MC838P which is guaranteed only to 20 MHz.

The operate/calibrate switch switches the 100 Hz line frequency to the pulse shaper for a rough calibration check.

The frequency/pulse switch selects the mode of operation. Essentially, it interchanges the input signal and the internal oscillator signal to count gate inputs.

The period/period +10 switch provides a reduced frequency clock signal to the d.c.u.s to allow the longer periods to be read without over-ranging the readout.

The frequency/pulse multiplier and gate time switch provides decade ranging for both frequency and period measurements, selects the gate times for random pulse counting, and establishes the recycle time in the automatic reset mode.

The auto/manual switch selects the input signal sampling mode. The manual reset button is a momentary push button which resets and recycles the input signal sampling manually. The on/off switch is self-explanatory.

Power supply
A power supply circuit is not given here. Two d.c. voltages are required 6V at 100 mA and 3.6 V at 500 mA. A low voltage 100 Hz output is required from the power unit as a calibration signal.

Additions and Corrections
In the article "Tone-balance Control" in the March issue the following section was inadvertently omitted from p. 124, column 3. It should be inserted between "to" and "frequencies" in the 19th line from the bottom. "Provide a chosen maximum bass boost of x 2.5 and the nearest standard value of 68 kΩ was selected. At low frequencies I/C, becomes very large and equation (2) reduces to...

The condition for maximum bass boost is $R_1 = 0$, $R_2 = 100kΩ$

- Next the value of $R_1 = R_1'$ was calculated to give a maximum treble boost of x 2.5. At high frequencies $I/C, becomes very small and equation (2) reduces to...

The maximum treble boost condition has $R_1 = 100kΩ$ and $R_2 = 0$. The standard value of $22kΩ$ was selected.

- Finally, the value of $C_1 = C_1'$ was calculated using the second root of equation (3), which is...

$$C_1' = \frac{1}{\omega^2 C_1}$$

so as to give a crossover frequency of 800 Hz, giving $C_1' = 4100 \mu F$. The value actually used was 1500 μF in parallel with 2200 μF (both polystyrene) giving $C_1' = 3700 \mu F$ and a calculated crossover frequency of 880 Hz.

The selected component values were substituted back in equation (2) and the system gain was calculated for a number of...

The following corrections should be made to the article "Stabilized Power Supply" by A. J. Ewins which appeared last month. The collector of $771$ in Fig. 4 should be connected as shown in Fig. 3. In Fig. 8 there should be no connection between position 6 and the wiper of $S_p'$ and similarly in Fig. 9(a) there should be no connection between $S_p'$ and position 1, and the 250Ω potentiometer. Finally amend note in Fig. 9(b) to read "+V output terminal".

Supply of low-noise f.e.t.s
The Amelco low-noise field-effect transistors specified for the "80-metre S.S.B. Receiver" (March 1970) and for the "Simple Audio Pre-amplifier" in this issue, are available from Souris Lectropon Ltd, Shirley Avenue, Vale Road, Windsor, Berks. The price is 6s 8d for the 2N4302 and 8s 3d for the 2N4303.
From the recent London Physics Exhibition

Digital topics: Opto-electronics: Capacitor-transistor delay line

An example of what can be done with adaptive logic was demonstrated by Twickenham College of Technology. An adaptive logic gate is in fact a combination of gates which are capable of carrying out any logic function on the inputs applied to it as directed by separate control inputs. If wished, the control input to a particular gate can be derived from the output of another adaptive logic gate and in this and other ways extremely complex networks can be built up. The whole point is that a network is not necessarily purpose-built for a particular application and the network adapts itself to perform the function required of it—which may not necessarily be known in the first instance. Much work is being done in the use of adaptive logic for pattern recognition purposes.

Twickenham College of Technology showed an adaptive logic network operating in conjunction with a simulated vehicle routing system. The position of a vehicle was indicated on a c.r.t. and was determined by the contents of two bi-directional binary counters, one operating in the X and the other in the Y plane. The output of the adaptive network was used to control the direction of the two counters and the object was to establish as many routes as possible between two arbitrarily selected points within a specified number of steps.

In the system the control inputs of the adaptive gates were connected to binary counters so that every possibility was tried in turn. The adaptive gates were arbitrarily connected and the connections were altered after trials with the object of finding the most successful network.

I.C.L. were demonstrating speech recognition equipment which enabled a complex computer programme to be controlled by unskilled operators who merely had to answer Yes, No, Wrong or Stop in response to instructions and questions presented on a c.r.t. by the computer. The speech analyser used split the sound into a number of parallel paths, each path being employed to recognize the presence or absence of some particular feature.

Some of these features are indicative of the way in which speech sounds are produced. For example it is possible to distinguish between voiced and unvoiced sounds on the basis of relative energy content. A voiced sound is a vowel or vowel-like sound produced when air is forced through the vocal chords causing them to vibrate. The resulting puffs of air excite the resonances of the vocal tract. These resonances are called formants. The formant frequencies are dependent on the position of the tongue and lips as these affect the shape and volume of the resonant cavities. Information about the speech sounds is conveyed by the formants rather than by the pitch of the voice (frequency of vibration of the vocal chords). An unvoiced sound is produced when air is forced through a narrow constriction in the mouth or throat, producing a hiss-like sound. Stop sounds, e.g. "t" in eight, are characterized by a short period of silence followed by a plosive sound as the built up air pressure is released.

Other features provide information as to where in the mouth the speech sounds were produced. Thus in the speech analyser, there are circuits for measuring the frequencies of the two lowest formants. At present, the outputs of these circuits are classified into one of four frequency levels. There is also a circuit for detecting high-frequency unvoiced sounds, e.g. "s" in see.

A computer for educational purposes was shown by the University of Durham in conjunction with the Darlington College of Technology which was designed and built with the aid of a grant from the National Research Development Corp. It does all the things one would expect an educational computer to do and has a 128-word store (a word is 12-bits long) which enables some useful computing to be done. Integrated circuits and printed circuit cards help limit the cost to something less than £2,000. Further information may be obtained from I. Sagues, Computer and Automation Group, N.R.D.C., P.O. Box 236, Kingsgate House, 66-74 Victoria St, London S.W.1.

There is a growing interest in the possibility of having communications systems operating at infrared or light frequencies. The main attraction for the developers here is the enormous number of channels available and also the complete immunity from electrical interference. Military authorities have a special interest in communications at light frequencies because a further advantage is that information transmitted over an optoelectronic link can be received only at the intended reception spot and it cannot be tapped en route.

The principles of communication at light frequencies were described in the November 1968 edition of Wireless World pp. 393–5 where we reported on technique for generating sub-millimetre waves, and how since the development of the laser, coherent optical transmissions have extended electromagnetic radiation into the visual spectrum of frequencies.

Two examples of infrared communication could be seen at the exhibition. The first was a simple audio rig by the North Staffordshire Polytechnic comprising a gramophone pickup at the transmitting end and an amplifier and loudspeaker at the receiving end. Signals from the pickup were amplified and used to modulate the current passing through a gallium arsenide diode. Modulated infrared radiation emitted from the electroluminescent diode was received by a silicon phototransistor some distance away and the photocurrent, after suitable amplification, was used to operate a loudspeaker. The circuits were developed from original ideas from Mullard and the second example of infrared communication to be seen was a similar set-up by Mullard themselves. This system was operated from internal 9V batteries to demonstrate its portability and since both diode and phototransistor work at wavelengths of the order of 0.9 m ordinary glass lenses were used for focusing. The prototype is claimed to work satisfactorily at a range of 600ft.

Both systems are intended for physics teachers to demonstrate the nature of infrared radiation. The techniques used have been known for a number of years. It is probable that the really advanced experiments in infrared communication are taking place behind locked doors in government research establishments and these will not see the light of day (or night) until they become redundant militarily.
A rather more ambitious system by Mullard, this time using light frequencies (0.63μm) transmitted through a 10-ft length of glass fibre bundle, demonstrated the transmission of a 4 MHz bandwidth television picture from a nearby camera tube, through the fibre-optic system, and displayed on a standard TV monitor. This had an electro-optic modulator at the transmitter and a photodiode at the receiver. Self-aligning plug-in mounts were employed thus allowing the interchange of light sources and detectors. The light source used in the exhibit was a small tungsten bulb and a lens focusing the light through the modulator on to the end of the fibre bundle.

Interest here was mainly the design of the modulator itself. It consisted of two crystals of ammonium dihydrogen phosphate (a.d.p.) separated by a half-wave plate. The incident light beam travelled through the crystals as two rays polarized at right angles, known as ordinary and extraordinary rays. The ordinary ray travelled normally through the crystal for normal incidence whereas the extraordinary ray was refracted through a small angle. The crystals were arranged so that the two rays coincided on emergence from the modulator. The half-wave plate rotated the polarization planes of the two rays through 90° so that the ordinary ray in the first crystal became the extraordinary ray in the second and vice versa. This cancels the natural birefringence and provides temperature compensation for changes in the refractive indices.

The rays travel through the crystals with different velocities depending on the applied electric field. Incident plane polarized light emerged elliptically polarized. A polarizer set at right-angles to the incident plane selected the component of polarization induced by the modulator. The intensity is given by:

\[ I = I_0 \sin^2\left(\frac{\pi Vt}{2\tau}\right) \]

where \( V \) is the applied voltage and \( V_0 \) the half-wave voltage. The half-wave voltage at 0.63μm is 260V. Capacitance of the modulator is 46pF. A frequency range of 0-36MHz is possible, using a 100-ohm source impedance.

Standard Telecommunication Laboratories were also showing a wideband optical communication system using an injection laser and glass fibre waveguide. The laser was pulse-code modulated by switching the pump current, allowing repetition rates up to about 1GHz. A feature of this system is that long communication links are possible using as many repeaters as necessary because p.c.m. repeaters can be cascaded indefinitely.

The exhibit simulated a 75Mbit/s signal which was fed into a pulse amplifier. This used eleven BFY90 transistors with their collectors distributed along a 1-2 line feeding the GaAs laser. Current through the laser was switched between 0.1A and 1.1A and the p.c.m. optical signal thus developed was coupled to a glass fibre transmission line. This was terminated by a photodiode, the received signal being amplified and fed into a regenerator which re-timed and re-shaped the pulses.

A drawback to this system is the need to cool the laser for operation at high duty ratio, but STL say they are pursuing a lead which may make a room-temperature laser possible.

Analogies with everyday objects have found common usage in electronics language to provide simple explanations of the principle of operation of some basic circuits, although sometimes the object to which the circuit is analogous is equally vague to some. For example, what to an Englishman is a "box-car"? He is more likely to derive his explanation the other way round by observing the waveform to which it is supposed to have a likeness. Readers may feel things have gone slightly too far when a temporary storage device for electronic signals is described as a 'bucket-brigade delay line' because its configuration is said to resemble an old-time fire brigade passing along buckets of water. Since it was developed by Philips' Eindhoven laboratories however, it could be dismissed as being Double-Dutch!

In fact this was an interesting piece of equipment based on a chain of storage capacitors and charge transfer circuits acting as an analogue switch register with externally variable shift rate. It is suitable for delaying audio and TV signals. Outstanding among the advantages over L/C and glass delay line systems is the facility to vary the delay time over a wide range.

Information is transferred along an array of capacitors as a moving charge "deficit" with one transistor per capacitor. This circuit could easily be made as an i.c. Two complementary clock signals are used, with a frequency equal to the frequency with which the input signal is sampled. The device provides a delay in which bandwidth and delay are inversely related and variable within wide limits, thus: \( n = 4BT \) where \( n \) is the number of 'buckets', \( B \) = bandwidth and \( T \) = time delay. Signal delay is varied electronically by varying the clock frequency which can be precisely controlled or synchronized. One application which can readily be foreseen is to compensate for undesirable echoes from widely spaced loudspeakers in public address installations.

New applications for colour television continue to be found. What at first sight looked like a colour TV designer's nightmare on the stand of Delft University of Technology, Netherlands, turned out to be a demonstration of the deliberate distortion of hues for the purpose of medical diagnosis. It was done by an electronic process of expanding the colour differences of colours which lie in the yellow/red sector of the chromaticity diagram, i.e. colours which cover flesh tones, and compressing the colours which lie outside the area of interest for purposes other than medical (e.g. colour matching), any sector of the chromaticity diagram could be selected depending on the axes chosen for the quadrature modulators.

Because colours outside the area of interest are compressed and those inside are multiplied by a factor of 6, the colours seen on a TV monitor screen are untrue, but this is of little consequence in diagnostic work. The important point is that small changes in skin colouring, indiscernible by normal observation, become substantial changes when viewed on the screen.

It is important to retain as much of the original information as possible, particularly luminance relations, and for this reason the luminance signal \( Y \) is extracted in a matrix, leaving the two colour-difference signals for processing independently of \( Y \). Unconvinced that we were not watching just a colour TV with a very poor grey scale, we asked the demonstrator to scan a black card covered by a white cross-hatch. It reproduced perfectly on the monitor receiver—in black and white.

In developing a sonar system for charting the ocean floor out to a range of 12 nautical miles (22km) the National Institute of Oceanography has devised an efficient piezo-electric transducer operating at about 6.5kHz and capable of delivering 600 acoustic watts (duty cycle 1:6).

The transducers are unusual in that they have no nodal mounting. They are secured in a pressure casing by a bezel ring forged from a die cast aluminium alloy RR77 to provide a high fatigue limit and low hysteresis. In order to inhibit any stress corrosion due to flexing near the ring the complete transducer diaphragm is coated electrostatically with an epoxy resin. The main advantages of this method of mounting are manufacturing simplicity, low mechanical losses, a reliable water-proof seal, and the availability of a pressure release medium for the rear surfaces provided by the air in the casting. The active material is lead zirconate titanate with a particularly low dielectric loss for high power operation.
Track-while-scan Radar System

How a radar system is used with a computer to provide automatic target tracking

by J. L. Sendles*

Radar contacts derived from a conventional surveillance pulse radar are normally displayed on a plan position indicator (p.p.i.). The formation of tracks from the radar "paints" has hitherto been carried out by an operator by keeping a joystick controlled marker nearly coincident with successive radar paints.

This method of tracking has two main disadvantages; firstly it requires the full-time attention of a man who can track up to about eight surface, or one or two air, tracks (the actual number of targets capable of being satisfactorily tracked depends on the degree of manoeuvre of these targets), and secondly, in order to achieve reasonable tracking accuracies, expensive p.p.i. displays with minimal registration errors are necessary.

Attempts have been made in the past to produce a completely automatic contact initiation and tracking system capable of processing information from pulse surveillance radars, but due basically to the presence of excessive clutter (interference) in certain environments these systems have now been rejected in favour of the less sophisticated systems which take advantage of the human operator's considerable skill in detection and subsequent initiation of radar contacts. Once initiated, the contacts are automatically tracked by a digital data processing system which is the subject of this article.

The advantages of this automatic radar contact tracking system are, firstly, that the man is relieved of the tracking task and can therefore devote virtually his full attention to the detection of contacts and initiation of tracks and, secondly, greater tracking accuracies than those possible from a purely manual system are in general obtained.

The article describes an autotracking system which has operated with an X-Band maritime navigational radar and an S-Band surface and air surveillance radar. Both of these systems have been successfully proved at sea. Also described is an autotracking system for a (ground-based) three-dimensional C-Band air surveillance radar which has also been successfully proved.

System description

All autotracking systems to be described are based on similar equipment which is shown in block diagram form in Fig. 1. The display incorporated in these systems is a 16-inch horizontal p.p.i. which displays synthetic alphanumeric information supplied by the character generator, interlaced with the conventional radar range and bearing information derived from the radar's aerial bearing, video and synchronisation signals. Attached to the display console is a general purpose keyboard and "rolling ball" module, the outputs of which are processed respectively by the keyboard decoding unit and the reversible counter unit, the outputs of which are fed to the 920 computer via the peripheral controller.

The "rolling ball" provides a means of manually moving a synthetic marker on the p.p.i. display which, in conjunction with the keyboard, is used to initiate or cancel tracks. The outputs from the radar to the autotrack peripheral equipment are the radar video signal, the radar synchronisation pulse and the aerial's bearing which is the output of an incremental encoder together with a ship's head marker signal. In the case of the three-dimensional radar the beam's elevation is also controlled by a data processor and is fed by the computer to the radar via the peripheral controller and the autotrack peripheral equipment.

The computers incorporated in these systems are members of the Elliott 920 computer series. The associated paper tape station comprises a paper punch, reader, controller and power supplies.

Two-dimensional surface and air surveillance

A block diagram of the track-while-scan (t.w.s.) peripheral equipment is shown in Fig. 2. The t.w.s. facility is manually initiated by an operator viewing the p.p.i. display and placing the synthetic rolling ball marker over the radar paint of the contact he wishes to track, and by feeding the appropriate instruction to the computer using the keyboard. The computer immediately stores the cartesian co-ordinates of the target and begins to track it. The computer also calculates the polar o-co-ordinates of the target (range and bearing $R_1$ and $B_1$) and derives the co-ordinates of the t.w.s. window; indicated by the shaded area of Fig. 3. This window is defined in the equipment by the opening of two gates, the range gate and the bearing gate. The bearing gate start (or open) signal is derived by comparing the output of a position digitiser attached to the radar aerial with the bearing of the leading edge of the window, already calculated by the

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*Elliott Bros.

Fig. 1. Track-while-scan block diagram.
computer, and opening the bearing gate (BGS) when coincidence occurs, i.e. when the aerial is in line with the leading edge of the t.w.s. window.

As soon as the bearing gate opens 1 μsec spaced pulses are fed to the range counter of Fig. 2. The contents of this counter are compared with the contents of the range gate start register which holds the range of the t.w.s. window previously calculated by the computer. When the contents of the range counter are the same as the contents of the range gate start register, shift pulses at 0.5μsec intervals are allowed to reach the sequence register. By virtue of the circuitry just described these shift pulses only reach the sequence register when the radar aerial is receiving returns from the area defined by the t.w.s. window.

Video signals, after being processed in a manner to be described later, are fed to the data input of the sequence register and can have the value of 1 or 0 depending on whether the signal is above or below a computer controlled threshold. After 18 shift pulses (9.5μ secs) the shift pulses are stopped and the contents of the sequence register are transferred to the computer.

At the start of the next radar pulse repetition interval the range counter is reset and the process is repeated.

Before arriving at the sequence register the video signal passes through the video processor unit and the threshold control unit. The purpose of the video processor is to ensure that the input to the threshold unit is virtually independent of receiver output noise variations caused by receiver gain changes—which is particularly important when autotracking targets which give a weak return signal.

The threshold control unit comprises a six-bit digital to analogue converter which is driven by the computer. The d.c. output is differentiated with the output of the video processor unit in order that the video, after being quantized and processed, is controlled in bearing width for each target plot being extracted to approximately one beam width. The actual threshold control programme within the computer in order to achieve optimum performance depends on factors such as the type of radar and its mode of operation.

The process of video digitization over the extent of the sequence register starting when the range and bearing gate opens continues on each p.r.i. until a sufficient area around the contact's indicated position has been covered. A pictorial representation of the information which is derived and stored in the computer for further processing is shown in Fig. 4. The black areas represent points at which the processed video is above the computer controlled threshold and the remaining areas represent points at which it is below.

Controlling by the threshold control unit the threshold level above which video will enter the sequence register is a valuable facility, particularly when tracking surface contacts, for two main reasons; the first is that greater tracking accuracies can be achieved and the second that greater discrimination can be obtained in a multicontact environment.

Plot extraction

Plot extraction techniques for conventional surveillance pulse radars are well known and basically involve what is known as moving average detection criterion (m.a.d.c.).

The m.a.d.c. which is used to detect the start and end of a plot states that a target start is established if, at any particular range, three out of five (say) quanta are present, and the end of a target is detected when the average drops to two out of five or less. With this particular criterion of three out of five and referring to Fig. 4 it can be seen that target starts occur at $R_s (B_3, B_4, B_5, B_6)$ and at $R_a (B_4, B_5, B_6, B_7)$. Having established the extent of the target by means of the m.a.d.c. as described above the computer next derives its centre and thereby the co-ordinates $(B_n, R_f)$ of the target with respect to the window, and thence to a suitable datum.

This plot extraction procedure, leading to the derivation of the target's co-ordinates or plot, is repeated on each aerial rotation. The position of the 'window' is fixed in the first instance as we have seen by means of a manual injection but subsequently its position is predicted as a result of a target tracking and smoothing programme.

Three-dimensional air surveillance

As can be seen from the track-while-scan system block diagram shown in Fig. 1, the only difference between two- and three-dimensional systems as far as the equipment is concerned is that in the case of the three-dimensional system the elevation of the aerial's beam, which is driven electronically, is computer controlled via the peripheral controller. The main difference between the two systems is in the computer plot extraction programme which, as its name suggests, derives the contact's position (or plot) from the quantized video input to the computer.

Having described the plot extraction process which has been adopted for the

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*www.americanradiohistory.com*
two-dimensional surveillance radar, we shall now consider the three-dimensional case. As stated previously the elevation of the aerial’s beam is electronically controlled via the computer so therefore, by means of a suitable programme, it is an easy matter to execute an elevation scan as the aerial rotates at a constant speed such that the bearing separation between each vertical scan does not exceed the horizontal beam width, and also the elevation separation between each range scan does not exceed one vertical beam width, see Fig. 5. In this way the video signals returned from a volumetric element of sky are digitized in the same way as in the two-dimensional case and are stored in the computer in ‘bearing blocks’, for subsequent processing using the moving average detection criteria in order to derive the range, elevation, and bearing of the ‘plot’.

Cases often arise, both in the surface and air environment, where two contacts, after all processing including integration by the m.a.d.c., remain within the same ‘window’. Examples of this are a ship passing a buoy, two ships passing a ship passing close to shore, a ship in a clutter environment, aircraft passing, aircraft in a clutter environment etc.

In order to minimize the requirement for manual override in such confused situations, which obviously is one method of resolving the problem, a detection shape criterion was introduced into the system. This ensures that only genuine contacts or contacts which appear to be genuine are accepted. Furthermore, it is possible by this means to detect merging tracks and thereby to predict the contact’s established track until the two contacts again separate, when derived plots are once more used to update the track. Lost situations occur due to fading contacts, which can either be long term or short term. Short term fades are no problem since the loss of one plot normally has little effect upon the track formation. Long term fades in the presence of established non-manoeuvring contacts are again no problem since when the contact reappears it will be sitting at or near the centre of the ‘window’ which is predicted on by the tracking programme in lost situations. The circumstances which normally require manual intervention are those in which an extended contact fade is accompanied by a contact manoeuvre so that when the contact reappears it does not appear in the predicted window.

Results

Fig. 6 shows the range and bearing plots derived by the two-dimensional track-while-scan system from a slow air contact with a speed of 100 kn, detected on a medium range air/surface surveillance radar which has a p.r.f. of 400 Hz and an aerial rotation rate of 1 rev. per 2.5 seconds. No confused plots and only isolated missed plots occurred due to contact fading.

Fig. 7 shows the range and bearing of plots derived by the two-dimensional track-while-scan system from a surface contact. Smoothing of this data is carried out by a track smoothing programme which follows the plot extraction programme. This contact was detected by a navigational radar which has a p.r.f. of 1000 Hz and an aerial scan rate of 1 rev. per 2 seconds. The contact is that of a slowly moving surface vessel at a range of 25 miles. The radar echo was rather weak and consequently short sequences of missed plots occurred which amount to 30% of all plots. Two steps of 4 × 1/96 dm (dm—data miles = 2000 yd) can be seen on the range plot, which is equivalent to one ½ μs range increment (which is the resolution) of the sequence register. The other variation in the range plot is caused by the averaging which is being carried out within the computer.

Fig. 8 shows a graph of the plots in bearing and elevation against range obtained from the three-dimensional air surveillance radar aerial.
surveillance track-while-scan system while tracking an aircraft target with a speed of about 300 miles/hour.

The aerial of the three-dimensional air surveillance radar is shown in Fig. 9. Elevation scanning is performed by electronic switching, whereas azimuth scanning is achieved by the aerial rotating about a vertical axis. Fig. 11 shows the horizontal p.p.i. display on which the range and bearing of the radar contacts are displayed together with (computer derived) alphanumeric characters. Adjacent to the display is a keyboard and rolling ball module incorporating a four-digit numerical read-out.

The computer system employed for the three-dimensional track-while-scan system is shown in Fig. 10. It incorporates an Elliott 920M micro-miniature computer with 16k word store, computer power supply unit, control and monitor panel, display unit and a paper tape station, comprising an on-line teleprinter, punch, reader and controller with an associated power supply unit.

Acknowledgements

I would like to thank the Admiralty Surface Weapons Establishment and G.E.C. Space and Weapons Systems Limited for the support they have given prior to and during the preparation of the article.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses.

LONDON
May 5-15
Mechanical Handling Exhibition
(Illiffe Exhibitions, Dorset House, Stamford St., London S.E.1)
May 11-13
Middlesex Hosp. Med. School
Television Measuring Techniques
(I.E.R.E., 8-9 Bedford Sq., London W.C.1)
May 11-16
Olympia
Instruments, Electronics & Automation Show
(Industrial Exhibitions, 9 Argyll St., London W.1)
May 19-21
Savoy Place
Signal Processing Methods for Radio Telephony
(I.E.E., Savoy Pl., London W.C.2)

EASTBOURNE
May 5-6
Grand Hotel
Instruments in Working Environments:
Design, Specification, Operation
(Mrs. S. Bryant, British Scientific Instrument Research Assoc., South Hill, Chislehurst, Kent BR7 5EH)

MANCHESTER
May 19-22
Belle Vue
ITEX 70: Industrial Training Exhibition
(John Clarke (P.R.) Ltd., St. James House, 44 Brazennose St., Manchester 2)

OVERSEAS
May 4-6
Gaithersburg
Transducer Conference
(H. P. Kalmus, Harry Diamond Labs., Dept. of Army, Washington, D.C. 20430)
May 7-8
Minneapolis
Circuit Theory
(Department of Conferences and Institutes, Nolte Center for Continuing Education, University of Minnesota, Minneapolis 55455)
May 11-14
Newport Beach
Microwave Symposium
(R. H. Daflamel, Granger Assoc., 1601 Calif. Ave., Palo Alto, Calif. 94304)
May 13-15
Washington
Electronic Components Conference
(Electronic Industries Association, 2001 Eye St., N.W. Washington, D.C. 20006)
May 18-20
Dayton, Ohio
Aerospace Electronics Conference
(I.E.E.E., 124 E. Monument Ave., Dayton, Ohio 45402)
May 25-30
Versailles
IMEKO Measurement Conference
(A.F.C.E.T., Centre Dauphine, Place de Tassigny, Paris 16e)
May 27-6une 4
Paris
Mesucora
(Mesucora Secretariat, 40 rue de Colisée, 75 Paris 8e)
May 28-June 1
Basel
Didacta: European Educational Materials
(Schweizer Mustermense, CH-4000 Basel 21)
Personalities

Among those recently elected Fellows of the Royal Society are John F. Coales, O.B.E., M.A.(Cantab.), F.Inst.P., professor of engineering (control) at the Engineering Department, University of Cambridge, "distinguished for his work on the development of radar, digital computers and on the theory and application of modern control systems for industrial purposes"; Brian D. Josephson, M.A., Ph.D., assistant director of research at the Department of Experimental Physics, Cavendish Laboratory, University of Cambridge, "distinguished for his contributions to the theory of the behaviour of junctions between superconductors, including the discovery of the Josephson effect" (readers may recall Dr. Josephson’s article on superconducting devices in our October 1966 issue); and F. Graham Smith, M.A., Ph.D., professor of radio astronomy at the Nuffield Radio Astronomy Laboratories, Jodrell Bank, University of Manchester, "distinguished for his contributions to radio astronomy, and especially for investigations of sources and of the magnetic field of the galaxy."

Percy A. Allaway, chairman of EMI Electronics Ltd, has been elected president of the Electronic Engineering Association in succession to Sir Ian Orr-Ewing, Bt., O.B.E., M.A., M.I.E.E. Mr. Allaway, who is 55, joined the Gramophone Company in 1930 and spent the war years designing equipment for radar and other electronic devices for the Armed Forces. After the war he transferred to the domestic appliance side of EMI. He was appointed general manager of EMI Engineering Development Ltd in 1953 and works director in 1956. When EMI Electronics Ltd was formed to integrate the Group’s activities in military electronics and industrial capital equipment, Mr. Allaway was appointed works director becoming managing director in 1961. He was appointed to the board of Electric & Musical Industries Ltd in 1965, and from 1st July 1969, when EMI formed its U.K. Electronics and Industrial Operations Unit by bringing together EMI Electronics with all its other electronics and industrial operations, he became chairman of EMI Electronics Ltd and deputy chairman of the U.K. Electronics and Industrial Operations.

Data Recognition Ltd, a member of the Unitech group of companies, has announced the appointment of Roy Roper as managing director. He was previously deputy managing director and marketing director of Racal Instruments Ltd, which he joined in 1966. Mr. Roper, who is 39, was a director of Weir Electronics (another Unitech company) before joining Racal.

A. J. Young, C.B.E., B.Sc., M.I.E.E., chairman of GEC Electronic Tube Company and managing director of English Electric Valve Company, has in addition been appointed chairman of GEC Semiconductors Ltd which embraces AEL Semiconductors at Lincoln and Marconi-Elliott Microelectronics at Witham and Glenrothes. Mr. Young, who is 62, joined the Marconi Company in 1934 as a valve engineer. He was recently appointed chairman of the U.K. Electronic Valve and Semiconductor Manufacturers’ Association and chairman of the Electronic Components Board in succession to Dr. F. E. Jones, F.R.S.

G. H. Doust, group managing director of the Plessey Company, has been elected chairman of the U.K. Radio and Electronic Component Manufacturers’ Federation, and succeeds A. J. Young as vice-chairman of the Electronic Components Board.

C. C. McCallum, director, Thorn Radio Valves and Tubes, is the new chairman of the British Radio Valve Manufacturers’ Association.

A. J. Brunker, B.Sc.(Eng.), A.C.G.I., D.I.C., F.I.E.E., at one time chief engineer to the Ekco Group and latterly a director of a number of Ekco companies, has retired. During the war Mr. Brunker, who graduated at the City and Guilds Engineering College, was appointed deputy director of radio production in the Ministry of Aircraft Production. In 1947 he joined E. K. Cole Ltd, as general manager of the Export Department and in 1953 was also appointed director and general manager of the newly formed Ekco Electronics Ltd. He later became chief engineer to the Ekco Group and in 1956 was appointed to the board of E. K. Cole Ltd, having also become a director of a number of the Ekco group of companies. Mr. Brunker was a council member of the Electronic Engineering Association and founder chairman of its Industrial Electronics Division.

Ivan J. P. James, B.Sc., F.I.E.E. F.I.E.R.E. who has been with EMI since 1937, was recently appointed director-technical, Television Equipment Division of EMI Electronics Ltd. Hayes. Mr. James has been concerned with the company’s development of television equipment for the past twenty years and led the team which designed the 2001 colour television camera. For the past three years he has been general manager of television development and production.

M. W. Blades, who joined Plessey last year from AEI Semiconductors Ltd where he was manager, signal semiconductors, has been appointed general manager of the Plessey Components Group’s Microelectronics Division. Mr. Blades joined Edison Swan Electric Company, Brimsdown, as a graduate apprentice in 1953, and later, when the radio and electronic components department of Edison Swan was merged with other component interests in AEI, became head of product research (semiconductors) for the AEI Valve and Semiconductor Group at Lincoln.

J. E. Morley has retired from his position as sales director of Grampian Reproducers Ltd. He joined the company in 1940 as service manager and became sales manager shortly after the war. He was appointed to the board of directors in 1966.

Bob Powell, who joined Hewlett-Packard as a sales engineer in 1965, and has successively been manager of the analytical group, North European analytical manager and marketing services manager at Slough, has been appointed to the new post of electronics sales manager at the company’s south Queensferry plant, Scotland. Hewlett-Packard also announces the appointment of Arthur Hendrie as sales promotion manager.

A. Frank Boff, B.Sc., F.I.E.E. who joined Racal Instruments Ltd, as technical director five years ago has resigned "to devote himself to a wider range of interests." He will continue as a consultant to Racal Electronics Ltd. A graduate of London University Mr. Boff, who originated the Boff snap-off diode, went to America in 1950 where he joined Beckman Instruments. He then spent some time in Canada with the Marconi Company on communication system designs. Returning to the U.S.A. he became manager of research and development for the Dymec Division of Hewlett-Packard and from 1960-64 was technical manager of Hewlett-Packard in the U.K. Mr. Boff is succeeded as technical director of Racal Instruments by Keith R. Thrower, M.I.E.E. who has been with the Racal group for nine years and two years ago became a director and chief engineer of Racal Instruments Ltd. The company also announces the appointment of J. E. Engledew as marketing director.

Bob Powell
Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES
Semiconductor literature available from AEI Semiconductors Ltd, Carholme Rd, Lincoln, gives the vital statistics of microwave devices, signal diodes, reference diodes, rectifier diodes, thyristors and triacs.
AEI quick reference data ................................................. WW401
Price list ................................................................. WW402

"Valve and Picture Tubes—Data Book, 1970" from Thorn Radio Valves and Tubes Ltd, Publicity Department, 7 Soho Square, London W1V 6DN, gives abridged data and pin connections of Mazda components. It contains an "obsolescent section" giving early warning of valves which will not be manufactured again.
Mazda 1970 data book .................................................... WW403
Wall chart colour TV tube and valve replacement .................. WW404

A wall chart listing Motorola silicon power transistors is available from Celdis Ltd, 37-39 Loverock Rd, Reading RG3 1ED ........................................ WW405

"Industrial Discrete Devices" is the title of a catalogue from SGS (U.K.) Ltd, Planar House, Walton St, Aylesbury, Bucks, giving data on a wide range of transistors ................................. WW406

Amendment No. 12 is available for the loose-leaf catalogue issued by Hvac Ltd, Stonefield Way, Ruislip, Middlesex HA4 1JT ............................. WW407

We have received more literature on the d.l.l./t.t.l. compatible m.o.s. integrated circuits produced by General Instrument Microelectronics, Stonefield Way, South Ruislip, Middlesex.

"An introduction to the Giant family" .................................. WW408
SS-6-1032: Multiple shift registers (1 package contains 2 x 1-bit, a 2-bit, a 4-bit, an 8-bit and a 16-bit shift register) ...................... WW409
SL-6 2050/64: dual 50/64 shift register ............................... WW410

Two water-cooled thyristors (2WD CR15203B and 2WD CR7K03135), both rated at 700V, are described in leaflets from AEI Semiconductors, Carholme Rd, Lincoln. The first thyristor is rated at 700A and the second at 1,200A r.m.s. .................. WW411

PASSIVE COMPONENTS
The "Electronic Component Catalogue—1970" from SASCO, P.O. Box 2000, Crawley, Sussex, lists capacitors, connectors, ferrite components, fuses, lamps and holders, potentiometers, semiconductors, etc .... WW425

"Gardners new catalogue of old transformers" lists obsolescent transformers which are still available or can be manufactured to special order and is published by Gardners Transformers Ltd, Christchurch, Hampshire BH23 3PN ........................................ WW426

We have received some literature concerned with ceramic filters from Brush Clevite Co., Ltd., Thornhill, Southampton, SO9 1QX. The first item listed below shows how 455kHz i.f. filters can be made using standard ceramic filters, the dB bandwidth and selectivity being altered by external capacitors.

Identical resonator design tables ..................................... WW427
Bulletin 66006/A, miniature ladder filters .......................... WW428
Bulletin 66007, ladder filters .......................................... WW429
Bulletin 66009/A, "A guide to the use of piezoelectric ceramic filter elements and ladder filters" ...................... WW430
Bulletin 66021/B, hybrid coil and ceramic resonators .......... WW431

"High rejection filter in miniature ladder case for 12.5, 25, and 50kHz spacing communications systems" ........................................ WW432
Bulletin 66042, low-frequency ceramic filters (9-50kHz) .... WW433
Bulletin 66035, miniature low-cost ceramic filters (i.f.) .... WW434
Price list ................................................................. WW435

GENERAL INFORMATION
A large wall chart containing tables for converting British and U.S. units of length, area, volume, weight and liquid capacity to metric measure, and vice versa, has been produced by the Babani Finance and Trading Co, Ltd, The Grampians, Western Gate, Shepherds Bush Rd, London W10. The chart costs 7s 11d from booksellers.

List No. 171 "UKAEA list of publications available to the public" may be obtained from Atomic Energy Research Establishment, Harwell, Didcot, Berks ............................. WW458

The Computer Services Bureaux Association (COSBA), Berkeley Square House, Berkeley Square, London W1X 6JU, has available a directory of its members and the services offered by them ........................ WW459

Lloyd's Register of Shipping, Garret House, Manor Royal, Crawley, Sussex, have published a booklet "List of type-approved instruments and control equipment" for the shipping industry price £1 including postage.

H. F. Predictions—May

Since February solar activity has been somewhat higher than predicted by smoothed sunspot numbers so conditions for May are expected to be the same as for 1968 and 1969. Seasonal changes are most striking on routes within the northern hemisphere, the peaks of recent months are depressed giving optimum traffic frequencies (FOTs) below 20MHz which vary only very little for the most of the 24 hours. Daylight FOTs on the trans-equatorial paths continue above 20MHz and amateur 10-metre band openings should be possible.

LUF curves are for reception in the UK of point-to-point telegraph services using several kilowatts of power and high-gain aerials. For other services they will be displaced vertically but generally the proximity of FOT and LUF is a measure of difficulty of communication.
New Products

Filters for Marine Communications
Anticipating that all new ships will have to comply with the new G.P.O. and European Post and Telegraph Marine Communications Specification from 1972, Cathodeon Crystals have introduced crystals and L/C filters which meet this specification. Double, upper and lower sideband crystal filters are available at a reference frequency of 1.4MHz. An L/C filter, type BP4805, provides the r.f. selectivity in the 1.6 to 3.8MHz band. A single sideband filter for A3A and A3J transmission has an upper and lower sideband rejection at 1.4MHz of type BP4705 (A3A and A3J), offering bandwidths of type BP4704 of > 6dB with an insertion loss of -3.5 to +1kHz, insertion loss < 6dB, terminating impedance 1kΩ/15pF; type BP4705 (A3A and A3J), 6dB bandwidth +350Hz to -2kHz, insertion loss <6dB, terminating impedance 1kΩ/15pF or 5Ω, type BP4805, 2dB bandwidth 1.605 to 3.8MHz, insertion loss <3dB, rejection at 1.4MHz > 70dB, terminating impedance 200Ω or 50Ω. Cathodeon Crystals Ltd, Linton, Cambridge. WW316 for further details

F.M. Signal Generator
An f.m. signal generator, model 188, manufactured by Measurements, of New Jersey, U.S.A., is available in the U.K. from Wessex Electronics. Two-speed tuning is featured and modulation can be internal or external. This can be measured in three ranges without the need for an external voltmeter. Frequency range is 86-108MHz with ±0.5% accuracy. Output is 0.1-100,000μW and modulation 400, 1,000 and 10,000kHz (internal). Deviation is in three metered ranges of 0-30kHz, 0-100kHz and 0-300kHz, and deviation response is within 1dB from d.c. to 75kHz. Wessex Electronics Ltd, Royal London Buildings, Baldwin Street, Bristol 1. WW 316 for further details

Clutch/Brake Precision Potentiometer
Fairchild Controls have introduced a precision potentiometer incorporating a clutch/brake unit in one complete package. When the potentiometer is de-energized, the rotor-wiper is braked to prevent rotation imparted by shock, acceleration and vibration. At the same time, the input shaft is free to rotate. With the clutch/brake energized with 24-32V d.c., the input shaft is coupled to the rotor-wiper to permit adjustment of the potentiometer. The clutch/brake module is easily adaptable to all Fairchild Controls precision potentiometers ranging in size from 1/2 to 3 in. Fairchild Controls, Seestrasse 233, 8700 Kusnacht, Zurich, Switzerland. WW320 for further details

TO-3 Packaged Power Amplifiers
A family of hybrid i.e. class-D power amplifiers introduced by TRW Semiconductors Inc. is being marketed by MCP Electronics. The first four type specifications released are designated MCA1001/2 and MCB1001/2. They handle currents up to 10A from voltage lines up to 40V. With appropriate external connections a linear, efficient power control function is obtained. A complementary planar output stage is employed, and the circuits operate from a dual unregulated power supply. Typical electrical characteristics are: input hysteresis 200mV, input offset voltage 100mV; thermal resistance 2°C/W; switching time MCA series 1.0μs, MCB series 0.5μs. Absolute maximum ratings for the MCB1002 include: power stage supply voltage 40V; continuous d.c. output current 5A; peak output current (25% duty cycle), 10A; and switching frequency 40kHz. MCP Electronics Ltd, Station Wharf Works, Alperton, Wembley, Middlesex, HAO 4PE. WW321 for further details

Current Monitor
A precision current monitor designed to replace the ammeter in the control of mechanical, electronic, heating and security systems is announced by G & M Electronics. When the input current exceeds or falls below the required setting, the monitor provides a signal. It is adjustable and can detect currents of the order of 1-10mA. Higher currents can be monitored by shunting the input with a precision resistor. For transient input currents, an optional look-up feature is available, which retains the signal until reset. G & M Electronics Ltd, 46 Castle Road, Bedford. WW304 for further details

Wide-range Autobridge
Autobalance universal bridge, type B642, from Wayne Kerr measures an extended range of R, L, C and G values with an accuracy of 0.1%. Two meters respond immediately to changes in the resistive or reactive term of any impedance (including negative resistance) with decade controls available for backing-off to increase the discrimination up to 4 or 5 figures on all ranges. Normal frequency of operation is 10,000 radians/sec (1592Hz) but the bridge can be balanced manually at any frequency from 200Hz to 20kHz using an external source and detector. Analogue outputs are available from both meter circuits. Connectors are also provided for external standards. Sensitivity increases automatically as digits are backed-off; for special

www.americanradiohistory.com
applications, however, operators can select the sensitivity. This allows sudden changes to be accommodated without re-setting the back-off controls. The electronic nulling process is fully operative at all sensitivity levels. Overall measurement ranges are 1 femtofarad (0.001pF) to 10 farads, 10 picohms to 100 kilohms, 1 nanohenry to 10 megahenrys and 10 micro-ohms to 100gigohms. Two-terminal and three-terminal connections are available on most ranges, with a four-terminal arrangement to overcome lead losses for low impedance measurements. The bridge measures $482 \times 311 \times 152$mm ($19 \times 12\frac{1}{2} \times 6$in) and weighs 11kg (241b). Wayne Kerr Co. Ltd., New Malden, Surrey.

**WW309 for further details**

**Coils for P.C. Boards**

Cambion are now offering a range of shielded variable coils with pins that can be directly soldered to p.c. boards. Six coils in the series P/N558-7031, cover an inductance range of 12-120mH. Individually the mean inductance values are 15, 22, 33, 47, 68 and 100mH with a variable range of ±20% from the mean. The coils are vertically tuned and have an operating temperature range of $-55$ to $+125^\circ$C. Protection from both electrostatic and electromagnetic interference is claimed.

Cambion Electronic Products Ltd, Cambion Works, Castleton, near Sheffield.

**WW318 for further details**

**Colour TV Grey-scale Generator**

Designed for checking non-linear distortion on colour and monochrome 625-line television transmission systems a new grey-scale generator, type TF2909, is announced by Marconi Instruments. It offers a differential gain accuracy of 0.1%, a differential phase accuracy of 0.1° and a wide range of test facilities. When used together with the sine-squared pulse and bar generator TF2905/8 a versatile combination is formed which will perform a major number of tests required on TV transmission systems. For 525-line systems, version TF2909/1 and TF2905/9 are available. Output waveforms provided are: sawtooth, 5, 7 or 10 riser staircase on every line or on every 4th or 5th line, or full line bar on every line. An internal (crystal controlled) or external sub-carrier can be superimposed on the sawtooth or staircase with a colour burst on every line. Provision is made for an r.f. input of 0.5 - 6MHz and the generator can be locked to external pulses to produce a composite video waveform.

Marconi Instruments Ltd, Longacres, St. Albans, Herts.

**WW314 for further details**

**Video Output Transistor**

General Electric's (U.S.A.) 300V video output transistor type D40N is now available from Jermyn Industries. This transistor has a continuous rating of 300V, 6W, 100mA and the flat pins can be formed to TO5 or TO66 configurations. It is a silicon n-p-n power type suitable for video and audio output stages and for horizontal sweep drive. Price 15s each for 100 upwards, Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

**WW315 for further details**

**Marine V.H.F. Radio-telephone**

Cossor Electronics have announced a new solid-state 28-channel v.h.f. radio-telephone designed to meet international maritime specifications for ship-to-ship and ship-to-shore communications. It is designated type CC.414.ME28. Simplex and duplex operation is provided on the 50kHz channels 1 to 28 (maritime band) and the set can be easily modified to meet future 25kHz channel separation requirements. A dual watch facility is incorporated as standard and local control can be provided as an optional extra. Operation is stable over a wide range of battery voltages and protection is given against reverse polarity. The transmitter output is 20W and the receiver audio output 3W to a built-in loudspeaker. Power supply is a nominal 24V d.c. and a range of converters is available for operation from any a.c. or d.c. ships' mains. Transceiver and extended control unit can be bulkhead mounted. Cossor Electronics Ltd, The Pinnacles, Elizabeth Way, Harlow, Essex.

**WW312 for further details**

**I.C. Mounting Cards**

Dualine i.c.-cards available from Shirehall Electronics, are intended for mounting and interconnecting dual-in-line packages (up to 16-way), for development or test application. Two card sizes are available: DL 109 (95mm x 94mm), which will accept 9 i.cs and DL 110 (95mm x 152mm), for 15 i.cs—each with 22 gold-plated edge contacts. Each size is also available with double-sided contacts (44-way), designated DL 109/44 and DL 110/44. The board is s.r.b.p. with roller-tinned copper conductors, and supplied drilled ready to accept d.i.ps or i.c.-sockets. Supply lines are adjacent to all i.e. locations, which have 3-hole pads for ease of connection. Also provided are plain holes for terminal-pin into connection of circuit networks. These cards are part of the Dualine "100" series and fit any of the standard range of housings—pack, box, rack or case. The price range is 14s to 21s. Shirehall Electronics Ltd, Borough Green, Sevenoaks, Kent.

**WW328 for further details**

**High-frequency Video Amps**

Voltage gain of 20dB at 100MHz, five nanoseconds rise and fall times, and fixed or variable gain are features of a new group of monolithic video amplifiers being

**WW250 for further details**

www.americanradiohistory.com
Contactless Signal Couplers

The first in a range of contactless signal couplers based on gallium arsenide emitters and light-to-current converters contained in a single device, is announced by MCP Electronics. Type ISC52 is a high-sensitivity, medium-speed, low-voltage device primarily intended for d.c. insulated connections in telephone terminals and computer peripherals. Input and output are insulated from each other, electrically, therefore no loading effects are felt at the input when circuit conditions change at the output. Bandwidth covers many more octaves than transformers, starting at genuine d.c. Thus in digital applications no d.c. restoration is necessary. With the ISC52 a typical input necessary to produce a “useful” output is 7.5mA. Recommended supply voltage is 3V and typical rise time 10μsec (4μsec in a special version). Fan-out is 3. In digital applications, four modes of operation are possible: voltage in/voltage out, voltage in/current out, current in/ voltage out, and current in/current out. Input/output insulation will withstand several hundred volts. The pin pattern is spaced at 2.54mm pitch. MCP Electronics Ltd, Alperton, Wembley HA0 4PE.

WW 313 for further details

N-Channel GaAs Transistor

An n-channel gallium arsenide field effect transistor, type GAT1, particularly suitable for u.h.f. low-noise amplifier applications, is being produced by Plessey. It has high transconductance—typically 6mmhos at 900MHz, and low input and feedback capacitances (around 1pF and 0.15pF respectively). Housed in a four-lead TO-18 package, the device operates up to 1.5GHz, and offers low noise characteristics, typically 3.5dB at this frequency. Common source power gain is a minimum of 11dB at 1GHz. Power supply requirements are 5V for the source-drain, and up to 12V for the gate. Plessey Components Group, Microelectronics Division, Optoelectronic and Microwave Unit, Wood Burcote Way, Towcester, Northants NN1 2JN.

WW 326 for further details

Video Delay Lines

Matthey Printed Products announce a new range of Silver Star video delay lines for 625-, 525- or 405-line colour television

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transmission, designed jointly with the B.B.C. Three small fixed modules replace bulky delay cable and equalizer circuits and provide 75-µ delays of 200 and 500n and 1 µs. Built in equalizers give insertion loss/frequency response of 0.7dB, 1.5dB and 2.6dB ± 0.1dB respectively up to 5.5MHz. The modules simply plug in and no adjustment is necessary. Data sheets are available on request. Matthey Printed Products Ltd, William Clowes Street, Burslem, Stoke-on-Trent.

WW305 for further details

Field Strength Meter
G.P.O. Radio Receiver type 35A, available from Microwave International, is a portable transistorized field-strength meter used for the measurement of radiated field strength and conducted voltages in the v.h.f. frequency range 34–225MHz.

The receiver is powered by three 8.4V dry batteries. A dipole aerial with adjustable telescopic elements is used for the measurement of field strengths. The output meter is scaled to read microvolts or dB relative to 1 µV. The dynamic range of the meter is

from 10-100µV and 0-40dB relative to 1 µV. Two 20dB attenuators and one at 10dB are provided. These may be switched into the i.f. amplifier permitting voltages up to 90dB above 1µV to be measured. A standard jack socket is provided on the front of the receiver enabling an operator to listen to the transmitted signal via an audio amplifier. The case is fitted with shoulder straps and carrying handle. Microwave International (U.K.) Ltd, 33-37 Cowleaze Road, Kingston-upon-Thames, Surrey. WW329 for further details

Originally designed for work with the Australian Electricity Board, the Ancom 15A-1b high-power op. amp. is now available as a standard production item. It has an output of ±10V at ±10mA and a typical open loop gain of 36,000. Frequency response is 2MHz at small signal unity gain, and offset voltage and current are 5µVmax and 6nA (differential input). The module, which occupies only 12.3cm², is fully protected against overload. Ancom Ltd, Devonshire Street, Cheltenham, GL50 3LT.

WW320 for further details

Tunable Filter
A twin-channel tunable filter, type VBF/1 comprising two fourth-order Butterworth filters which can be each used in the high-pass or low-pass configuration, has been announced by KEMO. Each section has a cut-off rate of 24dB/octave. The channels can be used in series or parallel to produce a bandpass or band reject response. Alternatively with both units switched to high- or low-pass function a cut-off of 48dB/octave can be achieved. The voltage gain is unity while channel 1 has additional amplification of ×3, ×10, ×30 and ×100. Input impedance is 100kΩ and output impedance 50Ω. The instrument is continuously variable from 1Hz to 100kHz using five switched-in decade ranges. The noise level referred to input is 5µV. Price of the VBF/1 is £250; dimensions 254 x 140 x 190mm. KEMO (Consultants) Ltd, 42 Chancery Lane, Beckenham, Kent.

WW303 for further details

10-turn Potentiometers
Precision 10-turn potentiometers with 0.2% linearity in less than 1 cubic inch have been introduced in the U.K. by GDS (Sales). These potentiometers, the Fairchild MF-78 series, are available in nine standard resistance values from 50Ω to 125kΩ with 3% tolerance. Rating is 2W at 40°C and resolution is

from 0.007% (125kΩ) to 0.033% (500Ω). It is claimed that the wiper carriage and drive will withstand severe shock and vibration without deterioration in performance. Cost of the MF-78
Logarithmic Amplifier

A wideband logarithmic amplifier, type WLA125, has been announced by AIM. It is a 100mm module designed for fields where exponential functions occur or where dynamic range may be unknown. The amplifier has a range of 60dB for a.c. and d.c. signals in a voltage mode, and 40dB for d.c. signals in a current mode. Three input

impedance microphone inputs. Controls include separate bass and treble cut and boost. The radio microphone receiver incorporated is a standard unit working at 174.8MHz. It is complete with a 430mm telescopic aerial and a coaxial aerial socket. The loudspeaker enclosure contains three 200mm cone units. Additional loudspeaker systems can be connected where required and alternative signal sources can be fed into the amplifier. This unit, designated ISR/10, can be used in conjunction with any Reslo Audac transmitter. It measures 855 x 305 x 230mm and weighs 13.5kg. Reslosound Ltd, Romford, Essex.

WWW319 for further details

Portable Sound System

A p.a. system and radio microphone receiver combined with a loudspeaker in one transportable unit is being offered by Reslosound. An amplifier with an output of 10W and a frequency response of 50Hz to 10kHz ±3dB is used, and there are three low

Switching m.o.s.f.e.ts with low On-Resistance

Two p-channel m.o.s.f.e.ts, 3N167 and 3N168, from Siliconix have built-in zener diodes between gate and body to eliminate static-charge accumulation on the gate (a potential source of oxide breakdown). Drain/source, gate/source and gate/drain breakdown voltages are 30V (3N167) and 25V (3N168); threshold voltage is 6V maximum. On resistances \( r_{d,n} \) are 20 and 40Ω maximum respectively for the 3N167 and 3N168; drain or source cut-off current \( I_{d,n} \) is less than 0.5nA and 1nA respectively. The encapsulation is TO-72. Siliconix Limited, Saunders Way, Sketty, Swansea.

WWW324 for further details

Fast Thyristor Family

A new family of fast-switching thyristors announced by Mullard is intended for pulse modulation in radar equipment. The thyristors, which comprise the BTX95 series and have SO-35A encapsulation, can switch peak powers of up to 150kW at 5kHz. Voltage ratings are from 500 to 800V. They have a low forward voltage drop during conduction and a \( dI/dt \) rating of 1000A/μs. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

WWW322 for further details

Correction

In last month's issue, p.196, the new audio transformers by Gardner's have a 2,000V capability, not 20,000V as stated. They come in three basic sizes, not two.
Real and Imaginary

by “Vector” (with apologies to Longfellow)

Electronic totem

Where the turgid Thames drifts slowly Slowly, slowly ever seaward To the oil-slicked North Sea water Past the Big Smoke tranquil rising From the lodges of the Koknees In the land of Owseyfarver, Dwell the tribesmen of West-minster Lofting in their hot-air wigwams —House of Lords and House of Commons— Making laws for all the nation (Except when on the beach at Capri) Driving all the common people Up the creek without a paddle.

There the bigger smoke drifts heavenward From the pipe of Aroldwilson Aroldwilson, chief of chieftains Overlord of all trade unions Father of the Labour party Patron saint of all the Scillies, Wily, crafty Aroldwilson Smokes the calumet, the peace-pipe Planning strategy and tactics For the General Election. See the puffs of smoke arising In a simple on-and-off code Summoning the beavers to him —All those not so-eager beavers Chiefs of all the Civil Service— From their lodges hard by Whitehall. See Ahmeek the King of Beavers (Wedgewood Benn in paleface language) Wedgewood Benn the King of MinTech Sitting in his lodge in Whitehall Amid the clutter of the tea-cups Awaiting word from Aroldwilson.

See the blue-grey smoke arising From the tenth tepee at Downing “Come at once, O King of Beavers Remove the Ph! do not dally Or my tomahawk may chop thee” —Thus the message in the smoke-rings From the pipe of Aroldwilson From the chief of all the chieftains.

In the tenth tepee at Downing In the lodge of Aroldwilson Sits Eye-Bee-Em the great computer —Eye-Bee-Em the magic maker From the land across the water Bought with many bales of wampum To foretell for Aroldwilson

All the fortunes of his party In the General Election In the choosing by the people Of their true accepted leader. Will they root for Aroldwilson? Or for Edward the Digressor? (Full of blandishments and pleadings For a chance to prove his mettle.) “Welcome in, O faithful Wedgewood Welcome in, my dear old china!” Thus the voice of Aroldwilson As he stands beside the lodge-pole Of the tenth tepee at Downing While Eye-Bee-Em the great computer Crouches monstrous in the background Winking evil eyes of neon Muttering incantations darkly, “Bend thy head O Chief of MinTech” (Thus Aroldwilson, sotto voce) “Let me whisper in thy ear-hole Lest Eye-Bee-Em should overhear me For I fear this Yankee monster Which thou didst connive to get me On the never-never system. List, O Wedgewood and I’ll tell thee Reasons for my dark forebodings About this diabolical computer And, when I have done the telling, Thou must be the judge of whether I am round the twist of reason.”

Thus the voice of Aroldwilson In the ear of trusty Wedgewood “Know you, O my Chief of MinTech That I, when more than apprehensive Of our fate in the Election Have, at divers times and often Turned to Eye-Bee-Em for solace Feeding him with signs and portents Trends and tendencies together! All the data I have gathered Into appetising programs That Eye-Bee-Em may work his wonders And tell us plainly of the future Who will win the next election. But alas! I fear that gremlins Are having fun with his internals With L.S.D. his memory filling Giving him hallucinations For, no matter how he’s programmed His print-out message never varies —Always ‘The Star-Spangled Banner’ Every verse and every chorus— While upon his cathode-ray tube Appears the picture of a wasteland Charred and blackened tree-stumps lying

Upon a plain of ling and heather. —Tell me, Wedgewood, tell me truly Are we harbouring a nut-case Within the walls of this computer?”

At these words the face of Wedgewood —Wedgewood Benn the Chief of MinTech— Turns as pale as any spectre’s “’Tis a curse!” he mutters weakly “’Tis the curse of Little Nuddy! They have wished this ill upon us Because we bought a Yank computer They have tampered with its innards Rugged the print-out “to remind us Of its foreign antecedents Every time we seek to use it.” “—But the picture?” Aroldwilson Quavers as his peace-pipe Shatters in a hundred fragments On the wig-wam’s floor before them. “Why the wasteland, bleak and sombre Why the desolated landscape?” Wedgewood’s face is grim and tortured As he answers Aroldwilson “’Tis an omen! ’tis a symbol! ’Tis a dreadful allegory Of the General Election. ‘The blasted Heath’ is plain its message Written in the beam’s electrons Of the cathode-ray display tube!”

Still the bigger smoke drifts heavenward From the pipe of Aroldwilson (Stand-in for the fractured favourite) Aroldwilson, chief of chieftains Planning strategy and tactics How to win the wayward voters Of electronics engineering How to placate Little Nuddy (Free research for every member? Green stamps with every MinTech contract? Banish every Yank competitor?) Aroldwilson, chief of chieftains Feeding all the trends and portents To a British-made computer Obtaining now much cheerier answers (At least he does when it is working).

So at last we leave our hero Overlord of all trade unions Father of the Labour party Dispensing cheer to all his cohorts Via a British-made computer (And, of course, those daily columns Disclosing what the stars foretell us)

“Vector” has pointed out that a printer’s gremlin sabotaged a sentence in his March contribution. The sentence in question, in the middle column, should have read: John’s definition of high-quality reproduction was a big bad woof in the bass register . . . , not “big bad wolf”!
The beginning

of a beautiful friendship

To make life smoother for you . . . we give all our new instrument designs the shakes. Every new Marconi design is subjected to environmental tests, covering climatic extremes, vibration, bump and mechanical endurance conditions, simulating the worst it is ever likely to meet in practice. The sort of treatment that makes most of our competitors' designs look very woebegone (we know, because we've tried them).

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<td>9000-9700</td>
<td>200</td>
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<td>Solid state microwave switches</td>
<td>BS392</td>
<td>S</td>
<td>2925-3075</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>BS460</td>
<td>X</td>
<td>any 100 MHz</td>
<td>0.5</td>
</tr>
</tbody>
</table>

---

Please send a copy of 'Duplexer Devices'. I am interested in a device with the following parameters:

Frequency_________Power_________Type_________

Name & Position

Company

Address

Tel. exchange or code

Number Ext.

ENGLISH ELECTRIC VALVE CO LTD

WW—008 FOR FURTHER DETAILS
TRIO's New JR-310 SSB Professional Perfection for Amateur Enjoyment

JR-310
SSB COMMUNICATIONS RECEIVER

* High-stability VFO of 2 FET's and 2 transistors and easily handles QSO's for hours. * Precision double gear dial—a TRIO innovation—with linear frequency variable capacitor. Possible to get finer reading 1KHz. One dial rotation covers 25KHz, makes SSB demodulation easier. * Frequency range covers entire amateur band from 3.5MHz to 29.7MHz. One-touch selection system switches bands. WWV reception of 15MHz possible. * MHz band circuit structure patterned on Collins type double conversion system so first oscillation is b, crystal control, second local oscillation by VFO.

Model SP-5D
COMMUNICATION SPEAKER

* Communications Speaker which has been designed for use with the 9R-59DE.
* Dimensions: 3-9/16"(W), 7-1/8"(H), 5-3/16"(D).

SPECIFICATIONS OF JR-310

* FREQUENCY RANGE: 3.5-29.7 MHz (7 Bands)
* SENSITIVITY: 1µV (at 10 dB S/N)
* IMAGE RATIO: More than 50dB
* FREQUENCY STABILITY: ±2 KHz in 1–60 min. after switching on, subsequently within 100Hz per 30 min.

Model 9R-59DE
BUILT IN MECHANICAL FILTER 6 TUBES COMMUNICATION RECEIVER

* A mechanical filter enabling superb selectivity with ordinary IF transformers. * Frequency Range: 550KHz to 30MHz (4 Bands) * Sensitivity: 2µV for 10dB S/N Ratio (at 10MHz) * Selectivity: ±5 KHz at −60dB (±1.3 KHz at −6dB.) When using the Mechanical Filter *

Dimensions: Width 15", Height 7", Depth 10"
You can view X-ray pictures in daylight using only a 5 micro-Röntgen dosage

What would it mean to you? An X-ray picture that is so bright you can view it in direct daylight as it happens. EEV's Image Isocon is now being used in X-ray equipment for this very purpose — reducing X-ray dosages to as little as 5 micro-Röntgens, allowing longer exposure times for 'live' X-ray picture study, saving time by eliminating the need for operators' eyes to become 'dark-adapted'.

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The Image Isocon is another product of EEV advanced tube technology. For complete data, please post the coupon.


with the EEV Image Isocon

To: English Electric Valve Co Ltd Chelmsford, Essex, England.
Send for full details of EEV Image Isocon range.

Name & position
Company
Address
Tel. exchange or code
Number Ext.

ENGLISH ELECTRIC VALVE CO LTD

WW—010 FOR FURTHER DETAILS
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A Garrard gives you the perfect setting for music — silence.
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The SL95B features the constant-speed Garrard Synchro-AB motor and incorporates:
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- Calibrated fine stylus-force adjustment
- Automatic play of single records
- Styling of elegance and distinction
Hard-wood base and rigid clear plastic cover available as optional extras.

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"... have tested it for wow, flutter and rumble and found them too low to be measured with any confidence. In every way I have tried to impede its working, I have failed!"
"I greatly admire the cueing device and I would not dream of setting my own manual clumsiness against the delicacy with which the automatic mechanism puts down the stylus in the groove. This is near perfection." Percy Wilson
Audio Record Review, August '68

Garrard Engineering Limited, Newcastle Street, Swindon, Wiltshire, England
Telephone: Swindon 5381

WW—01: FOR FURTHER DETAILS
UHF klystron efficiency? You can rely on it with EEV.

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Each one offers economy and ease of use, solid-state compatibility and, above all, efficiency—even at low drives.

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To get the full facts about the tube you need, please post the coupon.


To: English Electric Valve Co Ltd, Chelmsford, Essex, England
Please send EEV data on UHF television amplifier klystrons.
I am interested in a klystron with the following parameters:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Bandwidth</th>
<th>Power</th>
</tr>
</thead>
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<td></td>
</tr>
</tbody>
</table>

Name & position

Company

Address

Tel. exchange or code

Number Extension

ENGLISH ELECTRIC VALVE CO LTD

WW—012 FOR FURTHER DETAILS
Wireless World, May 1970

Take a filter tip from us

on how to suppress interference from kHz to GHz

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Telex: 97421.

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Please send full data on power triodes for industrial heating.
Please recommend triodes for an equipment with these ratings.

Output power (kW) Anode voltage max. (kV) Frequency (MHz)

Name & Position
Company
Address

Telephone exchange or STD code
Number Extension

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Position

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TS Distortionless Servomechanical Stabilisers provide high-speed, accurate stabilisation without distortion of waveform. Accuracy ±0.25%. Correction speed up to 60/100 volts per sec. Unaffected by load, frequency or power factor variations. 1 to 120 kVA single phase and up to 360 kVA three phase.

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Telephone: 061-789 5081 Telex: 66711
Member Company of GEC Electrical Components Ltd

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Bede Industrial Estate, Jarrow, County Durham.
Telephone: Jarrow 897771 Telex: 53353

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From whom?

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Our product range includes L, C and R Decade Boxes, variable Mutual Inductors, Standard Resistors, Conductance Boxes, a.c. and d.c. Potentiometers, Electronic Galvanometers, power loading Resistors and Capacitors, Dynamometers and an interesting range of instruments developed specially for educational laboratories.

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- Discrimination: ±5μV.

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J.J. Lloyd Instruments Limited
Brook Avenue, Warsash, Southampton, SO3 6HP. Tel: Locks Heath 4221
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Fact: magnetic cartridges are more compatible with transistor amplifiers than crystal cartridges.

Fiction: magnetic cartridges are too expensive to warrant use with any but the more sophisticated units.
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The 850 assures you of true tracking, superior sound quality and minimal groove destruction. But unlike most magnetic cartridges, it's British. It's made by Goldring!

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WW—023 FOR FURTHER DETAILS

WW—024 FOR FURTHER DETAILS
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THE VORTEXION 50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.

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Phone: Northbourne 4845

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2 Watt and 3 Watt
Professional IC Audio Amplifiers
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Through large scale production Plessey can now make these devices available to home constructors at reasonable prices.

Each circuit incorporates a preamplifier and a class A-B power amplifier stage and needs only a minimum of external components.

Take a look at these specifications opposite!

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Tel: Leeds 636311 Telex: 55147

SDS (Portsmouth) Ltd
Hillsea Industrial Estate, Hillsea, Portsmouth, Hants.
Tel: Portsmouth (0705) 62332 or 62180 Telex: 86114

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<th>Characteristic</th>
<th>SL402A</th>
<th>SL403A</th>
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<td>3W</td>
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<td>Input impedance</td>
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</tr>
<tr>
<td>Preamplifier</td>
<td>20 M Ω</td>
<td>20 M Ω</td>
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<tr>
<td>Main amplifier</td>
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<td>100 M Ω</td>
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<td>Distortion</td>
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<td>Preamplifier</td>
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<td>0.3%</td>
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<td>Frequency response</td>
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<td>Operating voltage</td>
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<td>+18 V</td>
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<tr>
<td>Min. operating load</td>
<td>7.5 Ω</td>
<td>7.5 Ω</td>
</tr>
</tbody>
</table>

PLESSEY microelectronics
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WW—029 FOR FURTHER DETAILS
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The new 'Astrolite' headset has been adopted by many of the leading Television, Broadcasting and Programme companies for studio and O.B use, and no wonder.

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Title
Address

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Number 10
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Figure 1 shows an amplifier connected to a bridge ready for measurement.

By varying the frequency of the bridge oscillator, a complete analysis can be made of the characteristics of an amplifier using this simple technique.

A similar arrangement can be used to calibrate an attenuator. Figure 2 shows a 4 section step attenuator connected to a bridge.

The voltage output from the left hand transformer is connected to the attenuator input and by setting the attenuator switch to position 1 an initial value for RT can be determined.

As the attenuator is sequentially switched to each step position and the bridge re-balanced, the ratio of each measured value to the initial measurement can be assessed. These ratios represent the voltage attenuation of each step and the phase shift along the network can be readily determined from the value of reactive term required to complete the bridge balance.

The turns ratio of a transformer may be obtained with an arrangement similar to Figure 1. In this case the primary winding is connected to the left hand transformer and the secondary winding to RT.

The value of RT must be high compared with the output impedance of the transformer and, provided that this requirement is observed, the turns ratio is simply the bridge conductance reading multiplied by the resistance value of RT.
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<td>17 x 10 x 9</td>
</tr>
<tr>
<td>U</td>
<td>15 x 9 x 9</td>
<td>49/-</td>
<td>Z</td>
<td>19 x 10 x 8</td>
</tr>
</tbody>
</table>

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Type N has a removable bottom, Type U removable bottom or back, Type W removable front, Type Y all-screwed construction, Type Z removable back and front.

BLANK CHASSIS
FOUR-SIDED 16 SWG ALUMINIUM

<table>
<thead>
<tr>
<th>Size</th>
<th>Price Base</th>
<th>Size</th>
<th>Price Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 x 4 x 2&quot;</td>
<td>3/11</td>
<td>10 x 5 x 2&quot;</td>
<td>12/- 5/6</td>
</tr>
<tr>
<td>7 x 4 x 2&quot;</td>
<td>2/11</td>
<td>12 x 7 x 2&quot;</td>
<td>12/- 5/11</td>
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<tr>
<td>8 x 4 x 2&quot;</td>
<td>3/11</td>
<td>14 x 7 x 2&quot;</td>
<td>13/- 6/6</td>
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<tr>
<td>9 x 7 x 2&quot;</td>
<td>3/11</td>
<td>17 x 10 x 2&quot;</td>
<td>16/- 6/7</td>
</tr>
<tr>
<td>12 x 4 x 2&quot;</td>
<td>3/11</td>
<td>18 x 10 x 3&quot;</td>
<td>19/-</td>
</tr>
</tbody>
</table>

Plus post and packing.

TO FIT OUR CASES

<table>
<thead>
<tr>
<th>Size</th>
<th>Price Base</th>
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<th>Price Base</th>
</tr>
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<tbody>
<tr>
<td>7 x 5 x 1 3/4&quot;</td>
<td>3/9</td>
<td>12 x 6 x 2&quot;</td>
<td>10/- 5/11</td>
</tr>
<tr>
<td>7 x 5 x 2 3/4&quot;</td>
<td>3/9</td>
<td>14 x 8 x 2&quot;</td>
<td>13/- 7/11</td>
</tr>
<tr>
<td>11 x 6 x 2&quot;</td>
<td>5/9</td>
<td>15 x 9 x 2&quot;</td>
<td>17/- 9/9</td>
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<tr>
<td>11 x 6 x 2&quot;</td>
<td>5/9</td>
<td>17 x 9 x 2&quot;</td>
<td>18/- 10/6</td>
</tr>
</tbody>
</table>

Plus post and packing.

WITH BASES

<table>
<thead>
<tr>
<th>Size</th>
<th>Price Base</th>
<th>Size</th>
<th>Price Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 x 4 x 2 1/4&quot;</td>
<td>3/9</td>
<td>3 x 2 x 1&quot;</td>
<td>6/6</td>
</tr>
<tr>
<td>4 x 4 x 1 1/4&quot;</td>
<td>6/6</td>
<td>1.5 x 2 x 1&quot;</td>
<td>5/6</td>
</tr>
<tr>
<td>3 x 3 x 1 1/4&quot;</td>
<td>7/3</td>
<td>2 x 2 x 1&quot;</td>
<td>5/6</td>
</tr>
</tbody>
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Type KB1

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<tr>
<th>6 RANGES</th>
<th>0.000005 to 0.0015 ohms</th>
<th>0.0005 to 0.015</th>
<th>0.005 to 0.15</th>
<th>0.05 to 1.5</th>
<th>0.5 to 10.5</th>
<th>5 to 105</th>
</tr>
</thead>
</table>

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VOLTMETER RANGES
15µV, 50µV, 150µV ... 500V f.s.d.
Acc. ±1% - 1% f.s.d. ± 1µV at 1kHz.
db RANGES
- 100dB, - 90dB, - 80dB ... + 50dB.
Scale - 20dB/± 60dB rel. to 1mV/600µV.
FREQUENCY RESPONSE
Above 500µV: ± 3dB from 1Hz to 3MHz.
± 0-3dB from 4Hz to 1MHz.
Type TM3B can be set to a restricted B.W. of
10Hz to 1kHz or 10kHz.
INPUT IMPEDANCE
Above 50mV: > 3-MΩ < 20pf.
On 50mV to 50mV: > 5MΩ < 50pf.
AMPLIFIER OUTPUT
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SIZES & WEIGHTS
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TM3B: 7 × 10½ × 6½, 8lb, 5½" mirror scale.
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Square law scales. Acc. ±4% of
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Scale - 10dB/± 60dB rel. to 1mV/600µV.
H.F. RESPONSE
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± 6dB from 400MHz to 450MHz.
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As TM3 except for the omission
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proportional to square of input.

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CURRENT RANGES
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Acc. ±2% ± 1% f.s.d. ± 0.3pA LZ & CZ
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Test currents 1µA & 1mA on kΩ & MΩ.
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Radio World, May 1970

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The PA 50 is a transistor power amplifier having a power output in excess of 50 watts. The SPA 50 is a dual channel power amplifier having identical characteristics. The amplifier was designed basically for sound reproduction for professional use, but its exceptional characteristics in respect of distortion, transient response and power bandwidth make it also suitable for commercial and industrial uses.

The presentation is a low format of a depth suitable for shelf mounting. The amplifier is supplied in a metal housing suitable for fitting into a cabinet if required. The front facade is of extruded aluminium section with end pieces to form a complete frame. It is fitted with an anodised aluminium panel, screen printed.

The amplifier uses a true complementary symmetry output circuit with matched NPN and PNP transistors to obtain a virtually zero 'crossover' distortion. Improved circuitry has been developed to provide high gain in the output stages and drive circuits with wide bandwidth permitting a large amount of feedback to ensure an extremely low overall distortion. The success of the circuitry and the devices used is exhibited by the power bandwidth characteristic of 0.5 MHz at the —3 dB point.

The amplifier is unconditionally and absolutely stable with any form of output load of any impedance characteristic, from short-circuit to open-circuit. The amplifier itself is fully protected by current and voltage limiting and in addition is protected against the failure of a device in the power amplifier itself by a high speed current protection circuit in the power supply.

A new low distortion level of 0.01% has been reached for the amplifier at the —3 dB reference to the rated output, with the distortion proportionally decreasing with output power. Approximately 60 watts (continuous tone rating) is available at clipping level at 0.025% distortion both channels driven simultaneously.

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110 volts, 120 V. 130 V. 220 V. 230 V.
240 V. 50-60 Hz.

Output Matching
4-16 ohms (100 V line extra).

Output Power
50 Volt-amperes nominal.
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0.025% at clipping onset.
0.01% at —3 dB ref: clip level.

Input Facilities
High impedance 22K ohms.
Low impedance, optional 200/600 ohms balanced/unbalanced.

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Electronics, Television, Radio, Audio

May 1970

Volume 76 Number 1415

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<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>Medium short 40µs</td>
<td></td>
</tr>
<tr>
<td>Bluish-purple (UV)</td>
<td>Very short 0.12µs</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>Medium short 40µs</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>Short 1.5µs</td>
<td></td>
</tr>
<tr>
<td>Purple</td>
<td>Long 0.5s</td>
<td></td>
</tr>
<tr>
<td>Very long</td>
<td>7s</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>Medium 25ms</td>
<td></td>
</tr>
<tr>
<td>Very long</td>
<td>2s</td>
<td></td>
</tr>
<tr>
<td>Very long</td>
<td>5s</td>
<td></td>
</tr>
<tr>
<td>Very long</td>
<td>4s</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>Medium short</td>
<td></td>
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Both the vertical and horizontal mainframe amplifiers are "dual trace" providing a unique level of flexibility with plug-in combinations. A relatively small number of plug-ins can then meet a wide range of application requirements. The CHOP and ALT modes permit simultaneous displays of delaying and delayed sweep, and, through switching logic, may be "slaved" to provide a functional dual-beam type of display.

7A13 Differential Comparator Amplifier
Bandwidth—DC to 100 MHz (3.5 ns tr) in the 7704; DC to 75 MHz (4.7 ns tr) in the 7504. Min deflection factor—1 mV/div at full bandwidth.

7B71/7B70 Time-Base Units for the 7704
2 ns/div maximum sweep speed. Operable singly or in combination for delaying-sweep capability.

7A11 Captive FET Probe Amplifier
Bandwidth—DC to 150 MHz (2.4 ns tr) in the 7704; DC to 90 MHz (3.9 ns tr) in the 7504. Min deflection factor—5 mV/div at full bandwidth.

7A12 Dual-Channel Amplifier
Bandwidth—DC to 105 MHz (3.4 ns tr) in the 7704; DC to 75 MHz (4.7 ns tr) in the 7504. Min deflection factor—5 mV/div at full bandwidth.

7A14 AC Current Probe Amplifier
Bandwidth—25 Hz to 105 MHz depending on mainframe and current probe; two probes available. Min deflection factor—1 mA/div at full bandwidth.
C-51/C-50 Trace-Recording Cameras

Two new compact trace-recording cameras have been designed for direct compatibility with the 7000-Series Oscilloscopes. The C-51 and C-50 cameras are basically identical units, differing only in the lens system. The C-51 has an f/1.2, 1:0.5 lens; the C-50 uses an f/1.9, 1:0.7 lens. The C-51 is recommended for single-shot photography at the fastest sweep rates, the C-50 for more general purpose applications. Photographic writing speed of the two 7000-Series mainframes with the C-51 and 10,000 ASA film (without prefogging) is 3300 cm/µs (7704) and 2500 cm/µs (7504).

The cameras offer a new level of operational convenience for mistake-proof trace photography. The guess work normally associated with selection of f stop and shutter speed to match the ASA index and trace brightness is eliminated. After setting the ASA index, the built-in photometer allows a visual correlation of trace intensity to the correct f stop setting and shutter speed. After initial adjustment, a change of f stop or shutter speed will still maintain the same exposure. Focusing is accomplished by two beams of light projected on the CRT which, when superimposed, indicates optimum focus. The insert shows the photometer spot and the range-finder focusing images.

SCOPE-MOBILE® CARTS

The 204-2 Scope-Mobile® Cart is specifically designed for the 7000-Series instruments. It provides a securing mechanism for the oscilloscope, nine positions of selectable tray tilt, a large storage drawer, storage for five 7000-Series plug-ins, and large locking-type wheels.

PROBES

The P6053 is a miniature fast-rise 10X probe designed for full compatibility with the 7000-Series instruments. Input R and C is 10 MΩ, 10.3 pF. Probe risetime is 1.2 ns or less.

The P6052 is a passive dual-attenuation probe designed for measurements below 30 MHz. A sliding collar selects 1X or 10X attenuation. Input R and C is 1 MΩ or 10 MΩ, 100 pF or 13 pF. Risetimes are 60 ns (1X) and 7 ns (10X).

Tektronix U.K. Ltd. Beaverton House, P.O. Box 69, Harpenden, Herts. Telephone Harpenden 61251. Telex: 25559

For overseas enquiries: Australia: Tektronix Australia Pty. Ltd., 4-14, Foster Street, Sydney, N.S.W. Canada: Tektronix Canada Ltd., Montreal, Toronto & Vancouver. France: Relations Techniques Intercontinentales, S.A., 91, Orsay, Z.I. Courtaboeuf, Route de Villejust (Boite Postale 13), Switzerland: Tektronix International A.G., P.O. Box 57, Zug, Switzerland. Rest of Europe and the Middle East: Tektronix Ltd., P.O. Box 36, St. Peter Port, Guernsey, C.I. All other territories: Tektronix Inc., P.O. Box 500, Beaverton, Oregon, U.S.A.

www.americanradiohistory.com
The Sinclair IC-10 is the world’s first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a full guarantee on every IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

**MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP**

**SPECIFICATIONS**

- **Output:** 10 Watts peak. 5 Watts R.M.S. continuous
- **Frequency response:** 5 Hz to 100 KHz ±1dB
- **Total harmonic distortion:** Less than 1% at full output.
- **Load impedance:** 3 to 15 ohms.
- **Power gain:** 110dB (100,000,000,000 times) total.
- **Supply voltage:** 8 to 18 volts.
- **Size:** 1 x 0.4 x 0.2 inches.
- **Sensitivity:** 5mV.
- **Input impedance:** Adjustable externally up to 2.5 M ohms.

**CIRCUIT DESCRIPTION**

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory.

**APPLICATIONS**

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

**SINCLAIR IC-10 with IC-10 manual Post free. 59/6**
Project 60 an exciting alternative

It is not likely that anyone purchasing an amplifier today would have difficulty in finding one that met all his requirements, although the price might not be as low as could be wished. But one’s needs can change, also the technically correct amplifier may be physically inconvenient. If there is an amplifier available, of the right size and price, to meet all your needs for the foreseeable future, then that is your best buy. If not, we offer a possibility which we believe to be an exciting alternative approach. That alternative is Project 60.

Project 60 now comprises a range of modules which connect together simply to form a complete stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare in overall performance. Now with the addition of three new modules to the range, the constructor has choice of assemblies with either 20 or 40 watts output per channel, with or without filter facilities.

The modules now are: 1. The Z.30 and Z.50 high gain power amplifiers, each of which is an immensely flexible unit in its own right. 2. The Stereo 60 preamplifier and control unit. 3. The Active Filter unit with both high and low audio frequency cut-offs. 4. The PZ.5 and PZ.6 power supplies. A complete system could comprise, for example, two Z.30’s one Stereo-60, and a PZ.5. The PZ.6 is stabilised and should be used where the highest possible continuous sine wave rating is required. An A.F.U. may be added later. In a normal domestic application, there will be no significant difference between using PZ.5 or PZ.6 unless loudspeakers of very low efficiency are being used, in which case the PZ.6 will be required. For assemblies using two Z.50’s there is the new PZ.8 supply unit to ensure maximum performance from these amplifiers.

All you need to assemble your Project 60 system is a screwdriver and soldering iron. No technical skill or knowledge whatsoever is required and, in the unlikely event of you hitting a problem, our customer service and advice department will put the matter right promptly and willingly. Project 60 modules have been carefully designed to fit into virtually all modern cabinets or plinths and only holes need be drilled into the wood of the plinth to mount the control unit. Any slight slip here will be covered by the aluminium front panel of the Stereo 60. The Project 60 manual gives all the buildings and operating instructions you can possibly want, clearly and concisely. Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future as the latest additions to the range show. A stereo F.M. tuner is next to come. These and all other modules we introduce will be compatible with those already available and may be added to your system at any time. And because Sinclair are the largest producers of constructor modules in Europe, Project 60 prices are remarkably low.

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Telephone: 0223 52731

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Z-30
TWENTY WATT R.M.S. (40 WATT PEAK)
POWER AMPLIFIER

The Z-30 is a complete power amplifier of very advanced design employing 9 silicon epitaxial planar transistors. Total harmonic distortion is incredibly low being only 0.02% at full output and all lower outputs. As far as we know, no other high fidelity amplifier made can match this specification, no matter what the price. Thus you can be utterly certain that your Project 60 system will do full justice to your other equipment however good it may be. The Z-30 is unique in that it will operate perfectly, without adjustment, from any power supply from 8 to 35 volts. It also has sufficient gain to operate directly from a crystal pickup. So in addition to its use in a high fidelity system you can use a Z-30 to advantage in your car or a battery operated gramophone for your children, for example. These, and many other applications of the Z-30, are covered in the Project 60 manual.

SPECIFICATIONS

Power output—15 watts R.M.S. (30 watts peak) into 8 ohms using a 35 volt supply; 20 watts R.M.S. (40 watts peak) into 3 ohms using a 30 volt supply.

Output—Class AB.

Frequency response: 30 to 300,000 Hz ± 1dB.

Signal to noise ratio: better than 70dB unweighted.

Distortion: 0.02% total harmonic distortion at full output into 8 ohms and at all lower output levels.

Size: 3½ x 2½ x 1 inches.

Input sensitivity: 250mV into 100 Kohms.

Damping Factor: 500.

Loadspeaker impedances 3 to 15 ohms.

Power requirements: 8 to 35 v.d.c.

STEREO 60 PREAMPLIFIER AND CONTROL UNIT

The Stereo 60 is a stereo preamplifier and control unit designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout and great attention has been paid to achieving a really high signal-to-noise ratio and excellent tracking between the two channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs. The tone controls are also very carefully designed and tested.

SPECIFICATIONS

- Input sensitivities—Radio—up to 3mV;
  - Magnetic Pickup—3mV. Connect within ±1dB on R.I.A.A. curve. Ceramic Pickup—up to 3mV. Auxilliary—up to 3mV.
  - Output—250mV.
- Signal-to-noise ratio—better than 70dB.
- Channeled matching—within 1dB.
- Tone Controls—TREBLE +15 to –15dB.
  - BASS +15 to –15dB at 10 kHz.

SINCLAIR POWER SUPPLY UNITS

PZ-5: 30 volts unsteadfast—sufficient to drive two Z-30's and a Stereo 60 for the majority of domestic applications.

£4 19s. 6d.

PZ-6: 35 volts stabilised—ideal for driving two Z-30's and a Stereo 60 (less mains transformer) at very low efficiency speakers are employed.

£7 19s. 6d.

PZ-8: 45 volts unit for use with two Z-50's and Stereo 60 (less mains transformer).

£5 19s. 6d.

APPLICATIONS

High fidelity amplifier: car radio amplifier: record player fed direct from pick-up: intercom: electronic music and instrumentation: P.A., laboratory work, etc. Full details of these and many other applications are given in the manual supplied with your Z.30.

STEREO 60
Ready built, tested and guaranteed.

£9 19s. 6d.

BUILDING A PROJECT 60 ASSEMBLY

The illustration here shows quite clearly how easily Project 60 can be contained in one of today's slim, modern plinths. Very little space is required to house these Sinclair units, and within the space of the motor plinth, you can install a stereo amplifier of the very highest quality. If, for example, you have already put together an assembly as illustrated here, adding the Active Filter Unit would be very easy.

GUARANTEE

If at any time within 3 months of purchasing Project 60 modules from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you. Whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter.

sinclair

WW-110 FOR FURTHER DETAILS

www.americanradiohistory.com
New for Project 60

Active Filter Unit

The Sinclair Active Filter Unit is a new addition to our Project 60 range of high fidelity modules and is designed to complement the other modules in the range. Its performance is such, however, that users of other amplifier systems might well consider adding it to their assemblies.

The purpose of a filter unit is to reject frequencies above (scratch) or below (rumble) a specific cut off frequency when these frequencies contain unwanted interference. The Sinclair A.F.U. is unique in that the cut off frequency is continuously variable for both the scratch and rumble units and, as the attenuation in the rejection band is rapid (12dB per octave), the removal of interference can be achieved with less loss of the wanted signal than has previously been possible.

Each channel of the A.F.U. has an overall gain of unity and, as the input impedance is high and the output impedance is low, it may be connected between the pre-amplifier and power amplifier sections of any amplifier. Both amplitude and phase distortion have been made quite negligible by the careful design and the large amount of negative feedback employed.

Specifications

Designed for connection between the Stereo 60 pre-amplifier and two Z-30 or Z-50 power amplifiers.

- Employs two Sallen & Key type active filter stages, the first being a rumble (high pass) filter and the second a scratch (low pass) filter. The two stages use complementary transistors to minimise distortion.
- Supply voltage 15 to 35V. Current 3mA max.
- Gain at 1kHz, filters flat 0.98 (±0.2dB)
- H.F. cut off (−3dB) variable from 28kHz to 5kHz
- H.F. filter slope 12dB/octave
- L.F. cut off (−3dB) variable from 25Hz to 100Hz
- L.F. filter slope 12dB/octave
- Distortion at 1kHz (35v supply) 0.02% at rated output (250mV R.M.S.)
- Frequency response, flat position, 35Hz to 20kHz−1dB
- 25Hz to 28kHz−3dB

Z-50 FORTY WATT R.M.S. (80 WATT PEAK) HIGH FIDELITY POWER AMPLIFIER

The Z-50 has been designed for applications requiring higher output power than the Z-30. The maximum supply voltage is raised to 50 Volts and the output power is 40 watts continuous R.M.S. into 3 or 4 ohms and 30 watts continuous into 8 ohms. The Z-50 is otherwise identical to the Z-30 in design and specification, the increased power being obtained by using much higher current power transistors used well within their rated limits.

The Z-50 is, of course, compatible with the other Project 60 modules, such as the Stereo 60, and since the price is only 20% higher than that of the Z-30, customers may like to consider the advantages of buying two Z-50's for their systems now in case higher power is required later.

Where the full output power is not required the Z-50 may be used with the PZ-5 or PZ-6 but for the full output power the PZ-8 should be used. This unit is a stabilised power supply providing 45 volts at up to 3 amps. It is supplied without mains transformer as it is designed for use with a readily available "Radiospares" unit.

Z-50 Power Amplifier

Built, tested and guaranteed £5.9.6

PZ-8 Power Supply Unit

£5.19.6

Use this coupon to order A.F. Unit and Z-50's

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** Super 30 Amplifier (30 Watt) in veneered housing.**
** Or Super Gold Ceramic P.U. Bridge with 60 Watt fan-cooled FET.**
** A.S.C. Supreme MC Phono Cartridge.**
** Shure or Gold Ceremic Pick-up Cartridge.**
** Pair of Stavin II Loudspeaker Units.**

Special total price. 'Fully loaded cabinets as specified.**

Reasonably priced performance.

Retail £85.00.

Car. £75.00.

OUTPUT RATIO: 20 Watts RMS into 8 Ohms. Traveling wave output 0.5% at 1000 Hz, 0.1% at 12.5 dB, 1 watt RMS, 0.5% at 20 kHz, 20 dB, 1 watt RMS, 0.5% at 80 kHz, 400 Hz, 1 watt RMS, 0.5% at 22 kHz, 800 Hz, 1 watt RMS, 0.5% at 44 kHz, 1500 Hz, 1 watt RMS, 0.5% at 88 kHz.

TREBLE CONTROL: +1.6 dB to -1.6 dB at 2 kHz, 0.5% at 10 kHz, 20 dB, 1 watt RMS.

BASS CONTROL: +1.6 dB to -1.6 dB at 50 Hz, 0.5% at 1 kHz, 20 dB, 1 watt RMS.

LOW LEVEL SIGNAL: 0.1 mV to 300 MHz.

CROSSOVER: 40 dB at 1500 Hz, 0.1% at 22 kHz.

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Primary 0, 240v., Sec. 0, 115, 240v. 10a. Ideal for workshop supply, only 6in. x 7in. x 7in. £8, carr. 20/-.

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Primary 0, 240v., Secondary 0, 115v. 300 watts (conservatively rated). 4.5in. x 4in. x 4in. 45/-, p. & p. 8/.

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**DIODES, EX-EQUIP, SILICON**
150 PIV 10 amp. 4 for 10/-
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43in., 2in. diam. 16,000µF capacitor, withstands +200v. 30A10, 30A15 and etc. for £6.50, 4.50. £20/.

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Push Button Tuning Heart
This PRESTOLOCK 5 station Push-Button Tuner Heart with Manual Over-ride is an ideal basis for a quality AM car radio. Size 6in. x 4in. x 2in. Only £17.50 plus 2/- p. & p.

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**BUMPER BARGAIN PARCEL**
We guarantee that this parcel contains at least 1,750 components. Short-led on panels, including a minimum of 350 transistors (mainly NPN and PNP germanium, audio and switching types—data supplied). The rest of the parcel is made up with: Resistors 5% or better (including some 1%) mainly metal oxide, carbon film, and composition types. Mainly 1 and 2 watt . . . diodes, miniature silicon types, OA90, OA91, OA85, IS100, etc. . . . capacitors, including tantalum, electrolytics, ceramics and polyesters . . . inductors, a selection of valves . . . etc. . . . the odd transformer, trimpot, etc., etc., etc. . . . These are all miniature, up to date, professional, top quality components. Don’t miss this, one of our best offers yet!! Price 68/-, post and packing 6/6 U.K., New Zealand 20/- Limited stocks only.

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£10 each (not to be used in the U.K.)

**MINIATURE "JECO"**
Pocket "tape recorder" capstan driven over 1 hour recording time. Standard tape; superb reproduction through internal speaker. Highly sensitive microphone. Size approx. 7½ x 3½ x ½.

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**£25 FOR COMPLETE SYSTEM**

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EXTRACTOR/BLOWER FANS (Papst)
100 c.f.m. 4½ x 4½ x 2in. 2,800 r.p.m., 240v. A.C. Precision made in West Germany by Papst. These Fans are the best available. Genuine at 50/- each. P. & P. 5/-.

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Unique devices in a brand new electronic field that can be exploited in a wide range of applications. Miniaturized construction and solid state circuit design is combined with outstanding modulation and switching capabilities to provide infinite possibilities for short distance data and data links, remote relay controls, safety devices, burglar alarms, batch counters, level detectors, etc.

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Highly flexible light guides that transmit light to inaccessible places as easily as can be done by copper. Fiber optics devices can be miniaturized, split, reflect or transfer light from one source to many places at once and to operate photo devices. Inexpensive Crofon plastic fibres and devices offer both glass fibre optics or inexpensive Crofon plastic fibres for hundreds of experiments or serious applications in a fascinating new science.

RANK TAYLOR-HOBSON ENGINEERS KITS

Basic fibre optic components that demonstrate new ways of employing light in serious applications. Two kits are available — each contains high grade glass fibre light guides consisting of thousands of fibres tightly bunched in flexible fibres with tinned, optically polished, free ends, together with connecting and light source components. Each is supplied complete with cardboard walls containing technical and application data.

KIT 2
- £28 Post Free
- Contains: 3 mm, 10 in., 9 mm a 12 in. light guides; 1.5 mm, "Y" guides with two 12 in. long tails; 24 in. long, 12 element component for accounting or punched card applications. 24 in. lengths of Crofon 64 filament and monofilament plastic light guides. Also, coherent solids consisting of 25 mm. diameter polished ends. 4 mm. x 25 mm. image imput. Complete with 2-way adapter, fibre optic test and barriers. 3 mm. x 12 and 3 mm. x 15 mm. connectors.

LOW COST CROFON FLEXIBLE LIGHT GUIDES

Newly developed plastic light transmitting media by Dupont, which can be used for both serious projects and inexpensive prototype work. Ends can be ground flat, dyed or coated with epoxy resin. Temperature range: -45° to +170° F. No loss of light through bending. 12 page Data and Application booklet supplied free with each order. Types available.

Types: Multi-strand - 64 special plastic fibres; tightly bonded together in a tough, flexible conduit. 9/4 per foot. Maximum order 1227. Price: £1 per foot. Minimum order two feet. 4/- per foot. Minimum order six feet. £1. 4/- per foot.
Complete stereo system—£29 10s.

The new Duo general-purpose 2-way speaker system is beautifully finished in polished teak veneer, with matching vinyl grille. It is ideal for wall or shelf mounting either upright or horizontally.

Type 1 SPECIFICATION:
- Impedance: 8 ohms
- Frequency response: 40Hz to 20kHz
- Maximum power: 90W
- Dimensions: 12 x 6 x 6 inches
- Weight: 4 guineas each
- Pye 6003 amplifier included

SPEAKER SYSTEM £41

Duett Integrated Transistor Stereo Amplifier
- £9 10s.

The Duett is a good quality amp, attractively styled and finished. It gives superb reproduction previously associated with amplifiers costing far more.

SPECIFICATION:
- R.M.S. power output: 3 watts per channel into 8 ohms speakers
- Input SENSITIVITY: Suitable for vacuum or high output crystal cartridges and turntables. Cross talk better than 30dB at 1kHz
- CONTROLS: 3-position volume switch (100% mono and 2 pos. stereo), dual gain, volume, treble/tone, bass/tone controls
- TONE CONTROL: Treble lift and cut, mono operation

THE RELIANT MK.II
Solid State General Purpose Amplifier
In teak-finished case
£5 16s.

NEW COMPLETE HI-FI STEREO SYSTEM £41

ELSIESENEV

ELEGANT SEVEN MK. III
(350mW Output)
£5 50s.

7-transistor fully transistorised M.W.-L.W. superhet portable—ideal for family use. Simple and rugged circuit layout—6-valves for audio, 2 for detector and 2 for detector modulation. The font is a valuable saving in the cost of portable receivers.

THE DORSET
(60mW Output)
£5.50

DORSET

7-transistor fully transistorised M.W.-L.W. superhet portable. Simple and rugged circuit layout—6 valves for audio, 2 for detector and 2 for detector modulation. The font is a valuable saving in the cost of portable receivers.

X101 10W. SOLID-STATE HI-FI AMP
With integral Pre-amp.
£14 6s.

50 WATT AMPLIFIER
£28 10s.

AC MAINS 200-250V

RADIO & TV COMPONENTS (Acton) LTD
21a High Street, Acton, London, W.3.
also 323 Edgware Road, London, W.2.
Goods not dispatched outside U. K. Terms C.W.O. All enquires S.A.E.
LAFAYETTE TE-4 COMBINED SIGNAL GENERATOR

VHF, UHF, MILLIWATT METER

MULTIMETERS FOR EVERY PURPOSE!

MODEL TE-10, 10,000 P.D.

MODEL TE-10, 10,000 P.D.

LAFAYETTE TE-20 RF SIGNAL GENERATOR

TE-20R RF SIGNAL GENERATOR

ADVANCE TEST EQUIPMENT

ADC 38 ELECTRONIC MULTIMETERS

SOLARTRON CD 7152 DOUBLE SYSTEM

CAR LIGHT FLASHERS

ECHO HS-60 STEREO HEADPHONES

TAPES Cassettes

G.W. SMITH & CO. (RADIO LTD)
NEW 6-CHANNEL TIME AND EVENT RECORDER

A self-contained instrument, specifically for recording events without the need for a combined recorder. There is a separate and independent paper drive, with a monitor lamp indicating when it is in operation. The pens are displaced 1/16", activated by a close contact system. Each of the 6 channels works independently of each other, with the pens writing at 72 hours per filling at a maximum speed of 10 pulses per second.

The recorder is supplied either in a portable cabinet or with rack mounting adaptors and the size is 15" x 9" x 9" deep. It weighs 10 lb. and is available in 220-240 volt A.C. (50 cycles) or 110-115 volt A.C. (60 cycles). The 6-channel line and event recorder is available at the following speeds: 20, 20, 5, 5, 1 minute, 12, 5, 5 per hour. Width of paper roll is 9½", maximum diameter of roll is 3", length on standard 3" diameter paper roll is 200'. Price of the event marker is £75-10-0, plus £3-0-0 for the special vinyl-treated portable case.

The instrument is guaranteed for one year, and is available with a complete range of accessories, including telediapositive paper, graphic paper, plain paper, pens, pen containers and time bases. Prices of these items are available on application.

PORTABLE AC/DC PEN RECORDER

A new versatile recorder. Products a trace on a strip of carbon paper in strip chart. Two speeds 1 in. or 6 inches. Limiting contacts to give alarm, and limits the current when it exceeds the rated value. 6-0-6 A.M.A. D.C. Meter Resistance 400 ohms. Linear to 10 K ohms at 25 ma. Scale Division 10000 0-6 A.M.A. D.C. Meter Resistance 1800 at 25 ma.—10 to 15000 ohms for 1000 ohms. Chart Speed: 1 in. per hour; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 in. per hour. Single point. £40-10-0. Double point £50-10-0. Multi-point recorder available.

NEW PORTABLE RECORDING AMMETER

Specification: Type: Moving Coil, D.C. Range: 0-1, 0-2, 0-5, 0-10, D.C. Chart Width: 150 mm. Scale Length: 127 mm. Chart Speed: 50, 100, 200, 400 and 1000 mm; hr. Scale Division: 10000 0-200, 200-400, 400-800, 800-10 in., 10 in. per hour. Single point. £30-3-0. Double point £35-10-0. Multi-point recorder available.

PEN RECORDER

Portable, 2 in. by 6 in. chart recorder by Kelvin Hughes. General purpose recorders for industrial requirements with high sensitivity and high accuracy. The 6-0-6 A.M.A. D.C. strip chart recording unit has a high speed recorder with a 10000:1 chart roll. Limiting contacts to give alarm, and limits the current when it exceeds the rated value. £45-10-0. Two point recorder £55-10-0. Four point recorder £58-5-0 per unit. £65-5-0 per recorder. £85-5-0 per recorder with amplifier. £100-5-0 per recorder with amplifier and chart drive.

CANONICAL EXPORT

BRAND NEW

Graham Line 1 in. 1 1/2 in. chart recorder/plotter heads. Of the highest performance quality. £50-0-0. Price £125-10-0.

MULTI-CANAL CHROMATOGRAPH RECORDER

Type 2251 B. The equipment consists of 2 units. The unit mounted recording well with 12 scale divisions, lens and camera assembly, and the electronic console containing appropriate amplifiers, time base and chart markers. The instrument has been designed to suit maximum flexibility. £250-0-0 complete carriage extra.

OSCILLOSCOPE CAMERA

Leitnum-Thompson series 200 Type B for use with type 35 2100 AC Single shot, frame speed and exposure. Complete with camera £25-0-0.

LOPHELITRIP COLUMNS CARTRIDGE PUNCH TYPE HD97 & VERIFIER AVAILABLE

PROGRAMME BOARDS BY SEALECTRO

Three boards are illustrated, each complete with device mounting of 6, 5, 4, 3, 2, 1 (6, 5, 4, 3, 2, 1) with two contact decks in the Z Plane forming at 90 degrees to each other. Contact is made by electronic or mechanical action. £10-10-0. Price £30-10-0. Price available 25 sets.

MEMORY PLATES

Permits the use of memory plates with video Permit zones. Used for building your own computer, or as an interlocking device. £2-10-0. Price £25-10-0.

MULDAN MATRIX

CORE STORE STACKS

A.W. 211: 5 plates 15 x 20 core lattice plate. £20-0-0.
A.W. 217: 3 plates 20 x 20 core lattice plate. £20-0-0.
Single plate 40 x 20 x 4. £10-0-0.
New design 30 hole punch and keyboard £15-0-0.

MEMORY STORE

M.M. 1164 complete with keypad circuits mounted in metal cabinet. Complete with Admiril (Model 22 27-0).

COMPUTERS


BELL & HOWELL PUNCH OR READER

No motor drive required. Bell & Howell equipment, £18-0-0. Reader £10-0-0. Punch £10-0-0. Cartridge £5-0-0.

FLEXIWRITERS FP6

Both Punch and Read Type available. Any code can be loaded into the memory requirements. Price on application.

DATA DISC HANDLER MK. IV

Self-contained magnetic disc memory unit. Designed for integration with small computers and other digital systems. Suitable for Random Access. High density contact, recording, etc. Price £175-0-0.

RICHUER H 800

PUNCH OR READER

No motor drive required. Ricohenc (Model 100-001, compatible with TR700). £15-0-0. Reader £10-0-0. Punch £10-0-0. Cartridge 25-0-0.

HIGH SPEED 97 HOLE OPTICAL READER

30 characters per second.

CARD READERS

16-column 1800-channel punch. 30 columns 1400-channel model. £325-0-0. Excellent condition.

TELETYPYPE 8 HOLE PAPER PUNCH BRP-81 is above, above. This model has interchangeable heads. Complete with splicer. Price £50-0-0.

WIRELESS WORLD, MAY 1970
MULLARD
ALARM
T9ULARTRON QD
SOLARTRON CD
BOLARTRON CD
WIRELESS

MINIATURE SQUARE COUNTER 4 DIGIT

EVEED ROOT 6 DIGIT COUNTER

MINIATURE DIGITAL DISPLAY

Oscilloscopes

- 960-10
- 960-20
- 960-30
- 960-40
- 960-50
- 960-60

MOTORS

HYPERTENSION REVERSIBLE MOTOR

- Operates in both directions
- Suitable for the generation of high-frequency, high-impedance signals
- Has a thermal overload protection system
- Good for experiments requiring a high starting torque
- Available in various models

HIGH TENSION INDUCTION MOTOR

- 5-20V output
- Ideal for laboratory applications
- Suitable for driving low-speed equipment
- Various models available

LOW TENSION HYPERSTERO MOTOR MA2

- Ideal for instrument chart drives
- Extremely quiet, useful in sensitive applications
- Suitable for applications requiring high starting torque
- Available in various models

PHILIPS ELECTRONIC

- A leader in electronic components
- Offers a wide range of products for various applications
- Known for their reliability and performance

RESET
VEEDER

- Offers a range of products for industrial applications
- Known for their quality and reliability

HIGH PRECISION MAINS MOTOR

- Operates on 220-240V AC
- Suitable for industrial applications
- Available in various models

SYNCHRONOUS MOTORS

- Operates 50 or 60 Hz
- Ideal for industrial applications
- Available in various models

Veeder Root 4 Digit

- Suitable for counting and control applications
- Known for their reliability and accuracy

MINI DIGITAL DISPLAY

- Operates on a meter projection: 0.625 in.
- Useful for industrial applications
- Available in various models

BECKMAN

- A leader in scientific instruments
- Offers a wide range of products for various applications
- Known for their quality and reliability

COUNTERS

- Guaranteed to count all kinds of pulses
- Suitable for electronic and industrial applications
- Available in various models

MINIATURE DIGITAL DISPLAY

- Operates on a meter projection: 0.625 in.
- Useful for industrial applications
- Available in various models

HIGH PRECISION POTENTIOMETERS

- Suitable for high-precision applications
- Available in various models

DIGITAL VOLTMETERS

- Accurate to 0.0005%
- Ideal for laboratory applications
- Available in various models

MULTI-RANGE TRANSISTORIZED VOLTMETER

- Suitable for industrial applications
- Available in various models

VOLT/AMP RECORDER

- For industrial applications
- Available in various models

HYPERTENSION REVERSIBLE MOTOR

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VOLT/AMP RECORDER

- For industrial applications
- Available in various models
**STEPPHENS**

**ELECTRONICS, P.O. BOX 26, AYLESBURY, BUCKS.**

**SEND S.A.E. FOR LISTS GUARANTEE**
Satisfaction or money refunded.

---

**VALVES**

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<th>Description</th>
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<td>11/9</td>
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**CATHODE RAY TUBES**

**TWO YEARS GUARANTEE ON CATHODE RAY TUBES**

**Rebuilt**
Twin Panel
17in. 19in. 21in. 23in. 19in. 23in.
£4 £4.10 £5.10 £6 £7.15 £10.19.6

**New**
Twin Panel
17in. 19in. 21in. 23in. 19in. 23in.
£5.19.6 £6.19.6 £7.19.6 £9.10 £10.10 £12.10

Panorama
19in. 23in.
£8.10 £11.10

All types of tubes in stock. Carriage and insurance 15/-

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**SEMICONDUCTORS**

BY127 2/6 AC107 3/- AD149 7/6
AC127 2/6 AC128 2/6 OC475 2/6
AF117 3/- BC105 5/6 OC71 2/6
AF181 5/6 BC108 5/6 OC81 2/6
BF181 5/6 BC109 5/6 OC81D 2/6
BF200 5/6 AC126 3/-
OA79, OA81, OA91, OA95, OA200. OA202. 1/6

Add 5d. per item for Post and Packing for orders under 24 pieces.

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**STYLII**

TC8. GC2. GP59. GC8. DC284. Stereo 105. 106. 208. 2/- (each individually boxed).

ST3/5, STB8/9, 9TA, 9TA/HC. GP91. 8/- Diamond
Post and packing 5d. per item for orders under 24

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**TAPES (Polyester PVC)**

4in. L.P. 8/6 3in. L.P. 5/6

Standard Play
600ft. 5in. 8/6 900ft. 5in. 10/6 1200ft. 7in. 12/6
Long Play
900ft. 5in. 11/- 1200ft. 5in. 13/- 1800ft. 7in. 18/-
Double Play
1200ft. 5in. 16/- 1800ft. 5in. 19/- 2400ft. 7in. 28/-
Philips type Cassette. (In plastic library pack)
C60 10/6 C90 12/6 C120 19/6

Post and packing 1/6d. on all orders.

---

**ACOS CARTRIDGES**

GP91-1 Medium output Mono Crystal 21/- inc. P. Tax
GP91-3sc. High output Mono Crystal (TC8H TC8M BSR X3H X3M) 21/-

GP93-1 Stereophonic Crystal 24/9
GP94-1 Stereophonic Ceramic 31/-
GP95-1 Stereophonic Crystal 24/9
GP96/1 Stereophonic Ceramic 31/6

---

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

**TERMS, CASH WITH ORDER ONLY. POST & PACKING PAYABLE ON ORDERS UP TO £3, AFTER THAT, FREE EXCEPT Q.R.T.'s.**

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WW—II S FOR FURTHER DETAILS
### Ultrasonic Cleaners

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>E.M.I.</strong></td>
<td>13 x 8 x 10 in. 3/8 x 1/8 in. models. With two tweeters, plus &quot;X-over&quot;. 65/60/55/50 Hz. Brand new, £80.</td>
</tr>
<tr>
<td><strong>E.M.I.</strong></td>
<td>13 x 8 x 10 in. 3/8 x 1/8 in. models. With two tweeters, plus &quot;X-over&quot;. 65/60/55/50 Hz.</td>
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</tbody>
</table>

### Portable Radios

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td><strong>198F</strong></td>
<td>6 x 12 in. 12/44/36/14/18/20/25/30/35/40/45/50 Hz.</td>
</tr>
<tr>
<td><strong>208F</strong></td>
<td>6 x 12 in. 12/44/36/14/18/20/25/30/35/40/45/50 Hz.</td>
</tr>
<tr>
<td><strong>203F</strong></td>
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### LM1818 Magnetic Speakers

<table>
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<tr>
<th>Speaker</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>LM1818</strong></td>
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### LM2904 Magnetic Speakers

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### LM318 Magnetic Speakers

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<tbody>
<tr>
<td><strong>LM318</strong></td>
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### LM408 Magnetic Speakers

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<tr>
<td><strong>LM408</strong></td>
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### LM416 Magnetic Speakers

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<tr>
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### LM2918 Magnetic Speakers

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ELECTROVALUE

EVERYTHING BRAND NEW AND TO SPECIFICATION

LARGE STOCKS

BARGAINS IN NEW TRANSISTORS

ALL POWER TYPES SUPPLIED WITH FREE INSULATING SETS

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RESISTORS

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<td>G</td>
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<td>4-75Ω</td>
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MILLARD SUB-MINITYLICRESISTORS

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<td>1-5k</td>
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<tr>
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LARGE CAPACITORS, ALL NEW STOCK

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</tr>
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</tr>
<tr>
<td>100µF</td>
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<tr>
<td>1000µF</td>
<td>0.03 1-5</td>
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BLACK MILK CAPACITORS, 100% new stock

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SMALL ELECTROLYTICS

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<tr>
<td>1000µF</td>
<td>0.03 1-5</td>
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COMPONENT DISCOUNTS

15% on orders for components for £5 or more. 15% on orders for components for £5 or more. (No discount on netium sets)

POSTAGE AND PACKING

Free on orders over £2. Please add 1/6 if order is under £2. Overseas orders welcome. carriage charged at cost.

PEAK SOUND ENFIELDG KITS

Build it 12-12 or 25-25

Brilliant new styling and available in two forms: STEREO 15 WATTS PER CHANNEL

Supplied in kit form with complete amplifier and pre-amplifier modules and power supply components. Output per channel into 15Ω — 15 watts R.M.S.

Price £15/5/5

STEREO 20 WATTS PER CHANNEL

Supplied in kit form with complete amplifier, pre-amplifier and regulated power supply modules. Output per channel into 15Ω — 20 watts R.M.S.

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Specifications on these amplifiers in accordance with the Specifications in Guarantee published in Peak Sound advertisements.

Impedance: Magnetic, RIAA 3.5mV Tape 100mV

Ceramic 35mV Radio 100mV

Signal to noise ratios: Better than 60dB All Inputs.

ENFIELDG KABINET to house either assemblies (as illustrated) £6.0, Nett.

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VACUUM TUBE VOLTMETER

VIRa

DISCOTHEQUE

PORTABLE OSCILLOSCOPE

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Complete system comprising Control Unit, 4 Tannoy loud speakers, microphone and headphones, etc., 12 V.C. operation, low battery drain. 8 watts power output. The ideal system for mobile use, outdoor meetings, sports day, fashions, garden parties etc. Speakers can be spaced effectively over hundreds of yards. Also has rock box feature. In sealed cabinets. Original cost over £60.

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ORC 27A Price £30 p.p. 10/

WEAVERBRIDGE RC oscillator featuring four overlapping scales covering 1860 to 210 Kc/s. Output waveforms are sine, square and complex. Mirrored scale with smooth geared tuning control. Output 1.00 to 90% or 10 volts. P.P. Sounder and detent. High and low frequency standards. Stability & 1%. Accuracy ± 1%. D.P. input under 34 mV. Single mains operated. With handbook.

GRAVIER FIRE DETECTOR UNIT

Fire Detector Unit containing G31A photomultiplier and 40,000 mV 100 volt tube. Shock and fire proof. Originally made for £74. Price complete with data sheet £6. Brand new.

STC CRYSTAL FILTER

+7.5 KcS BAND WIDTH


PORTABLE GEIGER COUNTERS

PORTABLE VISIBILITY MEASUREMENT


Usually £75.

Desimeters 0.5/sr 12/sr 16/sr 36/sr.

HIGH CAPACITY ELECTROLYTICS

40,000 volts 200 µF.

£5 10/0.

25000 volts 50 µF. £5 15/0.

11,000 volts 10 µF. £5 20/0.

2200 volts 2 µF. £5 25/0.

Discounts for quantities. As a fraction of price. Made by Mallory, U.S.A.

E.R.C. DIGIVISOR No. II


STC DYNAMIC SCALES 2/5/3/2/5/3.

Ideal for experiments, educational purposes as well as for practical use. Delay adjustable 3/1.5 to 300 madi sec. Sizes 9/12 volts. Heavy Duty Connector. Complete range of stages available. Price £35.00 + 5% complete set. Sheet. £35.00 or 3 for £85.

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5 ports 5 6 6 6 6 6 6 6
6 ports 6 7 7 7 7 7 7 7
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- **1N534**: £2.20
- **1N535**: £2.30
- **1N536**: £2.40
- **1N537**: £2.50
- **1N538**: £2.60
- **1N539**: £2.70
- **1N540**: £2.80
- **1N541**: £2.90
- **1N542**: £3.00
- **1N543**: £3.10
- **1N544**: £3.20
- **1N545**: £3.30
- **1N546**: £3.40
- **1N547**: £3.50

### IMPENDENCE BRIDGE TF 369 (No. 5). Measures L & C at 10 kHz. £120.00
- **Price List E.H.F.**
- **Signal Generator**
  - Frequency: 1 kHz to 1000 kHz. Modulation: 0 to 100%. Sensitivity: 1 mV, 100 mV. £150.00
  - Type TF125. Frequency range: 1 kHz to 100 kHz. £100.00

### Solarton Signal Generator**
- Frequency: 1 kHz to 100 kHz. £150.00
- Type TF125. Frequency range: 1 kHz to 100 kHz. £100.00

### General Radio Amplitude Modulation Monitor Type 101A. £45.00 plus carriage.

### A.F. Sweep Frequency Oscillograph
- Range: 10 kHz to 250 kHz. Sensitivity: 0.5 mV/s. £50.00

### Knell Meters
- See our last month's advertisement for list and prices.

---

**Teletype Station**
- We are able to offer, one only, Teletype Model 122. A low cost direct print form aerial, Helical Antenna, oscilloscope receiver and all accessories. £250.00

**Hullard N.S.T. Transistor Radio**
- In one fibreglass-unit type, with top-hat output. £250.00

**Collins Type 31D 4KW Transmitter**
- Complete with aerial, antenna and manual. £1500.00

**Integrated Circuits**
- Many Others in Stock

**Pye PTC 2002 A.M. Ranger Mobile Radio Telephone, brand new.**

---

**W.W. MEGGERS**
- 150V, 380V, 500V £14.00
- **Price Type LI E.H.F. Signal Generator**
  - Frequency: 1 kHz to 1000 kHz. Modulation: 0 to 100%. Sensitivity: 50 mV, 500 mV. £150.00

**V.H.F. Signal Generator Type TF 125**
- Frequency range: 1 kHz to 100 kHz. £100.00
- Type TF125. Frequency range: 1 kHz to 100 kHz. £100.00

---

**P. C. RADIO LTD.**
170 Goldhawk Rd., W.12
01-743 4946

---

www.americanradiohistory.com
## New 1970 Prices

**Electronic Components Ltd.**

<table>
<thead>
<tr>
<th>Component</th>
<th>Price 1</th>
<th>Price 2</th>
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<tr>
<td>PA230</td>
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<td>TAA320</td>
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<td>UL702C</td>
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</tr>
<tr>
<td>3NB4</td>
<td>26/-</td>
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Data sheets available on request 1/- per copy.

**PLEASE NOTE:** Only new—full specification integrated circuits, no below-specification types.

### FAIRCHILD MICRO-LOGIC

<table>
<thead>
<tr>
<th>Type</th>
<th>Price 1</th>
<th>Price 2</th>
</tr>
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<tbody>
<tr>
<td>ul 900</td>
<td>9/-</td>
<td>8/-</td>
</tr>
<tr>
<td>ul 914</td>
<td>9/-</td>
<td>8/-</td>
</tr>
<tr>
<td>ul 923</td>
<td>12/-</td>
<td>11/-</td>
</tr>
</tbody>
</table>

For 100- and 1,000 in application. 5% discount and circuits article—2/-. Plastic spreaders—1/6 each.

### ULTRASONIC TRANSDUCERS

Operate at 40kHz. Can be used for remote control systems without switch, or for proximity sensors. Types of ultrasonic transducers can transmit and receive signals. **Price:** £5.00. Sold only in pairs.

### ZENER DIODES

<table>
<thead>
<tr>
<th>Type</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>2N3819</td>
<td>8/-</td>
</tr>
</tbody>
</table>

Texas MOS, 100W. 25 + 6/9 100 + 5/9

### IRC 20

8/- Plastic 5A trilistors, 250mA, 1.2mA (similar C01003). 25 + 3/3 100 + 3/3

### MGA 100

35/- Gallium arsenide emitter

### INFRA-RED DEVICES

56 CAY 29/- Gallium arsenide emitter

### MGA 100

35/- Gallium arsenide emitter

### 31F2

28/- Infra-red detector diode

**Note:** All prices quoted are current at the time of going to press and may be subject to variation without notice. Semiconductors offered in this advertisement bear the relevant Manufacturers' Prices. Relevant Markings are subject to our full replacement guarantee if not to published specifications. WE DO NOT OFFER "Re-marked" stock and will not accept returns of specification devices.

Please send a stamped self-addressed envelope with any query. Quantity prices on application! Many more types in stock and expandable stock. If you buy in bulk we can offer better prices. Export enquiries particularly welcome. Cable Address: Lestroco Semiconductors. **Terms of BUSINESS:** Retail orders; cash with order please. **TRADE:** Please furnish references if credit account required. **POSTAGE:** 1/- per order inland, 4/- Europe, 12/- Commonwealth.

---

[www.americanradiohistory.com](http://www.americanradiohistory.com)
**SUPER-BARGAIN STOCKTAKING SALE!!**

Use form below for your order. CONDENSERS MUST BE ORDERED BY STOCK NUMBER ONLY.

If any sale item is 'sold-out' when order received we shall substitute items of equal value.

## ELECTROLYTIC CAPACITORS

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Voltage</th>
<th>No. required</th>
<th>Stock</th>
<th>Price</th>
<th>£ s. d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 uf</td>
<td>6</td>
<td>1</td>
<td>4</td>
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<td>2 uf</td>
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<tr>
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<td>33 uf</td>
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<tr>
<td>390uf</td>
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<td>1</td>
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<tr>
<td>1000 uf</td>
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<tr>
<td>1200 uf</td>
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<tr>
<td>1500 uf</td>
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<td>1800 uf</td>
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<td>2200 uf</td>
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<td>1</td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**RESISTORS.** Mainly 5 per cent. 7 1/2 per 100 of any one value. 2/- per dozen of any one value.

Smaller quantities 3d. each. Most values in stock.

Mixed bags (our selection) 6/- per 100.

Mixed bags (our selection) 3/- at 750 watt 100.

MAINS DROPPER TYPE. Hundreds of values from .7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered

**COMPARISON TO DROPPER UNIT**

**SILVER MICA CERAMIC/POLYSTYRENE CAPACITORS**

1/- per 100 of any one value. 3/- per dozen of any one value. Smaller quantities 4d. each. As available.

**COMPARE THESE PRICES!!**

<table>
<thead>
<tr>
<th>MULLARD POLYESTER CONDITIONERS</th>
<th>No.</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 pf</td>
<td></td>
<td>3d. each</td>
</tr>
<tr>
<td>2200 pf</td>
<td></td>
<td>3d. each</td>
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<tr>
<td>3300 pf</td>
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<tr>
<td>10000 uf</td>
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<td>10000 uf</td>
</tr>
</tbody>
</table>

**RECTIFIERS.** Latest type. All marked. 800 volt peak, 1 amp mean current type 1N4006. 2/6 each, 24/- dozen, 67/-100. S.T.C. 3/4 (400 volts) 2/6 each, 24/- dozen, 67/-100. BYZ.13 or 16 (6 amp) 2/6 each, 24/- dozen, 67/-100.

**RECORDING TAPE GIVE-AWAY! ALL BRITISH MADE, BEST QUALITY!**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Price</th>
</tr>
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<tbody>
<tr>
<td>5' Standard</td>
<td>12/-</td>
</tr>
<tr>
<td>7.5' Standard</td>
<td>14/-</td>
</tr>
<tr>
<td>9' &quot;Oddity&quot;</td>
<td>15/-</td>
</tr>
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**Giant Polyurethane Solar Cells**

Only few to clear at half price!

**Co-axial Cables.** Semi-armpit, 100 ft. 60/- roll. 30/- per 500 ft.

**RECORD PLAYER CARTRIDGES**

<table>
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<td>GP1/3 300</td>
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**Stylus.** Diamond needle 32/-.

**TRANSMITTED FLUORESCENT LIGHTS.** 12 VOLT.

- 8 watt 12" tubes, Reflectors 58/8 15 watt 12" Barrels type 78/6

Complete with tube. Postage 3/-.

These prices cannot be repeated. Order now. Don't forget to add your name and address!

Please include suitable amount to cover post and packing. Minimum 2/-. G.F. MILWARD, DRAYTON BASSETT, near TAMWORTH, STAFFS. Phone: TAMWORTH 2321

---

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<thead>
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<th>BRAND NEW SEMICONDUCTORS &amp; COMPONENTS</th>
<th>GUARANTEED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRANSISTORS</strong> Brand new and fully guaranteed. Please note - A large number of our transistors have been redesigned over the past few years. Please see the accompanying transistor list.</td>
<td></td>
</tr>
<tr>
<td><strong>SILICON RECTIFIERS</strong></td>
<td></td>
</tr>
<tr>
<td><em>14v</em></td>
<td><em>70v</em></td>
</tr>
<tr>
<td>P139</td>
<td>200</td>
</tr>
<tr>
<td>P138</td>
<td>230</td>
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<td>P137</td>
<td>260</td>
</tr>
<tr>
<td>P136</td>
<td>290</td>
</tr>
<tr>
<td><strong>DIODES &amp; RECTIFIERS</strong></td>
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</tr>
<tr>
<td>N4001</td>
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</tr>
<tr>
<td>N4002</td>
<td>1.1</td>
</tr>
<tr>
<td>N4003</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>CIRCUIT WITH SPECIAL OFFER</strong></td>
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</tr>
<tr>
<td>2/6</td>
<td>3/6</td>
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<tr>
<td><strong>RESISTORS</strong></td>
<td></td>
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<tr>
<td>1k</td>
<td>0.99</td>
</tr>
<tr>
<td>100k</td>
<td>99.99</td>
</tr>
</tbody>
</table>

**FUSES**
- 80v, 80v
- 100v, 100v
- 150v, 150v
- 200v, 200v
- 300v, 300v

**CARBON POTENTIOMETERS**
- 30k, 30k
- 50k, 50k

**SPEAKERS (Johns)**
- 30 ohm, 30 ohm

**PRESET Components**
- Capacitor: 10,000uF, 50v
- Resistor: 10k, 5%

**RADIOS**
- 140-1000kHz
- 1000-10MHz

**AMPLIFIERS**
- 1W, 1W
- 2W, 2W

**TRANSISTORS**
- 2N3136
- 2N2925
- 2N5309
- 2N2865
- 2N2713

**SILICON DIODES**
- 1N4001
- 1N4002
- 1N4003

**SILICON RECTIFIERS**
- 1N4004
- 1N4005
- 1N4006

**POWER SUPPLIES**
- Linear regulators
- Switchmode supplies

**POWER DEVICES**
- MOSFETs
- IGBTs

**SPECIAL OFFER**
- Bag of transistors (new approx. 100 pieces) for 2/6

**TELEX**
- 01-452 0161/23

**A. MARSHALL & SONS LTD**
- 28 CRICKLEWOOD BROADWAY, LONDON, N.W.2

**CALLERS WELCOME**
- Hours: 9-6 pm Mon-Fri 9-5 pm Sat

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**Send 2/6 for our latest comprehensive catalogue containing transistor selection charts and full prices, and free vouchers value 6/-.**

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VARIABLE
Khi
2
Input
order over E10
BD121 17/3 TIP31A 17/-
BCY70
BC158 7/6 8F194 7/- TIS50 3/9
BC108 3/- BDY20
BC107 3/3 BD123 24/3 TIP32A 23/-
SILICON TRANSISTORS
1
PA234
This
Other
Add
CA3001
CA3000 54/9 CA3029 26/3
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BRAND NEW, keenest prices in the country. All Types (and spares) from 1 to 50 amp. available from stock.

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VARIABLE VOLTAGE TRANSFORMERS

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/360 v. A.C.

DOUBLE WOUND VARIABLE TRANSFORMERS

Fully isolated, low tension secondary winding. Input 230 v. A.C.

OUTPUT CONTROLLED, VARIABLE 0-36 v. A.C.

0-36 v. at 5 amp. £12.50

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These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

INSULATION TESTERS (NEW)

Test to I.E.E. Spec. Rugged metal construction for bench or field work, constant speed clutch. 50 60 Hertz. Weight 6 lbs.

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Similar in appearance to illustration below.

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0-260 v. at 1 amp. . . . . . . . . £5 10 0

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YAN DE GRAAF ELECTROSTATIC GENERATOR

Fitted with neon drive for 230 v. A.C. giving a potential of 50,000 v. Supplied absolutely complete with battery for carrying out a number of interesting experiments, and full instructions. The equipment is completely safe. Ideally suited for School demonstrations.

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Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE. Input 230 v. A.C. Output 25-325 v. A.C. 1 5 watt 10 amp model £16. 7. 6

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Input 100/110 volts or 220/240 V.A.C. 19KV, variable. Ideal for testing insulation, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker’s polished wooden carrying case. Offered at 25% of maker’s price £160.00 plus 7/6 p. & p.

36 volt 30 amp A.C. or D.C. Variable L.T. Supply Unit

INPUT 220/240 V. A.C.
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Is this your man in Munich?

Dunkelbräu, weisswurst, all-night carousing... Oktoberfest comes only two weeks a year, but business in Bavaria slows down to a walk. Import agents everywhere do take time out to observe local holidays and customs. And they do have other clients to accommodate as well as you. Face it: nobody can promote your sales more cheaply, consistently and convincingly than you yourself. And nobody can help you reach your world markets better than I.B.P.A.

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NEW HYSTERESIS MOTORS BY WALTER JONES. Type: 14050/12, 240v. 50 c/s 1500 RPM cont. rating. output 2.0 c/s. Normally 5000 c/s. Type: 3110, 3.5 Perlin. Overall length 110, 250. Type: 3110 B8, overall length 1 box of 100, 250.


**PARVALUX Type S.D.03 GEARED MOTORS.** 240v. 1, RPM. (14 lbs./in. Also 240v. 2, RPM. 11/16 dia. Standard Single hole mounting. Foot standard mounting, 6.15/0 each. P. & P. 10/-.

**NEW "CARLTON ELECTRIC"** 12 r.p.m. MOTOR.-Non-reversible, 3" spigot on 3/4" frame with cast aluminum cased gearbox. Sturdily constructed. Approx. 1/2. Overall size approx. 3/4" x 3/4" plus spindle. 45/- F. & P. 5/-.

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**BONNELLA** Is 160. AMP. 240v. SWITCHES.-Single pole change-over, 1. Long Dolly. Standard single hole mounting, 30/- per dozen. (Minimum order 1 doz.)

**NEW "CROYDON"** 240v. A.C. reversible motors. Choice of 3/150 HP, 1,500 RPM, or 1/100 HP, 750 RPM (Identical in appearance). Size 3/4" x 5 1/2 long plus spindle 11/16 diameter. A bushing motor at less than half maker's original price. £5.10 each.

**English Electric 3 h.p. Motors.** 240v. single-phase, standard output, 1,250 r.p.m. continuous rating. £14.16.7 each. £1 carriage. £5.16.10 each. £1 carriage.

**SCHMACK ROTARY STEPPING RELAY RT304 R8. coil. 22amps.** The relay has 48 basic segments shorted in step by the 4 sweep contacts to 4 pole-plates (banks of 12). There are 2 secondary switches: (1) one close to duty contacts set which changes over and back with each step; (2) two close to duty contacts which change over on each 12th step and return on the following 11 steps. Overall size 31/2 x 11/2 x 41/2. New in maker’s packing, also, as above, but 110 (1.290 ohm coil). £4.15.0 each.

Welwyn high value Resistors Type GA. 36912. Values between 100 and 10.9 megohm to 1% class, temperature encapsulated 15%. £9.20 each.

**WELWYN** RESISTORS.—Type H12. One value only. 1 kohm—20%, 5% each. (Minimum order 2.)

**THORN ILLUMINATED PRESS SWITCH for 250v. 15a. ONE HOLE. M.E.S.** Pressure on cap completes second circuit. Very robust. Length 44.5. mm. dia. 25.5 in. amber, green or red 10/4 each.

**Sylvania Magnetic Switch**—A magnetically actuated switch rating in a vacuum. Switch speed—40 ms. temperature —54 to +200°C. Silver contacts normally rated 3 amps. at 120v. 1.5 amp. at 240v. 10/- each. £4.18.0 per dozen. Special quotations for 100 or over. Reference Magneti available 16/- each.

**Sylvania Circuit Breakers**—Gas filled provided in a range of ratings between 20 Amps. and 1100 Amps. at 200v. and 1100v. The device is designed to protect against faults. Enclosure will also be available in various finishes.

**Miniature "LATCH-MASTER" RELAYS, 6, 12, or 24v. D.C. operation.** One make only. Designed to take 5 amps. at 24v. Current is applied, relay will latch and input polarity is reversed. Manufactured for high acceleration requirements by Spraying Gypsum Co. Size: Length 1" 1/2, width 5/16" (including mouts). Please state vertical or horizontal mount and voltage. £2.50 each.

**New 75-0-75 Micro-ammeter by Sifam, 750 ohm movement, clear reading.** Suitable for 0-75 micro-amperes. Price 75c. Placed on a suitable plastic front, projection 1" (sparking forward). Size: 11/4 x 3/4, 1761 each.

**Ellen Turner 5" 4-5/8" Ms. meter calibrated 0-10 In 50 divisions mirrored scale, handsome chrome escutcheon for flush mounting. A quality instrument. £6.10.0 each.**

**Miniature 6, 10, 15, 20, 25, 30 Micro-Ammeter, 13/16" Diam. Sc, Through-panel mounting, 45c.**

**Motor Driven Variable Voltage Transformers by Ohmite (U.S.A.). Input 120/240v, 50/60 Hz. Output 0-45v, 10-15v. A reversible 115v. x geared motor drives the contact screw in the direction required. There is a micro switch mounted at each end of the track which is non-operated and intended to give protection in the event of a safety-stop. First class condition, £8.15.0. P. & P. 10/-.

**"HONEYWELL" Micro-Switch.—Single and double bank, manual-push. Ideal for vending machines etc. Each "micro" bank comprises a change-over switch 15 amperes, 250v. h.v. A.C. Through-panel mounting assembly is in heavy phenolite, mounted by black knob. Neck dia. 1. Single 10/- extra. 15/- each. Also few only 3 bank. 20/- each.

**"HONEYWELL" V3 Series—Flush micro-switch 10 amp. c/c. The side panel is insulated. End-plate size: 2 3/8 x 3/4" per each.

**"HONEYWELL" Type 33AC-N—15 amp. change-over switch is fitted on a single metal panel with a loaded plastic rod operating 10/- each.

**"Tamper-Alert" (U.S.A.)—Tantalum, Wet Sintered Anode Polariad Capacitors. 1200 V, 6.0, 2200 V, 10, 15, 25, 45, 60, 100. Also 1000 V, 15, 25, 45, 60, 100, 15 0r, 35, 45, 60. A.C. size 3 1/2 x 1 1/2 x 1 1/4. One wire each 24v. and 48v. per each 10/-.

**"Tamper-Alert" MODULAR capacitors 2. H12. 15v, wired-ends, size: 3/8" dia. £1.60 per dozen.**

**WHERE NO CARRIAGE CHARGE IS INDICATED PRICES INCLUDE PERSONAL CALLERS WELCOME.**
Senior Television Technician

is required to be responsible for facilities in a small wired TV Systems Laboratory. He should be conversant with Colour Television Receivers and will be responsible for the maintenance of specialised test equipment. Other duties will include maintenance of records and equipment movement control. Qualifications in R.T.E.B. and Colour Endorsement or H.N.C. desirable.

Good prospects for promotion for a keen young man with initiative. Salary negotiable up to £1,500 p.a. depending on qualifications. Training can be given. Subsidised canteen.

Write, giving details of past experience to:
Head of Operational Services Dept.,
Rediffusion Engineering Ltd.,
187 Coombe Lane West
Kingston-upon-Thames, Surrey
Tel: 01-943 6641

Test Engineers

EKCO AVIONICS (A Division of Pye Telecommunications Ltd.) urgently require a number of tester Engineers for their expanding production lines.

They will be employed on the test and diagnosis of V.H.F. equipment and a City and Guilds Radio and TV Servicing or Intermediate Telecommunications Certificate qualification would be preferred. Salary commensurate with experience and qualifications. Excellent working conditions, good fringe benefits and opportunities for promotion.

Apply to: The Personnel Manager
EKCO AVIONICS
Priory Crescent, Southend-on-Sea. Tel: Southend-on-Sea 49491

Looking Ahead?

At Solartron we place great emphasis on the importance of career planning and development and we are concerned that people who consider joining us should be aware of the opportunities available to them.

Not only can we offer enormous scope for Test Engineers over a wide range of product lines but we also believe that they will be looking for moves into other areas of the company's activities in order to achieve greater flexibility and promotion.

Vacancies currently exist in the following areas:
- Dynamic Analysis
- Digital Voltmeters
- Oscilloscopes

Promotional moves can be made at a later date into:
- Test Gear Development
- Quality Engineering
- Technical Sales
- Technical Writing

- Contract Engineering
- R. and D.

Our present vacancies would suit young men, preferably with experience of modern digital and/or analogue techniques, who have a technical background equivalent to that of Inter. C. and G. (Telecomms.) or Radio and Television Servicing.

Experience of test work or of television servicing would be very advantageous.

We can offer rates of pay up to £1,200 per annum exclusive of overtime.

If you are looking for a successful career in electronics we would be pleased to talk to you. Please write us or telephone for an application form to:

R. D. Scamler,
Senior Personnel Officer,
The Solartron Electronic Group Ltd., Farnborough, Hants. Tel: 44433
Rank Pullin Controls is a precision mechanical and electronic manufacturing company within the Industrial Division of Rank Precision Industries Limited. The R & D Department’s current programme includes advanced sonar, metal and foreign body detection work, also research equipment developed for oceanography. The Company’s plans require the R & D Department to expand substantially in the next two years in both M.O.D. work and commercial products.

Vacancies exist for:

**Senior Electronic Development Engineers**

These vacancies will interest young engineers who are ready to take responsibility (including financial aspects for parts of projects) and who will advance to Principal Engineers. Applicants should be aged 23+, have a degree, H.N.D. or H.N.C., and at least two years’ relevant experience. Salary up to £2,250 according to age and experience.

**Electronic Servicing and Test Engineer**

To start a team for commissioning, servicing and maintaining in the U.K., experimental electronic equipment built in the Department. Applicants should be aged 23+, with H.N.C. or equivalent, and some years experience with solid state electronic equipment. Salary up to £2,250 according to age and experience.

**Draughtsmen**

(electro-mechanical and Printed Circuit)

To work in close co-operation with senior engineers on the design of sophisticated electronic equipment employing the latest techniques of electronic packaging. Applicants should be aged 26-40 years, with O.N.C. Electrical or Mechanical (C & G would be considered) and electronic or electromagnetic experience. Salary £1,400-£2,000 according to age and experience.

**Technical Assistants**

To build and test breadboards and prototype electronic equipment. Applicants should be over 21 years with O.N.C., and experience with wiring and testing electronic circuits. Salary up to £1,400 according to experience.

The Company offers favourable career prospects within the Organisation. There is a contributory Pension Scheme and free Life Assurance. There are many other staff fringe benefits including first class catering on site. Relocation assistance will be considered.

Write or telephone during office hours:

The Personnel Manager,
Rank Pullin Controls, Phoenix Works,
Great West Road, Brentford, Middx.
01-560 1212
Evenings: Mr. I. W. D. Cox
Gerrards Cross 83227.

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**THE STOCK EXCHANGE, LONDON**

require an additional

**Television Service Engineer**

To maintain a closed circuit television system recently commissioned for the display of market prices.

Applicants must possess appropriate television and radio servicing certificates and must be able to prove their ability as competent Service Engineers by a suitable trade test.

An attractive salary is offered in the region of £1,500-£1,600 per annum. In addition, there is a non-contributory pension scheme, 3 weeks holiday in a full year and 3s. luncheon vouchers.

Applications giving brief details of qualifications and experience should be sent to:

Personnel Officer,
Council of the Stock Exchange,
The Stock Exchange Building,
London EC2.

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Computicket wants

**MAINTENANCE TECHNICIANS**

Computicket is now implementing its entertainment seat-booking system. This service, which operates in real-time, will ultimately involve hundreds of on-line CRT Terminals, sited in a wide variety of public places.

Computicket is now recruiting Maintenance Technicians based in the London Area to perform a vital role in this exciting new service.

Applicants should have had experience in the maintenance of Electro-mechanical and Electronic equipment situated in the field and should be happy to find themselves part of a technically advancing but nevertheless consumer orientated team.

Salaries up to £1,700 are being paid. There are also posts vacant at senior level for Electro-Engineers with a broad design experience and leadership potential.

Write for an application form to:

Colin Roberts, Chief Engineer,
Computicket Limited
247 Tottenham Court Road,
London W.C.1.
RADIO ENGINEERS
CIVIL AVIATION - ZAMBIA

* Salary £2310 to £2590 according to experience.

* Low Taxation.

* Contract of 36 months.

* 25% Tax-free Gratuity.

* Educational Allowances.

Duties will involve the maintenance, overhaul and installation of ground terminal radio communication equipment and navigational aid at Airports and Flight Information Centres.

The equipment includes radar systems, H.F. and V.H.F. transmitters and receivers, I.L.S. and D.F. systems and tape recorders. Candidates, who should be under 55 years of age, should have practical experience and a knowledge of theoretical principles within this field.

In addition they should have attained one of the following:

i) completion of a 5 year apprenticeship,

ii) a service trade certificate,

iii) an I.C.A.O. certificate,

or iv) equivalent.

Apply to CROWN AGENTS, 'M' Division, 4, Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference No. M2Z/690315/WF.

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SCIENCE RESEARCH COUNCIL
RADIO AND SPACE RESEARCH STATION
EXPERIMENTAL AND ASSISTANT EXPERIMENTAL OFFICERS

are required for investigations of the propagation of radio waves through the troposphere and ionosphere, and for space research activities overseas.

At Slough duties will include the development of electronic and other apparatus, performance of experiments and the processing and analysis of results. Much of the current work is directed towards the improvement of communications particularly by studying the propagation of centimetre and millimetre waves. Experiments are carried out using rockets and satellites to study the upper atmosphere.

Suitably qualified staff may spend a tour of duty of up to 3 years' duration in the Falkland Islands to operate and maintain radio telemetry equipment for the reception of data from satellites.

QUALIFICATIONS
University or CNAA degree, HNC or equivalent qualification. If under 22 years, five G.C.E. passes including two science or mathematical subjects as "A" level or equivalent. Experimental Officers are normally expected to be 28 years of age with several years' relevant experience.

SALARIES
Assistant Experimental Officer: £683 at 18 years, £940 at 22 years, £1,208 at 26 years, rising to a maximum of £1,454 p.a.

Experimenal Officer: between £1,590 and £2,006 p.a.

These pay scales are subject to an 83% increase with effect from 1 April, 1970.

Non-contributory superannuation scheme.

Apply:

The Secretary, Radio and Space Research Station,
Ditton Park, Slough, Bucks. Telephone: Slough 24411
Closing date: 29 May, 1970.

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It's Racal 'quality year'
And we are looking for good quality
Test Equipment and Calibration Engineers
to help us maintain our standards of
Test Equipment service.

Specification:
Wide general experience
Good knowledge of circuit applications
Experience with H.F. S.S.B. Communications
Test Equipment.

Optional Extras:
City & Guilds or O.N.C. or H.N.C.

Power Consumption:
£1100 - £1300

Applications in writing please stating Ref. No. B1000 to:

RACAL
THE ELECTRONICS GROUP
Western Road, Bracknell, Berks.

Mr. L. A. Jemmett,
Personnel Manager,
Racal BCC Ltd.
Go places as a Computer Service Engineer

Men under 35 with experience in light engineering and electronics can build excellent careers in ICL servicing computers.

We want qualified men with HNC or C & G in electronics engineering, or a Forces training in electronics. Or, perhaps, you have a similar qualification which proves you have the serious interest in the subject necessary for further specialist training.

We pay realistic salaries while you train—about six months—on ICL equipment, learning how to sort out operational problems and maintain computers in peak condition.

You will have to take responsibility for highly sophisticated and expensive equipment, so if you have a worthwhile career in mind, here is the chance to apply your expertise and initiative to the full.

Career progression and promotion are limited only by your ability.

Write giving brief details of your career, quoting reference WW 103 C.

Installation Engineers
Technicians & Testers
Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.

Test Technicians
Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems. Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.
VISUAL SYSTEMS ENGINEERS

THE JOBS
Project & Systems Engineering on Advanced Training Aids for Aircraft.

THE MEN
Electronic Engineers preferably H.N.C. or B.Sc. having had practical experience in one or more of the following fields. Flight test, Auto Pilot, Weapons Control, General Process Control, Instrumentation, Systems Design, Colour Video, Systems Maintenance and Design, with a keen desire to learn new techniques and applications.

THE REWARDS
A salary up to £2,000 per annum. High job interest. Opportunity to work on complex systems incorporating digital and analogue computers, associated peripherals, colour television systems and servo systems as a member of a team. Opportunity to fly and operate simulated aircraft and other equipments. High quality training will be given.

OTHER BENEFITS
Our terms and conditions of employment are good and include contributory pension scheme, free life assurance, etc. We are not merely offering posts which will afford candidates opportunities of attaining a good job. Selected candidates will be offered long-term careers. Opportunities for occasional overseas travel, etc.

Apply, quoting reference WW/170 to:
H. C. Hall, Personnel Manager,
REDIFON LIMITED
Flight Simulator Division
Gatwick Road, Crawley, Sussex
Tel: Crawley 28811

BBC HOLIDAY RELIEF ASSISTANT FILM RECORDISTS

BBC Film Operations require Assistant Film Recordists on limited contracts for Holiday Relief duties during the summer months. Initial Contract will be for two months but may be extended as circumstances demand on a month by month basis.

Duties involve the operation of sound transfer equipment, also working in the recording rooms of dubbing theatres. Candidates must have some professional experience in film sound transfer and recording work, a good technical knowledge of sound recording practice and an understanding of the principles of cinematography. Work will be on a day or shift basis (not night shifts). Salary will be in the range of £1,280 to £1,404 per annum depending upon qualifications and experience. Based Ealing or Shepherds Bush.

Write for application form (enclosing addressed foolscap envelope and quoting reference 70.G.615) to Appointments Department, BBC, London W1A 1AA by April 28th.

RADIO TECHNICAL OFFICERS
Earnings up to £2,000 p.a.

The P.L.A. operate a wide telecommunications network from Tower Pier to the outer Thames Estuary, and vacancies exist at Gravesend and King George V Dock for Radio Technical Officers to maintain the equipment at maximum efficiency.

To ensure adequate coverage, a shift system is operated.

Salary scale:—£1,280 to £1,520 p.a.—plus an allowance for week-end and public holiday working, where applicable. Payment at enhanced rates is made for overtime working when required. Earnings of up to £2,000 p.a. are possible. Minimum qualifications:—

- O.N.C. Electrical Engineering
- City & Guilds Intermediate Certificate in Telecommunications Engineering plus Radio II
- or equivalent Service qualifications.

Applicants should have at least 5 years’ experience in two of the following fields:—

* V.H.F. and U.H.F. Radio
* Radar and Microwave Links
* Telemetry and Digital
* Telephone exchange equipment
* and land lines.

Application forms may be obtained from:—

The Chief Engineer (Personal)
Port of London Authority,
P.O. Box 242,
Trinity Square,
Electronics Maintenance Engineers

There are excellent opportunities in the Installation and Maintenance Division of U.K. Electronics and Industrial Operations of E.M.I. Ltd., at Hayes, Middlesex, for engineers to carry out maintenance work on a wide variety of electronic equipments including laboratory test gear and transceivers.

Candidates should be between 21 and 45 years of age and have some experience in this type of work. Consideration will be given to experienced Radio and Television servicing technicians and to ex service personnel.

Applicants are invited for the post of JUNIOR TECHNICAL OFFICER

with the MEDICAL RESEARCH COUNCIL.

Duties will include the construction, maintenance and development of electronic equipment and assistance in observations on normal subjects and patients occasionally during neurosurgical operations. Training in metal workshop practice would be an advantage. Male candidates aged 21-26 with O.N.C., H.N.C. or equivalent will be considered.

Salary in range plus £90 London Weighting. Applicants should give details of age, qualifications and experience to: Dr. J. A. V. Bates, National Hospital for Nervous Diseases, Queen Square, London, W.C.1.

Salary will be £21 per annum.

The job will be an introductory training period for a promising junior technical officer.

Applications are invited for a post in the following Department:

PHYSICS

EXPERIMENTAL OFFICER/ SENIOR EXPERIMENTAL OFFICER

The successful applicant will be responsible for the design of a wide range of electronic apparatus covering DC and pulse amplifiers and digital recording systems. Minimum qualifications: Degree in Physics or Electrical Engineering together with appropriate experience.

Closing date 30th April 1970.

SALARY SCALE: £995-£2,225.

Applicants giving age, qualifications and experience, together with the names of two referees should be sent to the Administrative Assistant, Physics Department, The University, Lents LS2 9JT.

Please quote reference number 491.

Senior Systems Engineers

With continued expansion the Digital Systems Department has vacancies for Senior Systems Engineers.

The Man. Applicants should preferably be graduates with engineering or science degrees or equivalent qualifications. Experience in one or more of the following fields is desirable:

- Digital computer and their application to real time digital computer systems.
- Digital computer peripherals.
- Military defence systems, including fire control systems.
- Radar and synthetic display systems.
- Surveillance and tracker radar systems.
- S.S.R. systems.
- Servo systems.

The Job. The work involves conducting technical negotiations with potential customers, carrying our System Design Studies and preparing technical proposals. The successful applicants will be based at Bracknell and travel in the U.K. and abroad will be necessary.

This appointment carries a high degree of personal responsibility and requires the ability to hold discussions with military and civilian personnel at a very senior level. The Digital Systems Department is situated in pleasant countryside surroundings. Working conditions and holiday arrangements are excellent. The Company operates a contributory Pension and Dependants Assurance Scheme. Promotional prospects are excellent.

Write giving brief details and quoting reference D/109/wt to:-

Mr. D. J. O'Connor, Personnel Officer, Ferranti Limited, Western Road, Bracknell, Berks. or telephone Bracknell 3232.

THE UNIVERSITY OF LEEDS

Applications are invited for a post in the following Department:

PHYSICS

EXPERIMENTAL OFFICER/ SENIOR EXPERIMENTAL OFFICER

The successful applicant will be responsible for the design of a wide range of electronic apparatus covering DC and pulse amplifiers and digital recording systems. Minimum qualifications: Degree in Physics or Electrical Engineering together with appropriate experience.

Closing date 30th April 1970.

SALARY SCALE: £995-£2,225.

Applicants giving age, qualifications and experience, together with the names of two referees should be sent to the Administrative Assistant, Physics Department, The University, Lents LS2 9JT.

Please quote reference number 491.

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technicians
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Everybody appreciates success. Three years ago when our development labs started work on a completely new range of Mobile Radio equipment we were on to a winner. Launched last year we now have the most advanced compact and competitive equipment on the market. Our problem now is to ensure that the quality of our products and our maintenance and service is as good as our design. We need Testers and Service Engineers to help.

test:
Based at a temporary site near Watford. Testers will transfer to our new factory between Radlett and St. Albans when it opens towards the end of this year.
Duties include testing, fault finding and alignment on UHF pocket phones and base stations. Senior test engineers will also take on systems test and trouble shooting work.

service:
Based at New Southgate—one vacancy at Croydon—service engineers are responsible for the repair and maintenance of our complete range of UHF and VHF equipment. A clear driving licence is essential as some local travel is involved.
If you have experience of test or servicing radio equipment this is your chance to link your success story with ours.

Write or phone:
T. G. Anderson, Asst. Personnel Manager,
Standard Telephones and Cables Limited,
Oakleigh Road, New Southgate, N.11.
01-368 1234, ext. 2878.

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DYMAR

Very IMPORTANT to YOU—Very IMPORTANT to DYMAR TEST ENGINEERS with a FUTURE

DYMAR is an independent rapidly expanding Company with long term plans and a very impressive order book for VHF communications equipment, including an immediate major export success of over $250,000 to the U.S.A., providing secure and interesting work, with high value and responsibility placed on the individual.

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- Free pension scheme with free life assurance.
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Contact John Cybulla by letter or telephone – reverse charges: Watford 21297
Dymar Electronics Limited,
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Watford,
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With current morse speed of 20 w.p.m. PMG Certificate, teleprinter experience essential. Salary from £1,000 according to qualifications and experience with all living and messing free.

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Record Works, Watthamstow Avenue, E.4
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Experienced in one or more of the following fields:
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- Dist Cutting Equipment;

Weekly staff appointment, 37-hour week. Good starting salary supported by generous holiday and sick pay schemes, and contributory pension fund.

Please apply in writing to the Personnel Manager at the above address.

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There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1970 and in subsequent years.

Specialist training courses lasting approximately nine months, according to the trainee's progress, are held at intervals. Applications are now invited for the course starting in September, 1970.

During training a salary will be paid on the following scale:

<table>
<thead>
<tr>
<th>Age</th>
<th>Salary per annum</th>
</tr>
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<tbody>
<tr>
<td>21</td>
<td>£800</td>
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<tr>
<td>22</td>
<td>£855</td>
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<td>23</td>
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<td>24</td>
<td>£925</td>
</tr>
<tr>
<td>25</td>
<td>£965</td>
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</tbody>
</table>

Free accommodation will be provided at the Training School.

After successful completion of the course, operators will be paid on the Grade 1 scale:

<table>
<thead>
<tr>
<th>Age</th>
<th>Salary per annum</th>
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<tbody>
<tr>
<td>21</td>
<td>£965</td>
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<tr>
<td>22</td>
<td>£1025</td>
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<tr>
<td>23</td>
<td>£1085</td>
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<tr>
<td>24</td>
<td>£1145</td>
</tr>
<tr>
<td>25+ (highest age point)</td>
<td>£1215</td>
</tr>
</tbody>
</table>

then by six annual increases to a maximum of £1650 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must normally be under 35 years of age at start of training course and must have at least two years' operating experience. Preference given to those who also have GCE or PMG qualifications.

Interviews will be arranged throughout 1970.

Application forms and further particulars from:
Recruitment Officer, (R.O.3) Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 6AJ
Telephone No. Cheltenham 21491, Ext. 2270
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We offer career growth in a rapidly expanding organisation.

Applicants with experience of writing, design, test or service engineering, preferably in test equipment or the communications industry should post the coupon to quoting reference M. 12/1.

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Personnel Department,
Hewlett-Packard Limited,
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Name
Address
Qualifications

TECHNICIAN or SENIOR TECHNICIAN REQUIRED

For work in the development of automated teaching equipment. Experience in electronics and/or television essential. Knowledge of optics, photography, cinematography desirable.

Salary scales (under review) £898—£1,252 p.a. or £1,181—£1,486 p.a. according to experience and qualifications.

Further information and application forms from the Laboratory Superintendent (T.EA1), Departments of Physics and Electronics, Chelsea College, Manresa Road, London, S.W.3.

CONSULTANCY REQUIRED

Messrs. Toshniwal Bros. Private Ltd. of Bombay, wish to contact persons in England to provide consultancy services on their know-how with a view to manufacturing the following items in India:


Please write to SHRI B. D. Toshniwal, 198 Jamshedji Tata Road, Bombay 1, who will be able to meet the persons concerned in England during June this year.

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APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from ex-Armed Services technicians.

HIGHLY COMPETITIVE SALARIES, negotiable and backed by valuable fringe benefits.

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WRITE or phone Personnel Department stating age, details of previous employment, training, qualifications, approximate salary required, quoting WW3.
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Applications are invited from Development or Systems Engineers of degree or HNC standard who are experienced or interested in SERVOS, ELECTROHYDRAULICS, or FAILURE SURVIVAL SYSTEMS. These positions offer excellent prospects to Engineers to join our teams currently engaged on Development of advanced Military systems at Rochester. Vacancies also exist for Technical Authors, Technical Assistants and Design Draughtsmen.

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For further details please write or telephone for application form to: Mr E. Moss, Personnel Officer, ELLIOTT FLIGHT AUTOMATION, Airport Works, Rochester, Kent. Telephone Medway 44400, Extension 64.

A GEC-Marconi Electronics Company

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(Instruments) for

TRAWSFYNYDD NUCLEAR POWER STATION
Trafsyfynydd, Merionethshire

Vacancies have arisen in the Instrument Maintenance Department at Trawsfynydd for Maintenance Craftsmen on shift or staggered day working. Applicants should have good training and experience in electronic equipment servicing and should be able after a suitable induction period to work on a wide range of nucleonic equipment with minimum supervision. Weekly Salary is £28.15.1 for a forty hour week, five cycle shift continuous cover or £26.3.2 for a forty hour five out of seven day staggered week. Conditions of employment will be in accordance with the National Joint Industrial Council Agreement for the Electricity Supply Industry. The posts are permanent and good sick, holiday and voluntary superannuation schemes are in operation. The Station is situated about ten miles from the coast on the fringe of the Snowdonia National Park and is within easy reach of the delightful beaches of the area. Council house accommodation may be available to the successful candidates. Applicants should write to the Station Superintendent, Trawsfynydd Nuclear Power Station, Central Electricity Generating Board, Trawsfynydd, Merionethshire, North Wales giving details of age, education, training and experience.
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ENGINEERING

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EXTERNAL DEGREES

B.Sc. (Eng.) (Hons.)—Electrical (including Electronics).

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For prospectus apply to: The Principal, Room 67, College of Technology, Lansdowne, Bournemouth, BR1 3JJ. Tel. B.20844.

A WAY OUT from
TV SERVICING

We believe an Ex T.V. Engineer may be just the type who would fit into one of our Electro-Mechanical Development teams.

We do prototype work in connection with an extremely wide range of industrial and laboratory processes. An experienced technician with at least an O.N.C. or R.T.E.B. Certificate is required to assist with construction and testing.

This staff appointment offers excellent prospects with a progressive Company. There are the usual benefits, a contributory pension fund, free lunches, etc.

Applications should be made in writing to the Assistant Staff Manager, Johnson, Matthey & Co. Limited, 78 Hatton Garden, London, E.C.1, quoting reference S.77.

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SOUND DIFFUSION, a rapidly expanding organisation, would like a word in your ear: about a job working on Hotel and Industrial paging, signalling and sound distribution systems. We envisage that the successful applicant will preferably have had between 3 and 5 years experience of working with

Fire Detection systems

Design and development of Audio and Public Address systems including low level signalling and solid state techniques.

If this is your field and you're between 25 and 35, with minimum C and G, but preferably of HNC standard, and looking for a job with security and good promotion prospects, you may be the man we are looking for.

The rewards are excellent—a good salary, pension and sickness schemes, subsidised canteen, sports and social facilities; and to go with these, assistance will be given towards removal expenses to the attractive South Coast. Sound Diffusion is expanding fast—we need YOU to expand with us—

The Sound Diffusion Group

Personnel Manager
Datum Works
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Hove BN3 1RZ Sussex
Tel: Brighton 775499

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Your chance of a shore job with good pay from the start!

If you hold a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General or the Minister of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic, the Post Office can offer you employment at a United Kingdom Coast Station, with a starting salary of £965–£1,215 (depending on age). Annual rises will take you to £1,650 and there are good prospects of promotion to more responsible and better paid posts.

If you are 21 or over, please write for more details to:

This opportunity offers good career prospects within an expanding Company.

Applicants should have a sound knowledge of electronics and electronic equipment and preferably some allied electro-mechanical knowledge. Experience of one of the following would also be considered advantageous:

- DC control systems and GPO equipment.
- Solid state logic circuits and testing in conjunction with telegraph switching.

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To repair range of professional and semi-professional recorders, cameras, monitors. Knowledge of electronic calculators an advantage.
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Sales-Coordination Manager
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Ascot Road, Feltham, Middx.

Hampshire Chief Technician
Farnborough Technical College

For the Department of Science to take charge of Physics, Electronics, Chemistry and Biology laboratories. He should have good qualifications and a particular interest in Physics and Electronics. He should be capable of servicing, maintaining and ordering instruments and apparatus.

The salary is according to Grade 4 (at present £1,130—£1,345 per annum); starting point depends on experience and qualifications.

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Electronics Commissioning Engineers—Digital Equipment

To join a small team responsible for commissioning and fault finding, both ex-works and on site. of computer type lighting control systems. These systems are being installed in the United Kingdom and overseas and applicants must be prepared to spend 3-4 weeks on location.

Applicants should be at least 24 with experience of working on radar or digital equipment employing semi-conductors either as commissioning engineer or in the services as an N.C.O., without direct supervision. A knowledge of and interest in theatre lighting would be advantageous.

Salary from £1,500. Based Brentford, Middlesex.

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Personnel Manager, Rank Strand Electric Ltd.,
29 King Street, Covent Garden, W.C.2.

The Rank Organisation
The man with the gong—a man of many skills

Sony (U.K.) Limited

Hampshire Chief Technician
Farnborough Technical College

Sony (U.K.) Limited

Hampshire Chief Technician
Farnborough Technical College

Rank Strand Electric Ltd

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Required for the design and development of solid state circuitry involved in the development and use of a cyclotron for medical research. Applicants should have a Pass Degree or HNC, and experience in the use of integrated circuits, switching circuits, or data handling techniques. Age under 35.

Salary in range £1,498—£1,789 + £90 L.W.

Apply to Director, Medical Research Council Cyclotron Unit, Hammersmith Hospital, London, W.12.

Meat Research Institute

Electronics Technician to assist in development, construction and servicing of electronic equipment mainly connected with data logging. Experience in layout, wiring and testing of electronic circuits and the location of faults in electronic equipment necessary.

Qualifications O.N.C. in Electrical Engineering; City and Guilds certificate for Electrical Technicians, or equivalent.

Salary £1,080 at age 22; £1,360 p.a. at age 28; rising to £1,650 p.a.

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Applicants must be fully experienced and qualified technicians/engineers and will be expected to carry out interesting test work using sophisticated test equipment.

Suitable engineers will be offered an attractive salary and a staff position with all usual benefits.

Applications should reach the Personnel Manager by 1st May.

Please write to Mr. B. H. DOCWRA
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Required to assist in the construction, testing and use of a computer-controlled flying-spot microscope for the automatic examination of biological material. The post is supported by the S.R.C. and the appointment will be for two years in the first instance.

Salary scales (under review) £668—£1,252 p.a. or £1,151—£1,486 p.a. depending upon experience, qualifications and age.

Day-release facilities.

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Tel. 01-352 6421.

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in the Evaluation Test and Development section of the Engineer-in-charge's Department at Tower Hill, E.C.3, to assist in the wiring and setting up of experimental electrical/electronic equipment.

Further details and application forms from The Secretary, Trinity House, Tower Hill, London, E.C.3.

Norwich City College

Department of Electrical Engineering

H.N.D. Course in Electrical and Electronic Engineering

The Department of Electrical Engineering of the Norwich City College offers students who have studied Physics and Mathematics at Advanced level in the GCE and passed in one subject or have obtained a good ONC or OND in Engineering a modern sandwich course for the Higher National Diploma in Electrical and Electronic Engineering. Subjects studied include Computation, Statistics, Economics and Law, Electronics, Control, Telecommunications, Power and Machines. Well balanced and interesting industrial training with pay will be arranged as required. The course is approved for major grant awards by Local Authorities.

Accommodation will be arranged by the College if desired.

Enquiries about the course starting in September 1970 should be made to:

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We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

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Phone: 01-397 5411
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Applications to:
Personnel Manager,
REDIFON AIR TRAINERS LIMITED,
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Applications are invited for the following vacancies with the County Television Unit based at Goldings, Hertford:

1. A TECHNICIAN, to maintain language laboratories and some other audio equipment in the County. A suitable technical qualification (e.g. H.N.C.) is required, and practical experience of audio equipment. Ability to drive essential. Salary: £1,130—£1,345.

2. A TECHNICAL ASSISTANT. A person with practical experience with audio visual equipment who could be trained as a camera operator and do preventative maintenance on video and audio equipment. Ability to drive essential. Salary: £836—£1,130.

For further details and application forms for these posts please write, within 7 days of date of publication, to: The Director, County Television Unit, Wall Hall College, Aldenham, Watford, WD2 8AT, stating which post is to be considered.

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**S.P. LOUDSPEAKERS**

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**The International Publishing Corporation seeks the following staff for their laboratories at Feltham & Hemel Hempstead.**

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Electronic technicians qualified to O.N.C. standard who have served a recognised apprenticeship or had similar experience.

The work involves construction testing of a wide variety of prototype analogue and digital systems.

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Applicants should have served a recognised apprenticeship or had similar experience. The successful candidates will be required to construct and wire electronic prototype equipment from sketches and also have some experience in the construction of mechanical systems.

**A Design Draughtsman**

A Draughtsman qualified to O.N.C. standard and experienced in the design of electro-mechanical systems.

The work consists of electro-mechanical drawings, electronic layouts, cable schedules and preparation of drawings for equipment manuals.

The Company pays progressive salaries and offers excellent working conditions.

For Application forms please write to the Director of Research & Development, IPC Services Ltd, Astronaut House, Hounsdown Road, Feltham, Middx.
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A comprehensive study of the subject covering the whole range of the techniques which may be employed and also the whole range of possible fields up to the extreme limits. 160 pp. 81 illustrations. 80s. net. 82s. by post.

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SIZE Q
Bib 12" Record Sleeve Protectors
Keep record sleeves like new. Made of extra strong, clear plastic. Pack of 5, 2s 6d or 12½p including p.t. (6d)

GENERAL MAINTENANCE

MODEL 6
Bib Wire Stripper and Cutter
Fitted with automatic opening spring for quick flex and cable stripping, also cuts wire. Screw adjusts for different wire sizes. Plastic covered handles with locking ring. 8s 6d or 42½p

SIZE D
Bib Flex Shorteners
Shorten without cutting, audio cables and flexes. Made of unbreakable plastic. Pack of 4, 2s 6d or 12½p

All prices are recommended retail. Obtainable from most audio stockists. If in difficulty send cash with 1/- for postage and packing for orders less than 10/- and 2/6 for orders above 10/- (United Kingdom only) to:

BIB Division Multicore Solders Ltd. Hemel Hempstead, Herts. Tel: Hemel Hempstead 3636