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Commentary

CONSIDERABLE satisfaction will be felt with the recent statement by the Postmaster-General in the House of Commons outlining the financial basis on which the BBC will operate for the next three years.

Expenditure has been in excess of revenue for some time past and in order to make both ends meet the BBC has had to draw heavily on its reserves. With a large development programme under way both in sound and television it has become all too obvious that the BBC must increase the main source of its income, namely the licence fee.

Briefly, the combined licence fee for sound and television will go up to £3 as from 1 June. Of the total revenue the Exchequer will retain £2M annually for the next three years and in the second and third years it will keep a further £750 000 which will be handed over to the proposed Independent Television authority. An annual sum of £1·6M will be given to the Post Office to cover the cost of collecting the licence fees and removing the causes of interference. The balance will go to the BBC.

The number of sound receivers, for which the licence fee is to remain at £1, has tended to remain steady, but it is predicted that with the present rate of growth of television in this country the BBC will receive some £17M in the first year, £18½M in the year after and £20M the third year, by which time it is anticipated there will be 5 300 000 television receivers—roughly one receiver for every ten of the population.

This is a large income but it is no more than the BBC estimated it would require and at long last it will allow the BBC to proceed with its development plans without incurring financial crises.

It is now expected that the plan for national coverage of the present television service will be complete by the end of next year and when this is done it will give coverage to 97 per cent of the population of the United Kingdom.

At the same time, there will be a considerable extension of the facilities for the service both in London and the Regions.

Colour television remains, as before, a technical problem, rather than one of finance as the questions of compatability and frequency allocations have not yet been answered and no one as yet can predict when colour television will be available. All that can be said at this stage is that it will not arrive within the present financial period of three years.

The second television service to be given by the BBC is now much nearer and both they and the television industry are preparing for its inauguration. New television receivers designed to receive the dual transmissions of the BBC together with those of the independent television authorities, will be on display at the Radio Industries Exhibition at Earls Court in the autumn, although it is by no means clear when the new transmissions will start.

The television set maker is, in fact, faced with somewhat of a dilemma at the moment, for the public has come to believe that both the second service and the independent television programmes are just round the corner.

It is perhaps difficult for the layman to appreciate how much work is involved to bring these plans into being. As far as we know, the BBC have carried out no studies in the way of propagation or in the problems of site locating and testing. It is only this month that the BBC have taken delivery of the first of six experimental television type transmitters for the particular purpose and results cannot be expected immediately.

These studies are very time-consuming and it is reasonable to suppose that at least another twelve to eighteen months must elapse before the second service is in actual operation.

The position with regard to the independent organizations is not known, but it is unlikely that these bodies are any more advanced.

A most gratifying feature of the increased resources of the BBC is that a start can now be made on the VHF FM network. A number of transmitters have already been ordered and within the next twelve months or so the new transmissions should be heard. The emphasis remains on television, but sound broadcasting has by no means outlived its purpose and the exceptionally high quality of reproduction with freedom from interference obtainable with the new system will attract a growing and more critical audience.

Epoxy Resins

By R. A. Johnson*

During the last few years electrical engineers have become familiar with the "Araldite" range of Epoxy Resins, either as adhesives or casting resins. This article presents a complete picture of the methods of use and properties of the casting resins. It also gives some indication of new developments which are taking place with these materials.

THE epoxide resins which are available under the name of "ARALDITE" (registered) have, by reasons of their many oustanding properties, become well known during the comparatively few years in which they have been available. This is particularly true in the electrical engineering industries where these materials, in the form of adhesives and casting resins, have made possible the development of electrical equipment along lines not previously possible. Since their introduction, however, the resins which were originally available have themselves been developed to a considerable degree. Furthermore, in the years since their introduction, much has been learned of their behaviour, their properties and techniques of use. Originally there was only one type of casting resin, this being known as casting resin B, and this is still the type most widely used.

Casting Resin B

This is supplied in the form of lumps, golden yellow in colour, which is used with hardener 901, a white powder, both of which can be stored under normal conditions for periods up to two years. In use, the resin is heated to 120°-140°C, at which temperature it can be kept for several days without any deleterious effect. While at this temperature, 25-30 parts by weight of hardener 901 per 100 parts of resin are added to the resin and stirred in until it has melted. As soon as the hardener is added and providing that the temperature remains above 100°C, the process of curing begins and at 120°C the pot life of the resin-hardener mix is between 1 and 1½ hours. Curing can be carried out at any temperature between 100°C and 200°C, the times and temperatures being as follows:—

Temperature	(°F.)	392	346	310	274	238	212
	(°C.)	200	180	160	140	120	100
Curing Times	(hours)	1–2	2–3	5–7	7–10	10–14	14–20

The most suitable temperature for curing casting resin B is dependent upon the materials of the component which is being treated. In some instances, the maximum curing temperature will be dictated by one or more of the materials which are being encased, as several materials and pieces of equipment used in the electrical industries are not able to withstand very high temperatures. Apart from such considerations it is usually an advantage to cure at the lowest economic curing temperature. This particularly applies to very large castings where it is advisable to keep the temperature down in order to minimize the shrinkage due to the thermal linear coefficient of contraction. As will be seen from the properties listed in Table 2, the coefficient of expansion and contraction of casting resin B is about 60 parts per million but this may be reduced to about 25 parts per million by use of suitable inert fillers.

Fillers

There are a large number of materials which may be used as fillers but they are not all equally suitable, as the percentage which the resin plus hardener will tolerate varies from 25 per cent to as high as 350 per cent. Among materials which have been tested are slate powder, mica dust, glass powder, quartz meal, sand and ground porcelain. Of these, it is found that sand of a type similar to that used in foundries can be used in the largest quantity but it is not necessarily the most suitable filler, as there is a tendency towards settling out during the curing process. The filler which offers the best all-round properties seems to be quartz meal of a particle size smaller than that which passes a 120 B.S.S. mesh sieve. Suitable silica sands, known as CH120 and M120 are marketed by Mellor Mineral Mills Ltd., of Etruria Vale, Stoke-on-Trent. Approximately 58 per cent of CH120 will pass a 300 mesh sieve while all will pass a 120 mesh, whereas 71 per cent of M120 will pass a 300 mesh sieve, all passing through 120 mesh. Of this type of filler, quantities between 150 and 200 per cent may be tolerated, and will remain in suspension in the resin during the curing operation. Apart from reducing the thermal linear coefficient of expansion, the addition of fillers also provides the means of increasing the heat conducting properties (see Table 2) and considerably reducing the cost of the resin mix, as these fillers usually cost only a few pence per pound.

Mixing of Fillers

When fillers are being used they have the effect of raising the viscosity of the mixture, and with most fillers it is the

Fig. 1. Resistors potted in Araldite D
(By courtesy of Evershed & Vignoles Ltd.)

* *Aero Research Limited.*

viscosity at pouring temperature which limits the amount of filler which may be added. The increase in viscosity means that there is a much greater possibility of any air which is entrapped in the mould being unable to escape, thus causing blow-holes in the final casting. In order to obviate this possibility, it is advisable to subject the resin and filler to heat (120°-140°C) under vacuum before the hardener is added. The most satisfactory way is to treat these before mixing in order to pull off any moisture which may be present in the filler, and also any which may be on the surface of the casting resin. When these are then mixed together (which may be done out of the vacuum chamber) all that is left to pull off is any air which may be included in the mixing operation. For this purpose, about 20 minutes in vacuum of 1-2mm of mercury is recommended. The time may be easily judged, however, from the fact that when the vacuum reaches this level a rather violent movement may be observed in the resin-filler mix which will cause the mixture to rise to a height equal to about twice its normal depth in the container. When this has died down and the surface has become more or less still, the mixture may be removed from the vacuum chamber. If the mixture is not required for immediate use, it may be run off into trays and allowed to solidify, being subsequently broken up and stored. If required immediately, however, the correct quantity of hardener 901 should be added and after stirring until the hardener has dissolved, the whole may be again subjected to a vacuum treatment. For this operation, a vacuum of 10mm is sufficient and this should be held for about ten minutes. Again a small movement occurs in the mixture but not as violent as that which takes place when the resin and filler are first subjected to vacuum.

Casting

The mixture may then be removed from the vacuum chamber and poured into the moulds which have been previously prepared. Unless the shape of the mould is very complicated, further vacuum treatment should not be necessary, but where the conditions demand it, the filled mould should also be placed in the vacuum chamber at a temperature of about 120°C and maintained under vacuum for about five minutes. The mould may then be transferred to an oven to complete the cure, or it may be allowed to cool and the resin cured at a later time. Such would be the technique used if curing were to be carried

TABLE 1

Comparison between Average Physical Properties of Porcelain and Casting Resin B with 200 per cent Filler

	PORCELAIN	CASTING RESIN B + 200% QUARTZ MEAL
Specific gravity	2·6–2·8	1·7–1·8
Tensile strength	4 300– 7 000 lb./sq. in.	10 500–12 000 lb./sq. in.
Compressive strength	57 000–64 000 ,,	28 000–31 000 ,,
Fatigue strength	8 500–11 000 ,,	17 000–20 000 ,,
Modulus of elasticity	$9–10 \times 10^6$	$1·7–2·0 \times 10^6$

TABLE 2

Physical Properties of Casting Resin B, with and without Fillers

	TEST METHOD	RESIN MIX 1	RESIN MIX 2	RESIN MIX 3	RESIN MIX 4	UNIT
Approx. adhesive strength (bonding Avianel M)	—	2 900– 3 750	2 000– 2 700	2 550– 2 900	1 150– 2 500	lb./sq. in.
Ash content	—	0·02–0·03	15–16	60–61	69–70	per cent
Combustibility	—	5–10	8–10	8–10	8–10	seconds
Compressive strength	ASTM D695-49T	15 500-18 500	17 000-18 500	28 000-31 000	206 000-220 000	lb./sq. in.
Decomposition	—	340–360	335–345	340–345	345–350	°C
Fatigue strength	VM77103	12 700–17 000	9 000–11 300	17 000–20 000	7 100– 8 500	lb./sq. in.
Flexural strength	ASTM D790–49T Schopper test bar 120 × 15 × 10mm.	12 800–17 000	9 300–11 400	10 000–14 000	7 000– 8 500	lb./sq. in.
Heat resistance (Marten's test)	Federal L–P–406a-2011	105–115	110–120	120–125	125–130	°C
Modulus of elasticity	ASTM D638-46T	$0·42–0·57 \times 10^6$	$0·64–0·78 \times 10^6$	$1·7–2·0 \times 10^6$	$2·1–2·6 \times 10^6$	lb./sq. in.
Shrinkage (depending on curing temperature)	—	0·5 – 2·5	—	—	—	per cent
Specific gravity	—	1·2 – 1·3	1·25 – 1·35	1·7 – 1·8	1·9 – 2·0	—
Tensile strength	ASTM D651–48	8 500–11 000	9 000–11 000	10 500–12 000	5 000– 5 600	lb./sq. in.
Thermal conductivity	—	approx. 0·17 ,, 0·008	—	approx. 0·54 ,, 0·036	approx. 0·73 ,, 0·036	kcal/m°h°C watts/ich²/°C/in.
Thermal coefficient of linear expansion	ASTM D696–44	$60–65 \times 10^{-6}$	60×10^{-6}	$30–35 \times 10^{-6}$	$25–30 \times 10^{-6}$	parts per million per °C
Water absorption, 10 days at 20°C	ASTM D570–42	0·25–0·35	0·25–0·35	0·25–0·3	0·15–0·2	per cent weight
1 hour at 100°C	—	0·3 –0·45	0·3 –0·4	0·3 –0·45	0·2 –0·3	,, ,,
COMPOSITION OF RESIN MIX						
Araldite casting resin B	—	100	100	100	100	parts by weight
Hardener 901	—	25–30	30	30	30	,, ,,
Filler	—	—	25 slate powder	200 quartz or porcelain flour	300 quartz sand	,, ,,

out overnight at a temperature of 100°C which appears to be favoured by most manufacturers. As already mentioned, there are advantages in keeping the curing temperature down to 100°C, but in addition, electric power is sometimes cheaper during the night-time.

Moulds

A wide variety of materials may be used for manufacturing moulds suitable for use with casting resins but, in general, it may be said that the simplest form of mould is usually the best. The design of mould will obviously be dictated by the nature of the component being treated but wherever possible sharp corners or sudden changes of section should be avoided. It has been found that aluminium alloys appear to be the most suitable materials from which to fabricate moulds, although steel is quite satisfactory and brass (sometimes chromium plated) is also used. Araldite casting resins have excellent properties of adhesion to metals and it is necessary to use a parting compound to prevent the cured resin from adhering to the mould; the use of curing temperatures in excess of 100°C rules out the use of most waxes. The parting agents recommended are those belonging to the silicone groups such as Releasil 7 grease and Releasil 14 liquid, both of which are procurable in this country from Midland Silicones Ltd., 19 Upper Brook Street, London, W.1, or

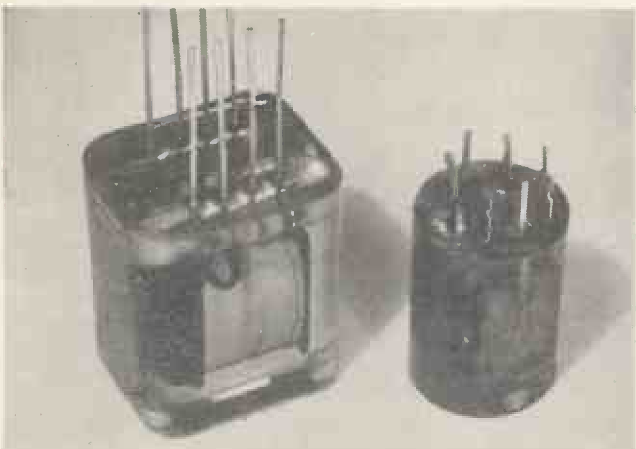


Fig. 2. Transformers potted in Araldite D
(By courtesy of Evershed & Vignoles Ltd.)

Silicone Resin R205 which may be obtained from I.C.I. Ltd., Nobel Division, 25 Rothwell Street, Glasgow, C.2.

When a mould is new it quite often happens that, when silicone greases are used, the first two or three castings produced in it do not free themselves very easily and it is therefore suggested that before casting into a new mould, the process of applying the parting agent and curing is carried out with the mould empty. After this treatment it is usually found that separation of the mould and casting does not present any difficulty. It should be remembered, however, that the fact that the resin has a higher shrinkage rate than the mould material means that if cores are used when casting, they must be removed while the casting is still hot, otherwise their removal will be impossible due to the shrinkage of the resin on to the core.

If the mould is itself large, this should be heated to a temperature slightly higher than that of curing before the resin mix is poured. This prevents the resin mix from cooling, thus making the removal of any air bubbles present more difficult owing to the increase in viscosity of the mix. With sheet metal moulds, however, this is not necessary.

It sometimes happens that the number of castings of any particular shape which are required is very limited, and the cost of metal moulds is not justified. In such instances the use of moulds made from sand offers a convenient and economic method of producing the required casting. To produce sand moulds, a wooden pattern is first made and around this is moulded the sand mixture. This is made by adding three parts by weight of resin 285 (Aero Research Ltd.), to 100 parts by weight of sand and, after mixing together, four parts of water are mixed in. It is sometimes an advantage to add one or two parts of Dextrine. This mixture after moulding round the pattern, is baked for one or two hours at a temperature of 150°C with the wooden pattern removed. In order to seal the pores of the sand mix, one and three parts of water and water glass respectively are brushed over the moulding surfaces, a drying period being allowed between each coat.

Uses of Casting Resin B

The most extensive uses of casting resins are found in the electrical industries where the combined properties of adhesion, moisture resistance, mechanical strength, temperature and ageing resistance, combined with excellent electrical properties are employed to produce equipment which was not practicable until comparatively recent years. The properties of casting resin B are shown in Table 3 and it will be seen that the high strength of adhesion, coupled with good electrical insulation value, means that components may be satisfactorily joined together but at the same time be adequately insulated one from the other. This is particularly useful when it is desired to embed the windings of electric motors in which the encasing of the whole after winding prevents movement of the wires in subsequent use and at the same time insulates the windings. Among the

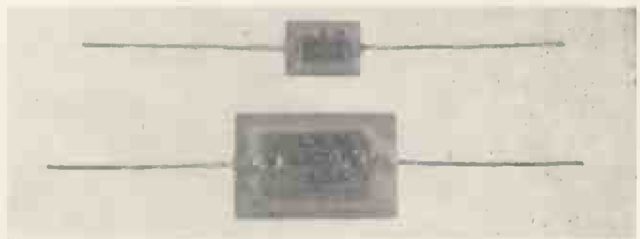


Fig. 3. Silver mica capacitors cast in Araldite casting resin B
(By courtesy of London Electric Manufacturing Co., Ltd.)

types of component which are being manufactured with the aid of casting resins may be listed: transformers, bushings, capacitors, insulators, terminal blocks with cast-in terminals, resistors, bobbins, servo motors, transistors, relays and potentiometers.

One development which appears to be gaining ground rapidly is the production of insulators from casting resin B plus silica, as a substitute for porcelain insulators. Table 1 gives a direct comparison between the properties of each type of insulator and it will be seen that the advantages generally lie with the insulator made from casting resin.

Any metal fittings required, which normally have to be attached to the porcelain, may be cast in situ, and due to the adhesion of the casting resin to the metal, freedom from electrical interference is obtained. Furthermore, the dimensional accuracy possible with casting resin is of the order of 0·1-0·2 per cent as compared with the normal variation of five per cent which is found in ceramics. Possibly the greatest advantage, however, is the resistance of the casting resin insulator to thermal and physical shock. Filled resin castings may be repeatedly dropped on to a concrete or stone floor without causing any damage other than possibly chipping the outside surface, whenever a protrusion or edge hits the floor at an awkward angle. Such castings may also be heated to temperatures of 100°C or more and plunged straight into cold water many times before showing any signs of cracks. The dielectric constant of the cast insulator is usually better than that of the ceramic insulator and the electrical breakdown strength is practically the same.

The largest users of casting resin B are transformer manufacturers and it has been found that a potted transformer offers many advantages over the conventional oil-immersed transformer. Among these advantages is the facility it affords of designing a transformer of a given capacity which is considerably smaller in bulk and consequently lighter in weight. Insulation resistance is also higher than that of a taped transformer and heat transfer compares very favourably with that of an oil-filled transformer. Possibly the most important factor, however, is that transformers potted in resin will satisfactorily withstand the full tropical tests laid down by Service standards and are not likely to catch fire if overheated. Many other items of electrical equipment are also being encased in resin in order to meet the requirements of tropicalization.

New Casting Resins

As mentioned earlier, since casting resin B was introduced, much development work has taken place and several other types of Araldite resins are now offered which are of particular interest to the electrical engineer. These new products all adhere strongly to metals and may be listed as follows:

1. Casting resin type D
2. Casting resin type F
3. Flexible casting resin type 33/896
4. Expanded casting resin type 33/912
5. Impregnating casting resin type 33/915

Of these, items 3, 4 and 5 are still considered as experimental products.

Casting Resin D

This is a cold setting resin used in conjunction with hardener 951 both of which are solvent free liquids. In use, ten parts by weight of resin D is mixed with one part by weight of hardener 951 (nine parts by volume of resin D with one part by volume of hardener 951) and thoroughly mixed together. The mixing is of great importance, as, unless this is complete, free hardener will remain in the resin with the result that complete hardening will not take place; there is the further danger that free hardener may cause corrosion of copper or brass. When mixed correctly there is no danger of corrosive action and should this occur it is a sign of faulty mixing. It has been found that the most suitable and possibly the easiest way of mixing these materials is by means of an electric-vibrator mixer working at a frequency of 60 cycles per second. By such means it is possible to mix about 2lb of resin and hardener in about two minutes (by other means at least 15 minutes would be required for this amount) and by such methods of mixing air is not added to the mixture. When the hardener has been added an exothermic reaction occurs and for this reason it is recommended that the quantity mixed should be kept to a minimum and that the container used for mixing should be made of a material which will enable the heat generated to be dispersed as quickly as possible. It is helpful if the container is of such dimensions that the depth of resin is small. It is possible to control the exotherm by maintaining the resin and hardener at a low temperature, say 5°C, before mixing. They should also be kept at this temperature immediately after mixing and poured into a cold mould. By regulating the rate of temperature rise of the mould and resin the exotherm may be controlled. After such treatment it is essential to post cure at a temperature of between 80° and 100°C for about two hours in order to fully develop the properties of the resin.

After the hardener is added the mixture remains pourable for 1½ hours at normal room temperatures (or considerably longer at lower temperatures) after which time setting takes place. Full curing, however, takes at least 24-36 hours at room temperatures but after about five hours the resin has set sufficiently to enable the casting to be removed from the mould. Although this is essentially a cold setting resin, the curing process may be accelerated by means of heating, which also has the advantage of improving the physical properties of the cured resin.

The electrical characteristics of type D are similar to those of casting resin B up to about 60°C but its heat resistance is lower and it softens at temperatures above 50°-60°C. It is less water resistant, but samples have satisfactorily withstood tropical tests.

Casting Resin F

Casting resin F, which is a solvent free liquid resin of fairly high viscosity, may, unlike the casting resins already mentioned, be used as a cold setting resin using hardener 951, or as a hot setting resin using hardener 901.

When used with hardener 951, 10-12 parts by weight of hardener are added to 100 parts by weight of casting resin F. As with casting resin D, there is an exothermic reaction and large amounts should not be mixed. At normal temperatures the pot life of the resin hardener mix is about 45 minutes and setting time is about 24 hours at 20°C. As with casting resin D, the application of heat will shorten the setting time, the times and temperatures being as for casting resin D.

Fig. 4. Pulse transformer embedded in Araldite casting resin B
(By courtesy of Aircraft Transformer Co., U.S.A.)

As a hot setting casting resin using 40-45 parts by weight of hardener 901 to 100 parts by weight of casting resin F, a liquid of low viscosity at 100°C is produced. At this temperature the pot life is over four hours. Due to the very low viscosity of this mixture and the fact that it does not contain any solvents, it is particularly suitable for the embedding and impregnation of very fine windings. A double process is recommended for the potting of finely wound parts, consisting of an initial impregnation using casting resin F with hardener 901, and after curing, the impregnated winding is potted in casting resin B and silica sand. This technique permits the use of the most suitable resin for each purpose.

Flexible Casting Resin 33/896

Although casting resin B meets the requirements of most users and is in fact used for potting current transformers which embody as much as 2 600lb of resin, it was felt that there was a need for a flexible casting resin which would retain its flexibility throughout the recommended temperature range of the resin. Furthermore, as it is not practical for the resin manufacturer to know the degree of flexibility required for each component, it seemed advisable that the resin should be so made that the user could vary the degree of flexibility by varying the proportions of the component which imparts the flexibility.

This development work resulted in the formulation of experimental resin 33/896, which is a three-part resin of which component B imparts the flexibility. The higher the proportion of component B, the more flexible is the final product. The ratio of A to B should not, however, exceed 3 : 2 and to every 100 parts by weight of component A, six parts by weight of component C must be used. Typical formulations would therefore be:—

100 parts	Component A		100 parts	Component A	
75 „	„ B	*or*	150 „	„ B	
6 „	„ C		6 „	„ C	

In use, component B is melted and added to component A. The two are mixed and held at a temperature between 60° and 80°C until free of bubbles. The higher the proportion of component B used, the higher the temperature required to remove the bubbles. The necessary amount of component C is then added and carefully, yet thoroughly, stirred in. The mixture may then be cast, and since none of the components is readily volatile, vacuum methods of casting may be used. The pot life and curing times of the mixture are as follows:—

Fig. 5. Servo motors. Laminations bonded with Araldite 15, potted in Araldite casting resin B
(By courtesy of Kearfott Co., U.S.A.)

Parts of Component B per 100 parts Component A ..	25	50	75	100	150
Pot life at 70°C ..	20 min	35 min	70 min	2 hr	4 hr
Curing time at 100°C	1 hr	3 hr	3 hr	3 hr	5 hr

The final cured product will retain its flexibility up to a temperature of about 180°C but it should be noted that the higher the proportion of component B, the more flexible will be the final product, but smaller quantities of component B give a higher sheer strength and better water resistance.

This material may also be used as an adhesive where its properties of elasticity makes it particularly suitable for joining together materials which have widely different thermal coefficients of expansion, particularly if one of the materials is of a brittle nature. Among materials which have been satisfactorily bonded using this adhesive are diamond grinding wheels to moulded phenolic backing pieces and glass to metal.

When used as an adhesive it is necessary to add a filler to the resin mix in order to prevent it from flowing out of the glue line. It has been established that aluminium powder makes a suitable filler, about ten parts by weight of aluminium powder being used for every 100 parts by weight of component A, but many other materials are equally suitable. The pot life of the mix at room temperatures varies from two to four days according to the proportions incorporated of the medium used to impart flexibility.

Expanded Casting Resin 33/912

Resins which may be foamed or expanded in situ are finding applications both as potting compounds and also as structural materials. In the latter instance, they are foamed between metal sheets and in filling up the gap between the sheets also adhere strongly to them. If it is not intended to adhere to the metal surrounds, as for instance in normal casting techniques, the sides of the mould should be coated with silicone mould release agents as previously described.

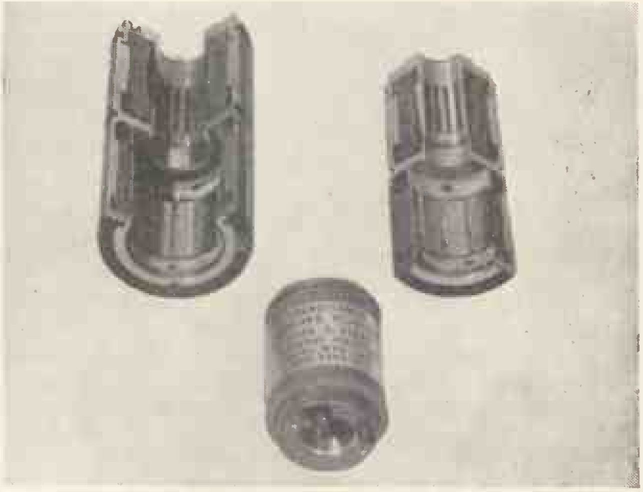


Fig. 6. Rotary Transformer.—Laminations bonded with Araldite 15, potted in Araldite casting resin B
(By courtesy of Ketay Manufacturing Co., U.S.A.)

The material is supplied as four components:—

Component A: The resin—a viscous liquid.
„ B: The hardener—a white crystalline powder.
„ C: The expanding agent—a crystalline powder.
„ D: The accelerator—a brown liquid.

One hundred and eighty parts by weight of component A and 63 parts by weight of component B are first mixed and maintained at a temperature of 100° ± 2°C for one hour. The material is then cooled to 50-55°C and one to ten parts (according to the amount of expansion required) of component C is added, followed by two to four parts by weight of component D. The mixture remains usable for at least one hour at this temperature, but as the mixture ages, so the density of the product from it increases. If, however, the mixture is immediately poured into a *cold* mould, it has a pot-life of approximately 24 hours. This will, of course, be affected by the heat capacity of the mould and the quantity of mixture involved. The expanded product is then produced by placing the mould in an oven so ventilated that the poisonous fumes evolved can be dealt with adequately. The oven should be at 80°C and the mould should be maintained at this temperature for three hours. If the heat resistance of the cured product is of importance, the mould should then be placed in an oven at 180°C for one hour.

The density of the foam is influenced by:—

(i) The proportion of component C added.
(ii) The proportion of component D added.
(iii) The quantity of material to be expanded.
(iv) The shape of the mould.

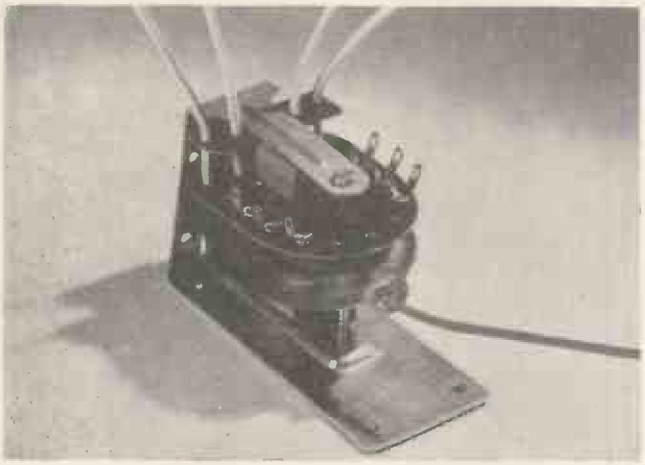


Fig. 7. Fly-back Transformer. Potted in Araldite casting resin B
(By courtesy of Todd-Tran Corporation, U.S.A.)

The effect of the various factors are:—

(i) Component C is the expanding agent, the more of it used the lower the density of the product.

(ii) Component D is the accelerator. For a successful product, the quantity of accelerator added should be such as to produce a reasonable viscosity, as expansion takes place, and then to gel when the maximum expansion has been reached. If gelation takes place before maximum expansion has been reached, the product will be much denser than expected, the bubbles will be very small and cracks will probably appear. If, on the other hand, gelation takes place after maximum expansion, the foam will collapse and the surface will be covered with craters.

Fig. 8. Valve for chemical plant cast in Araldite casting resin B. The bore of the valve is 4 in.

(iii) The accelerating action of component D is exothermic and, generally speaking, the larger the amount of material to be expanded the smaller is the proportion of component D that should be used.

(iv) The shape and size of the mould has a very marked effect upon the density and texture of the expanded product. The more intricate and restricted the mould, the denser the product. If the mixture used for the production of an expanded product with an S.G. of 0·15 is expanded in a solid mould with a cavity ¼ in. wide by 6 in. long by 2 in. deep the specific gravity will be 0·5. Sometimes it is desirable to reduce the amount of component D for a restricted mould and in the above case, a reduction from 4 to 2½ grams reduces the specific gravity to 0·4.

Expansion of the resin is caused mainly by the evolution of nitrogen but a small amount of hydrogen cyanide is also given off. Hydrogen cyanide is a poisonous gas and precaution should be taken to provide adequate ventilation during expansion and curing. Furthermore, if any process involves the machining or slicing of the expanded material,

TABLE 3
Electrical Properties of Araldite Casting Resins

	TEST METHOD	CASTING RESIN B	CASTING RESIN D	UNIT
Permitivity or dielectric constant	ASTM D150–47T			
60 c/s		3·8		
10^3 c/s		3·65		
10^6 c/s		3·62	3·76	
3×10^9 c/s		3·09		
10^{10} c/s		3·01		
Loss angle tan δ	ASTM D150–47T			
60 c/s		0·0017	0·015	
10^3 c/s		0·0024		
10^6 c/s		0·019		
3×10^9 c/s		0·027		
10^{10} c/s		0·022		
Dielectric strength (⅛ in.)	ASTM D149–44	400		volts/mil
Diffusion constant	ASTM D697–42T	1·0	1·1	
Surface resistivity	ASTM D257–49T	$>3{\cdot}8 \times 10^{13}$		ohms
Volume resistivity	ASTM D257–49T	$> 10^5$	6×10^{14}	ohms
Arc resistance time	ASTM D495–8T	50–180		seconds

TABLE 4
Chemical Resistance of Araldite Casting Resin B

TEST MEDIUM	CONCENTRATION	TEMP. °C	RESISTANCE	DURATION OF TEST
Acetone	100%	20	N.R.	
Benzene	100	20	R	6 months
	100	80	R	6 months
Distilled water	—	20	R	12 months
		100	L.R.	3 months
Ethyl alcohol	100	20	R	6 months
	100	80	N.R.	
Formic acid	100	20	R	6 months
Glacial acetic acid	100	20	R	6 months
Hydrofluoric acid	100	20	R	
Hydrochloric acid	10	20	R	6 months
	10	100	R	6 months
	100	20	R	6 months
Nitric acid	100	20	N.R.	
Potassium permanganate	6g/100g water	20	R	3 months
Oil (mineral)	100	20	R	12 months
Sodium chloride	1	20	R	6 months
Sulphuric acid	10	20	R	6 months
	50	20	R	6 months
	96	20	N.R.	6 months
Trichlorethylene	100	20	N.R.	

N.R. Not resistant. R. Resistant L.R. Limited resistance.

the presence of hydrogen cyanide within the cells should be borne in mind.

Impregnating Resin 33/915

Although casting resin F, when used with hardener 901, is of such a viscosity that it is suitable as an impregnating resin, it suffers from the disadvantage of a relatively short pot life and must be handled at an elevated temperature. In order to overcome these difficulties a new impregnating resin which has a life of about 14 days and can be used at room temperature has now been developed. If 50 per cent of the contents of a container of resin and hardener are replaced every day, it is clear that a mixture having a usable life of one week would, due to replacement, ensure an indefinite pot life. The other basic necessities were a low viscosity and absence of solvents, both of which characteristics are found in this resin.

Fig. 9. A 12 ft. high current transformer casting in Araldite casting resin B
(By courtesy of Oerlikon, Switzerland)

Impregnating resin 33/915 is the number given to this experimental product which is offered as a two-component material, component A being a golden-brown liquid and component B a white crystalline flake. To mix, 100 parts by weight of 33/915A is heated to 60°-70°C and 35 parts by weight of 33/915B stirred in until a homogeneous solution is obtained. The mixture is then cooled and is immediately ready for use.

After impregnation, which takes place in a conventional manner, the resin should be cured for three hours at 120°C followed by about ten hours at 140°C. It is important not to exceed 120°C for the first two hours or the curing may be exothermal. Early indications suggest that this material is also suitable for the impregnation of porous metal castings.

Other New Products

One of the new products which does not come in the category of a casting resin is a hot setting filler This is likely to have a considerable use in the motor vehicle industry as an alternative to lead-tin solders for the filling of weld channels, etc., during the manufacture of vehicle bodies. Like the flexible casting resins, the filler has been designed (at the request of the motor industry) to possess flexibility in order that it shall not crack during relative movement of the panels being filled.

The filler is supplied in three parts which, after mixing are of a similar consistency to that of putty. It remains usable for about three days but is usually freshly mixed each day. Application is most easily carried out by the fingers but several alternative methods are in course of being evaluated. After the filler has been applied it is cured for 40 minutes at 130°C, a curing cycle which has been evolved to suit the conditions prevailing in most paint ovens used in the motor industry. One of the outstanding properties of this material is that when applied to a vertical surface no movement takes place during the curing cycle and the filler remains exactly where it is placed. After curing it is cut down and dressed, and then painted at the the same time as the remainder of the body. Of equal importance to this lack of flow during the curing cycle is the fact that the temperatures applied when stoving synthetic paints do not cause any further movement in the filler. Other features of this filler are that it is considerably cheaper and lighter than solder. It is not expected, moreover, to exercise any deleterious effect upon the health of operators engaged in its application, a further factor which helps to make this filler attractive to the motor industry.

It should be noted that Araldite resins, particularly casting resins, possess properties which are of great interest to the chemical engineer as well as to the electrical engineer. Table 4 shows the chemical resistance of casting resin B which is already being used very extensively for making valves; taps, etc.; the fact that it machines very easily increases its usefulness.

From these notes it will be seen that the development of the range of epoxy resins is now taking place at a fairly rapid rate. In addition to the materials already mentioned several other products are now undergoing tests before being offered to industry.

An A.C. Voltage Stabilizer

By R. G. Ackland*, B.Sc., A.Inst.P.

A motor-operated A.C. *voltage stabilizer is described which provides a constant output voltage irrespective of wide variations in input voltage, load current, power factor or line frequency. No wave form distortion is introduced. As normally used the stabilizer maintains the output voltage at 230V ± 1 per cent with loads up to 9kVA and input voltages between 197 and 250V, but if desired it may be modified to control the output to within smaller limits, or to accommodate larger loads. The maximum correction time is 6·7 seconds, i.e., the correction rate is 8V per second for the input range 197-250V. A safety device is included which will isolate the controlling circuits within the stabilizer and virtually connect the load direct to line if failure of a component should cause the output voltage to vary from the desired value by more than a preset amount.*

WHILE it is true that the correction time of a motor-operated A.C. voltage stabilizer is large compared to that of a resonant transformer type, the latter cannot normally be used where frequency variations are encountered, where the waveform must be kept free from distortion, or where ratings greater than 5kVA are required. For many applications, the longer correction time of the dynamic stabilizer is not a disadvantage.

Although motor-operated Variac type stabilizers have been described recently by Collinge and Marsham[1] and by Long[2], it is believed that the stabilizer to be described will be of interest because of its relatively large power rating, and also because of the simplicity of the voltage control unit, which contains only one electron tube (a voltage regulator). In the form described, the stabilizer is intended to provide a constant output voltage, and information is given showing how the load-carrying capacity, the range of input voltage that can be accommodated, and the limits within which the output voltage can be maintained, may be modified to suit particular requirements.

Description of Circuit

A block diagram of the circuit is shown in Fig. 1(a). An adjustable voltage from a Variac is injected into the active line, through a transformer. If one winding of this transformer is connected between the brush and a tapping on the Variac, the voltage will be such as to oppose the line voltage if the Variac brush is to one side of the tapping, and to boost the line voltage if the brush is to the other side. The total range of the correcting voltage will depend on the ratio of this transformer, while the relative amplitudes of the opposing and boosting voltages will depend on the position of the Variac tapping. Thus with a centre-tapped Variac, connected to give a total of 270V across its winding, and a 1 : 1 correcting transformer, the output voltage may be adjusted to 230V for any input voltage within the range 230 ± 135V. By increasing the transformer ratio, the voltage correction range may be reduced and the current-carrying capacity increased proportionately. With a transformer having a ratio of 5 : 1, for example, the voltage range would be nominally ± 27V, and, for a 2kVA Variac, the current rating would be approximately 40A.

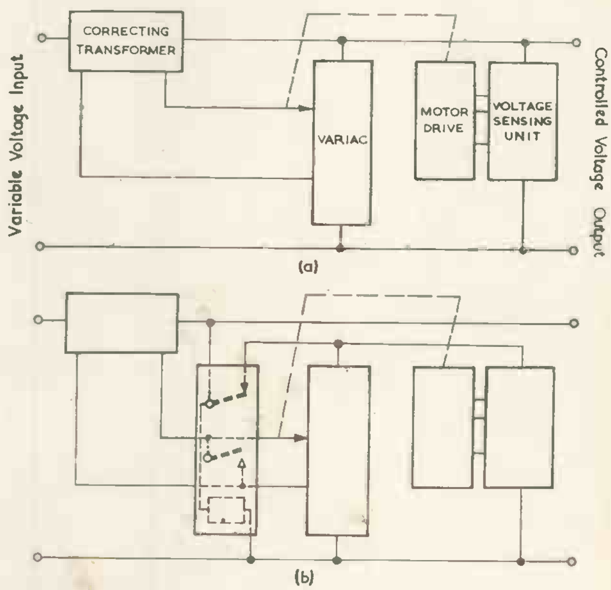
In the stabilizer described in this article a transformer having alternative ratios 155 : 30, 25 or 20 is employed, and the 2kVA Variac is tapped at turn No. 158 (total 256). For a 230V output this arrangement allows of alternative input ranges 197-250V, 203-247V, or 208-244V, at maximum output currents of 40, 49 or 63A respectively.

Automatic operation of the Variac is effected by a small reversing motor which is controlled by a voltage-sensing unit connected to the output side of the correcting transformer. To ensure that they operate at their correct voltage ratings, the Variac and its associated controls are also supplied from the output side of this transformer. The main winding and brush circuits of the Variac are protected by fuses. It would appear that failure of the brush circuit fuse would result in a dangerously high voltage appearing across the primary of the correcting transformer, but in a transformer having the correct power rating, saturation of the core limits this to about 400V. For the same reason, the maximum voltage likely to appear across the Variac, should it become isolated from its 230V supply, is limited to about 350V.

Failure of a protective fuse or of a component within the stabilizer could result in a relatively large change in the output voltage. Fig. 1(b) is a block diagram showing the addition of a safety device to isolate the controlling circuits and to short-circuit the primary of the correcting transformer should the output voltage vary from the desired value by more than a preset amount. Short-circuiting of the transformer primary virtually results in connexion of the load direct to line.

Fig. 2 gives details of the wiring between various components of the stabilizer; Figs. 3 and 4 give the complete wiring diagrams of voltage-sensing and motor-drive units and the under/over voltage safety unit.

Fig. 1. (a) Block diagram of Stabilizer. (b) Block diagram with added safety circuit



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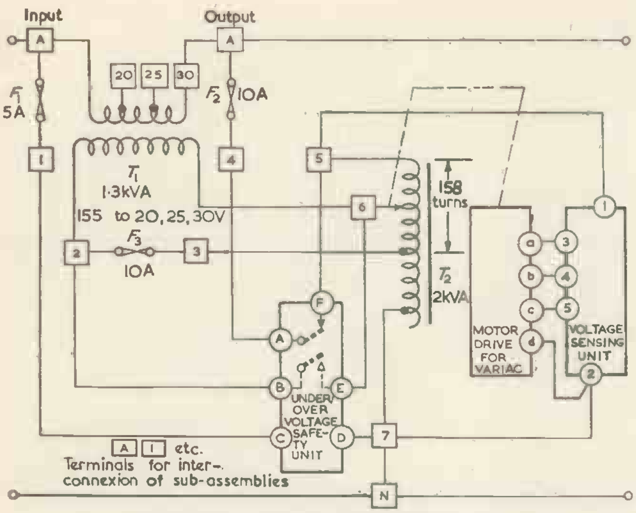

Fig. 2. Wiring diagram of complete stabilizer

VOLTAGE-SENSING UNIT

The voltage-sensing unit operates as follows: the output voltage from the stabilizer is rectified and fed into a bridge circuit having a voltage regulating tube in one arm and a moving-coil relay as a detector. The moving-coil relay *A* (Fig. 3) operates through one or other of two telephone type relays *B* and *C* to control a reversing motor which drives the Variac. To ensure stability, resistors R_4 and R_5 of the ratio arms of the bridge are of the wire-wound type, and a wire wound potentiometer VR_1 is included to enable adjustments to be made to the balance point of the bridge and hence to the output voltage of the stabilizer. Originally a VR150 was used as the reference voltage tube, but this was discarded because of its instability and temperature coefficient; because of one or other of these factors, most of the VR150 tubes tested were found to be worse than is suggested in the literature[3,4]. The QS150/15 (English Electric Valve Co. Pty. Ltd.) which was finally adopted, has been found to be very satisfactory. Use is not made of the special ignition electrode in this tube because the voltage across the bridge (300V) is sufficient to ensure ignition without it.

By varying the value of resistor R_2 the sensitivity of the detector relay (*A*) circuit can be altered. Because of the effect of the detector current on the bridge circuit, the maximum sensitivity (smallest control range) that can be obtained, when $R_2=0\Omega$ is $\pm 0{\cdot}2$ per cent, and the overall response of the voltage control unit is sufficiently fast to enable the output voltage to be held within these limits without hunting if desired. To maintain the output voltage within such narrow limits would, however, normally result in almost continual operation of the control unit with consequent increase in wear in the relays, motor and Variac bearings, and in the Variac windings and collector brush. For the purpose for which this stabilizer was developed (to supply the furnaces of high-sensitivity creep-testing machines) and for many other applications $\pm$ 1 per cent is adequate, and is achieved with the component values shown in Fig. 3.

Sparking at the contacts of relay *A* on opening is eliminated by capacitors C_2 and C_3, while resistors R_7 and R_8 prevent welding on closing.

The return leads of the energizing coils of relays *B* and *C* are connected into the ratio arms of the voltage-sensing bridge circuit in such a way as to modify the balance point when current is passing in a relay coil. When the voltage to be regulated is high, relay *B* is energized, with the result that the voltage at the tapping on VR_1 is reduced. Therefore, once relay *A* makes contact on either side, its coil is biased so as to increase the contact pressure. This not only ensures positive anti-chattering contact, but also makes it possible for the output voltage of the stabilizer to be returned to the centre of the control range whenever it reaches one of the limits, rather than to be merely prevented from exceeding that limit. This results in the output voltage being held near the centre of the control range for a greater percentage of the time, with consequent reduction in the frequency of operation of the control unit. The correct values for R_3 and R_6 depend on the sensitivity of relay *A*, but they must also allow for any overshoot present in the motor drive on the Variac; they can be calculated for any set of conditions, but as the equations involved are complex, it is much simpler to determine them experimentally. In the present case $R_3 = 0\Omega$, because when relay *C* is energized the effective internal impedance of the D.C. supply (MR_1 and C_1) is just sufficient to produce the desired voltage reduction at VR_1. If the sensitivity of relay *A* were to be reduced, R_3 and R_6 would have to be increased and *vice versa.* In the latter case, because R_3 cannot be reduced below zero, it would be necessary to return relay *C* to a tapping at the lower end of the ratio-arm network in order to reduce the effect of the internal impedance of the voltage supply on the bridge when relay *C* is energized. In the extreme case, i.e., when no biasing is required, relays *B* and *C* should both be returned to R_6, the approximate value of which should be 240Ω.

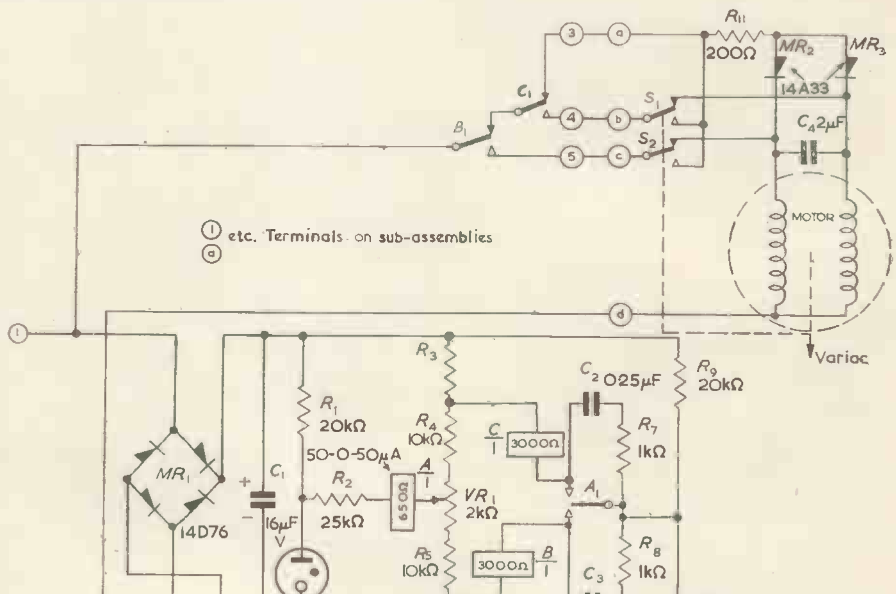

Fig. 3. Voltage sensing and motor drive circuits

Motor Drive

The Variac driving motor is of a small capacitor type with built-in gear box giving a final shaft speed of 8 R.P.M. These motors are readily obtainable, as they are of a type commonly used to drive the balancing mechanism of certain makes of potentiometric temperature recorders and controllers. The Variac is driven from the final shaft through a simple Oldham type universal coupling, full traverse being achieved in 6·7sec. Owing to the inertia of the rotor, which normally would result in an intolerably large overshoot of the Variac, braking is necessary. This is accomplished by passing D.C. through the windings when they are not energized by A.C. The wiring to the motor relay and limit switches is so arranged that, by using two half-wave rectifiers MR_2 and MR_3 with a limiting resistor R_{11}, the desired effect is achieved. With D.C. having approximately the same ohmic heating effect as the A.C. normally passed through the motor windings, the overshoot is reduced to about 3 degrees on the final shaft, which is equivalent to $2\frac{1}{2}$V on the Variac. For a correcting transformer ratio of 5:1 this corresponds to 1/2V, or approximately 0·2 per cent, in the output.

Although the limits set by overshoot in the drive are of the same order as the best obtainable from the voltage-sensing unit, it is possible to hold the output voltage within

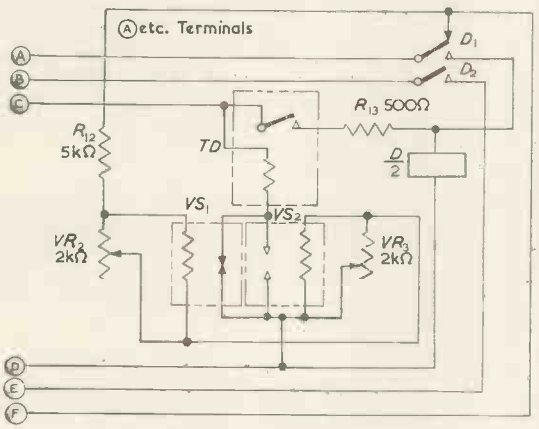

Fig. 4. Under/over voltage safety unit

these limits, because, when "inching," the motor does not attain full speed and therefore does not overshoot to the same extent. Under these conditions, biasing of the relay *A* should be reduced very nearly to zero.

Under/Over Voltage Safety Unit

The voltage-sensing device in the under/over voltage safety unit could well be a simple type of voltage sensitive relay having a sensitivity of about ± 5 per cent. As, however, no suitable relays were readily available, two Sunvic hot-wire vacuum switches have been used, one having contacts which open as it heats up and the other having contacts which close. By adjustment of the shunt rheostats VR_2 and VR_3 (Fig. 4) it is possible to set these switches to operate at any desired voltages, e.g., 220 and 240V respectively. Through an adjustable time delay switch, the vacuum switches control the relay *D*, the upper contacts of which arrange for the isolation of the control circuits within the stabilizer, and the lower for the short-circuiting of the correcting transformer primary. The time delay switch *TD* is included to prevent the stabilizer being rendered inoperative by short-duration voltage fluctuations outside its normal range or by the delay involved in starting up an automatic auxiliary generator in the event of failure of the main supply. Because it would be possible for the output voltage of the stabilizer to drop below the limit necessary for positive operation of this time delay switch, the supply for its heater is taken from the input side of the stabilizer where the voltage is not likely to drop below about 190V except in the event of a complete failure of the line. Resistor R_{13} is included to prevent large currents flowing in circuit *A* to *C*, which is across the secondary or heavy current side of the correcting transformer, should the lower contacts on relay *D*, which short-circuit the primary side of this transformer, fail to close.

Assembly

Fig. 5 gives a general view of the complete stabilizer. For its power rating it is a small unit, its dimensions being approximately 10 by 12 by 24 inches. The voltage sensing and under/over voltage safety panels, the Variac connexions and the motor drive are clearly seen.

Performance

As the voltage-sensing unit is in effect a controlling voltmeter which holds the output voltage of the stabilizer within set limits, the output voltage will be affected by variations in load, power factor or frequency, only to the

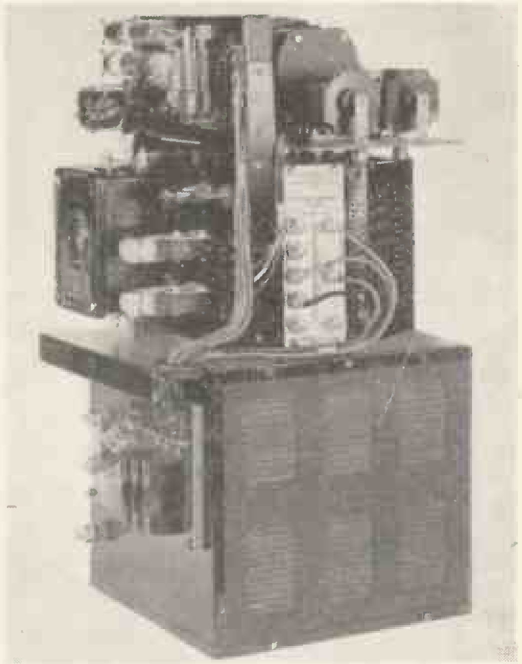

Fig. 5. The complete stabilizer with covers removed

extent to which the sensing unit is affected. Simple changes in load or power factor will have no effect, but, because the voltage-sensing unit actually controls the peak value of the output voltage, the R.M.S. value of the latter will be affected if there are changes in the peak factor of the voltage waveform. Significant changes in voltage waveform with varying loads are not normally experienced on supply lines, but they could be encountered in small auxiliary generating sets. From the component values shown in Fig. 3, it can be calculated that a deviation in frequency of a normal 50c/s supply by plus or minus 5 cycles would tend to produce a change of approximately plus or minus 0·33 per cent in the value of the voltage across C_1 and the bridge circuit, and hence, to correct this, the output voltage of the stabilizer would be automatically reduced (or increased) by 0·33 per cent. It can therefore be said that the stabilizer is virtually unaffected by changes in frequency.

Actual performance tests carried out on the stabilizer with equipment which allowed the input voltage, frequency, load and power factor to be varied independently, within the limits 200-250V, 46-54c/s, 0-5kVA, and 1-0 leading, respectively, have confirmed the above conclusions as to its performance. As a check on its mechanical reliability, it was also given an accelerated cycling test of 250 000 operations over the range 230V ± 2 per cent, after which it was still operating satisfactorily. There was no evidence of sticking of relays or of contacts, or of wear of the Variac winding, brushes or central shaft (the central shaft bearings were lubricated with a smear of graphited grease before assembly).

Acknowledgement

The author is indebted to the Chief Scientist, Department of Supply, Australia, for permission to publish this article.

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A Triode F.M. Discriminator

By I. G. Baxter*, B.Sc., A.R.C.S.

A triode valve is used as a frequency modulation discriminator, in a simple circuit where it functions as a gated rectifier. The output voltage changes linearly with carrier frequency over a useful range, but the output is also proportional to changes in amplitude of the carrier waveform.

THERE is a category of phase sensitive rectifier in which triodes are used in push-pull fashion[1,2]. According to whether the input signal is in or out of phase with a reference voltage, so do the valves conduct unequally, thereby determining the amount and polarity of the output. The present arrangement bears a general resemblance to such systems, being based on the use of a triode as gated rectifier. It differs, however, in being single ended, with the phase of the signal voltage varying continuously relative to the reference voltage, instead of being either 0° or 180°.

Principle

The working of the circuit may be followed by considering the action of a triode connected as a shunt rectifier to a source giving a trapezoidal waveform. If the grid is earthed, the anode will assume a mean voltage nearly equal to the peak amplitude of the input (Fig. 1(a)). On the other hand, if the valve is cut off at a certain point in each cycle with negative pulses at the grid, then rectification will take place as if with an input of smaller amplitude, and the mean level attained by the anode will be less (Figs. 1(b) and (c). By causing the instant of cut-off to vary with frequency, the rectified output can be made dependent upon frequency, and the device will function as a frequency modulation discriminator. It will, of course, give an output that varies with the amplitude of the input as well.

Practical Circuit

In practice, it has been found that a tolerable performance can be obtained from a circuit working on the above principles, but operated with sinusoidal waveforms. So far as the signal at the anode is concerned, the requirement is simply for the flanks of the waveform to be linear over a reasonable range; this is fulfilled by a sine wave, in which the straight portions extend over about one radian. In the case of the gating signal at the grid, the use of a sine wave is in principle less satisfactory, for the rounded crests preclude a well defined switching action.

The arrangement of the discriminator is shown in Fig. 2. A tank circuit, in combination with a series capacitance ($C + C_s$), is the load of a preceding driver stage, and serves also as a phase shifting network for providing the reference voltage at the grid. This potential arises from the load current flowing in $C + C_s$, and the grid is allowed to generate its own bias by local rectification. The component values shown are not particularly critical, nor is the type of valve. The amplitude of the grid voltage is the factor which seems to have most bearing on the performance, and an optimum value for C can be found experimentally. The calibration shown in Fig. 3 relates to the circuit of Fig. 2.

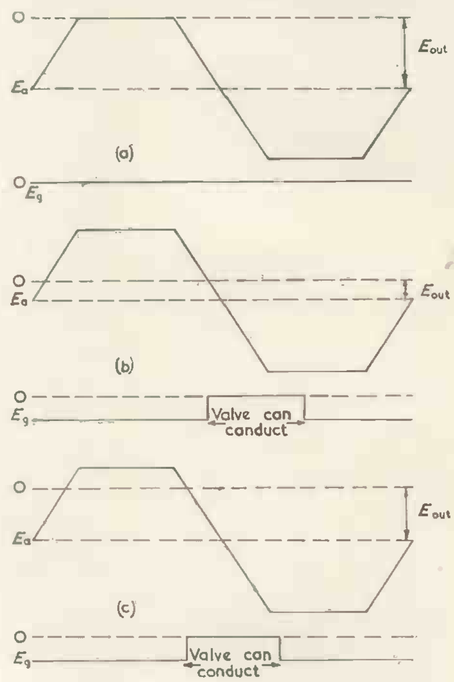
Use with Capacitance Pick-up

The discriminator has been used in conjunction with an oscillator whose frequency was modulated by a capacitance pick-up. The oscillator described by Gouriet[3] was employed, as it is simple, stable, and insensitive to lead capacitance; the output was amplitude stabilized and fed direct to the discriminator.

Conclusion

The working of the discriminator has not been rigorously

Fig. 1. Trapezoidal waveforms of discriminator



* *University Laboratory of Physiology, Oxford.*

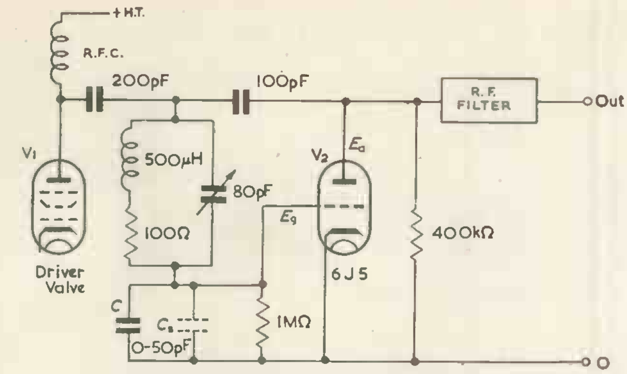
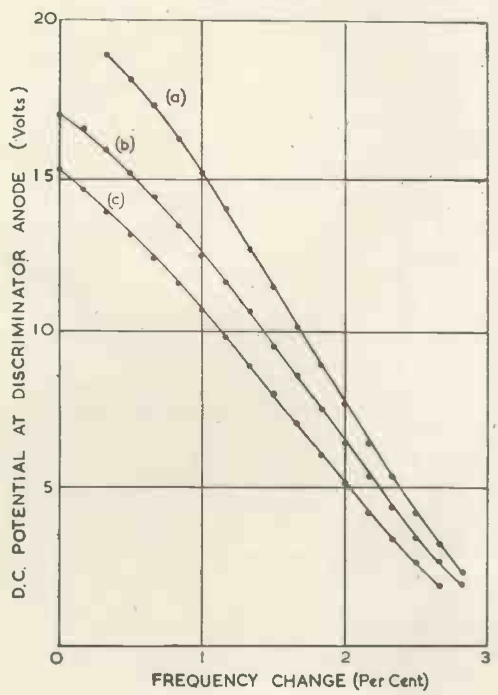


Fig. 2. Triode discriminator circuit (C_s represents the stray capacitance—about 20pF). Operating frequency 0·8 Mc/s

analyzed, but it accords with general expectations. By neglecting adverse factors one can make a crude theoretical estimate of the performance, but the measured characteristics fall rather short of this ideal.

Consider, for example, the circuit of Fig. 2, operating with an R.F. signal of 50 volts amplitude (peak) at the anode of the discriminator, and having Q = 20 for the tank circuit. The slope of the linear portions of the waveform will be approximately 50 volts/radian, and the phase shift of impedance with frequency will be nearly linear over a range of 1 radian, corresponding to a frequency change of about 2½ per cent. If the gating action occurred in an ideal manner, with the point of cut-off falling on the straight part of the waveform, and subject to a phase shift with frequency at the rate just given, it follows that the rectified output voltage would change at the rate of about 20 volts/1 per cent frequency change. By contrast, the measured performance is about 7·5 volts/1 per cent (Fig. 3). This result was obtained with the load resistor of the discriminator returned to cathode; ideally it would be connected to a positive bias, to extend the working range by permitting rectification during the negative going half cycles.

Fig. 3. Calibration of discriminator
E_a peak = 50V E_g peak ≈ 10V
(a) C = 0pF (b) C = 25pF
(c) C = 47pF



The frequency response has not been measured, but it should be adequate for rates of change of frequency up to some kilocycles per second, and could presumably be raised slightly by using a smaller coupling capacitor or load resistor for the discriminator.

A useful feature of the system is that it contains merely a single tank circuit which serves both as a load for the driving amplifier and as a phase shifter for the discriminator. Setting-up is exceedingly easy, and a fair range of carrier frequencies can be accommodated by simply retuning the tank circuit.

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A High Stability Variable Frequency Oscillator for Centralized Transmitter Drive Units

Under International Telecommunications Union regulations, the frequency of medium and high power radio transmitters in the band 4-30Mc/s must be kept within 0·003 per cent of its nominal value over periods of twenty-four hours. In order to achieve the necessary degree of frequency stability, it is usual to resort to crystal control. This has the disadvantage that it is necessary to obtain new crystals whenever channels are reallocated. To overcome this disadvantage, the Equipment Division of Mullard Ltd. have recently developed a variable frequency oscillator of exceptionally good stability, thus permitting continuous coverage of the short-wave broadcast band and avoiding the use of crystals altogether. The oscillator, in conjunction with suitable frequency multipliers and measuring equipment, therefore has considerable applications in the drive units of high frequency broadcast transmitters, civil aviation transmitters, and the radio telegraph and telephone links of Posts and Telegraph systems.

The construction of the High Stability Variable Frequency Oscillator has been made possible by the use of a precision variable capacitor in the tuned circuit. A stable inductor and its associated temperature compensating capacitors make up the rest of the frequency determining elements. The precision capacitors were originally designed to meet the need for a variable capacitor of outstanding reliability and long-term stability for use in communications equipment. Important features are: integral temperature compensation; exceptionally good capacitance repeatability and permanence; very low power factor; and excellent conformity to a straightline frequency law. In addition to the use of highly stable components, the oscillator is housed in a simple oven whose temperature is controlled to ±1°C. This precaution is adequate to keep frequency drift well within the prescribed limits of ±0·0003 per cent.

The high stability variable frequency oscillators are designed for rack mounting as part of a centralized transmitter drive unit.

The oscillator output, which is variable between the limits 1·0 to 1·7Mc/s, is passed through a tuned buffer amplifier to a frequency multiplier which will produce either the second (2-3·4Mc/s or the third (3-5·1Mc/s) harmonic of the oscillator frequency, as required. A final wideband power amplifier delivers an output of 0·5 watt into 70 ohms.

The Mullard high stability variable frequency oscillator should be of great use in centralized transmitter drive units, both in new equipment, where the convenience of continuously variable tuning is desired, and in older equipment where it is necessary to bring the frequency stability up to I.T.U. standards.

Minimizing Contact Potential in Apparatus Design

By E. C. J. Marsh*, B.Sc. (Lond.), F.R.I.C., F.I.M.

*Unless apparatus can be hermetically sealed, serious consideration must be given to minimize contact potentials at bimetallic junctions. Judicious choice of metal coatings—electroplated, sprayed or "hot-dipped"—can materially assist in this direction, and thereby give increased flexibility to the designer. Useful guides are given in the Radio Components Standardization Committee's document RCS/*1000*, and in the Radio Industry Councils' specification RIC/*1000 *B. At the same time, the designer must not allow consideration of contact potential to exclude an appreciation of all the other essential quality requirements of metal coatings.*

THE avoidance of excessive contact potential between the component metal parts of electrical communications apparatus has become of increased importance. This is particularly the case in those radio equipments from which higher performance is demanded from designs more compact in size and lighter in weight. Such units must function satisfactorily under conditions of exposure that cannot always be controlled, so that not only are fluctuations in temperature and humidity experienced, but other adverse influences including condensation of moisture, the incidence of salt laden and industrial atmospheres, and the deposition of dusts, are likely to be encountered. The complete enveloping of the functional parts of the equipment, or of the equipment itself, in a protective membrane is at present rarely practicable, and therefore metals and metal junctions must be chosen to resist the conditions likely to be encountered. This is by no means a simple requirement to satisfy in practice, especially when it is remembered that the fabricational needs of manufacture have to be met as well as the mechanical and electrical qualities of the design.

Confining consideration to the significance of contact potential between different metals in the assembly—and this is only one of several factors which demand attention—electrical designers in common with technicians in other spheres of engineering, have always given some general thought to this subject. The possibility of "battery action" under damp conditions between markedly dissimilar metals like copper and aluminium, and copper and zinc, has been appreciated. Thus bronze and brass inserts in aluminium and zinc alloy castings have been avoided where practicable. Again, with electroplated coatings, the sacrificial type of protection afforded to iron and steel by deposits of zinc or cadmium, which behave anodically, has been appreciated, in contrast with the blanket type of protection given by non-porous coverings of nickel (or nickel/chromium), which is cathodic to the ferrous base. In more recent years, however, electronic engineers have found it necessary to give more detailed attention to contact potential. To this end, the table (reproduced in Table 1) of potentials in sea-water against the saturated calomel electrode at room temperature given in the Inter-Services document RCS.1 000 and in the Radio Industry Council's Specification RIC.1 000B, as well as the table included in the latter as a general guide to metal-to-metal combinations which have been found satisfactory in practice, have proved invaluable. Guidance is also given in RCS.1 000 to the effect that the maximum potential difference should be limited according to conditions broadly defined as follows:—

(a) 0·25V when the conditions of service are such that the equipment is liable to wetting with salt water or is normally exposed to the weather;

(b) 0·50V for components or equipments that may be regarded as interior apparatus which may be exposed to condensation but not to contamination with salt; and

(c) No restriction for interior parts of hermetically sealed components or equipments.

Shortcomings may attend the lead given by these official documents, but it does represent major progress beyond the text-book table of the electro-chemical series of the metals which, not so many years ago, represented the only data available for engineers on this subject.

Laboratory corrosion tests can often be used to demonstrate the unsuitability of certain bimetallic junctions, and components or equipments returned from service due to premature failure sometimes show the disastrous results caused by the use in close contact of metals having a wide difference of contact potential. On the other hand, it is not always possible from artificial tests to establish that a combination, which theoretically should not be used, is actually detrimental, and again there are numerous examples in practice of wrong junctions giving excellent serviceability over long periods of time. There must exist good reasons to explain these discrepancies and generally they lie in the conditions obtaining in service, and/or the attention or lack of attention to other pertinent factors.

Where conducting contact is required between components, electroplating (or other method of metal coating such as hot dipping or spraying) is a practical way of eliminating or reducing the contact potential between adjacent parts. As most items need to be so coated for other reasons (protection from corrosion, reduction of contact resistance, maximum high frequency conductance, solderability), the economic aspect is unlikely to be significantly affected, and this affords an acceptable practical solution to the problem. In adopting it, however, it is most important that attention should not be given to the problem of contact potential to the exclusion of all other factors. The latter may conveniently be embraced in the expression of "quality of the electroplate coating." They include the general qualities of uniformity of distribution of the coating over the part, thickness of coating, density and freedom from porosity and discontinuities, and adhesion. Choice of the right metal coating in relation to the anticipated corrosive conditions as well as with respect to the contact potential aspect, and avoidance of mechanical mishandling after coating, i.e., no machining or filing, drilling or tapping, or other correction or fitting operations which would obviously produce discontinuities in the coating, is assumed.

Even when the most favourable metal combination is chosen and provided with best practicable commercial techniques, the engineer must be wary against assuming that perfection has been achieved. The extent of battery action at a bimetallic junction is dependent upon a number of factors in addition to contact potential. The latter and the resistence of the path determine the magnitude of the current flow and therefore the amount of corrosive action. Hydrogen may be liberated at the cathodic element, and if it adheres to the latter rather than becoming dispersed, the system may polarize, gradually building up resistance till the current stops, and corrosion therefrom ceases. Again, oxidation or passivation may occur at the anodic

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element, retarding or stopping the action. Further, chemical processes may follow the electro-chemical reaction, for example, the absorption of carbon dioxide, and insoluble compounds may be formed. If these are formed at the seat of the battery action, they may add resistance and fulfil a rôle in restraining attack; on the other hand, under conditions of, for example, heavy condensation, they may be produced in a more remote area or actually washed away from the junction, and thus play no important part in the course of the deterioration. Aeration, too, may complicate the process of corrosion due to differential oxygen concentration. In illustration of this, if two exactly similar pieces of iron are immersed in a dilute salt solution with a separating porous partition between them, and one section is aerated by bubbling air through the solution, a potential is set up and a current will flow from the unaerated to the aerated iron if they are connected by a conducting wire. In practice, complications can arise from such phenomena; for example, under "wet" conditions, it is evident that oxygen concentrations in crevices, e.g., clamped junctions, can be significantly different from those at the surface.

The table of contact potentials gives values for one set of conditions only, and it has to be assumed that the relative position of the metals under other conditions is the same, which is not necessarily true. The metallurgical and physical condition of the metals have their influence, e.g., grain size, hardness, surface condition, as well as metallographic aspects of eutectic, solid solution, compounds, disposition of impurities and the like. This emphasizes the need for quality control in the metals used, and in their fabrication into parts. The same stress can be laid upon the quality of metal coatings, particularly with reference to purity and freedom from inclusions.

In one application or another, practically all the metals are used in communications equipments, but those most used in the construction of apparatus and equipment are the steels and stainless steels, the copper rich non-ferrous alloys, especially brass, and aluminium and its alloys. Silver has to be included in contact potential considerations because it is an essential finish for high frequency conductance, and solder because it is an unavoidable joining material. The wide spread of potential of this range of metals is readily apparent from Table 1.

To some extent the range of metals employed is illustrated in Fig. 1 by a "drawer" type assembly for mounting in a radio receiver or transmitter cabinet. The

Fig. 1. Drawer type radio assembly with chassis in position
(By courtesy of S. T. & C.)

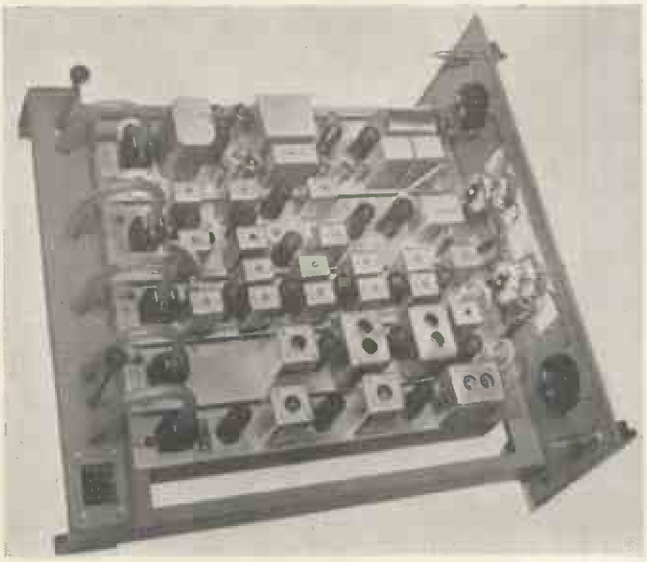


TABLE 1

Potentials Against Saturated Calomel Electrode in Sea Water at Room Temperature

MATERIAL	VOLTS
Magnesium and its alloys	−1·60
Zinc and its alloys :—	
Zinc die-casting alloy, B.S.1004	−1·10
Zinc plating on steel, D.T.D.903	−1·10
Zinc plating on steel, Chromate passivated, D.T.D.923	−1·05
Galvanized iron, B.S.729	−1·05
Tin-zinc alloy (80/20) plating on steel	−1·05
Cadmium and its alloys :—	
Cadmium-zinc solder, D.T.D.221	−1·05
Cadmium plating on steel, D.T.D.904	−0·80
Aluminium and its alloys :—	
Aluminium alloy casting, B.S./L5	−0·90
Aluminium alloy casting, D.T.D.424	−0·80
Aluminium alloy castings, B.S./L33, D.T.D.133	−0·75
Wrought aluminium alloy coated aluminium alloy, D.T.D.687	−0·90
Wrought aluminium, B.S./L4, L16, L17, L34, T9	−0·75
Wrought aluminium coated aluminium alloys, B.S./L38, L47, D.T.D.390, 546, 610	−0·75
Wrought aluminium alloys other than duralumin	−0·75
Duralumin type alloys, B.S./L1, L3, L39, 395, 396, T4, D.T.D.364, 464, 603, 646	−0·60
Irons and steels :—	
Non-stainless :	
B.S./S2, S6	−0·75
B.S./S3, T1, T45, Grey cast iron	−0·70
Stainless :	
12% chromium, B.S.61, 62, 85, D.T.D.161, 203	−0·45
High chromium, B.S./S80, D.T.D.60, 146, 185	−0·35
Austenitic, D.T.D.166, 171, 176, 189, 207, 211	−0·20
Lead and its alloys :—	
Lead	−0·55
Lead-silver solder (2½% Ag.)	−0·50
Tin and its alloys :—	
Tin-lead solders, B.S.219, Grades A and B	−0·50
Tinned steel, B.S./S20	−0·50
Tin plating on steel, D.T.D.924	−0·45
Chromium :—	
Chromium plating, 0·0005 inch on steel	−0·50
Chromium plating, 0·00003 inch on nickel-plated steel	−0·45
Chromium (massive, 99%)	−0·45
Copper and its alloys :—	
Brass, B.S.265	−0·30
Brass, B.S.249 ; Gunmetal, B.S.383	−0·25
Copper, B.S.899 ; Beryllium-copper, T.C.M. CuBe 250 ; Brasses, B.S.250, D.T.D.283 ; Bronzes, B.S.407, D.T.D.412 ; Nickel-silver, B.S.790 ; Cupro-nickel (70/30)	−0·20
Nickel and its alloys :—	
45% Nickel alloy, D.T.D.237	−0.25
Monel metal, D.T.D.10 ; Monel X	−0.15
Nickel-plating on steel, B.S.1224, Ni 85	−0·15
Silver and its alloys :—	
Silver solder, B.S.206, Grade C	−0·20
Silver ; Silver plating on copper	±0·00
Rhodium plating on silver-plated copper	+0·05
Platinum	+0·15
Gold (assay)	+0·15

base framework is of steel cadmium plated, while the individual chassis, and covers on the components mounted thereon, are of brass tin plated. The front panel is of steel, zinc plated and chromate passivated, and enamelled on the front face. Fig. 2 is another radio unit in which the main chassis, and that for the rotary transformer, are fabricated from aluminium alloy (unfinished). The components on these are mainly of brass tin plated. The castings of the transformer unit are aluminium-silicon alloy, chromate pickled and stove enamelled. The filter unit on the front of the equipment is of aluminium alloy, anodized and finished with black shrivel enamel on the face side. This also illustrates the effort made not only to keep the equipment cool, but to eliminate dust, which is one potential danger in promoting corrosion and loss of insulation.

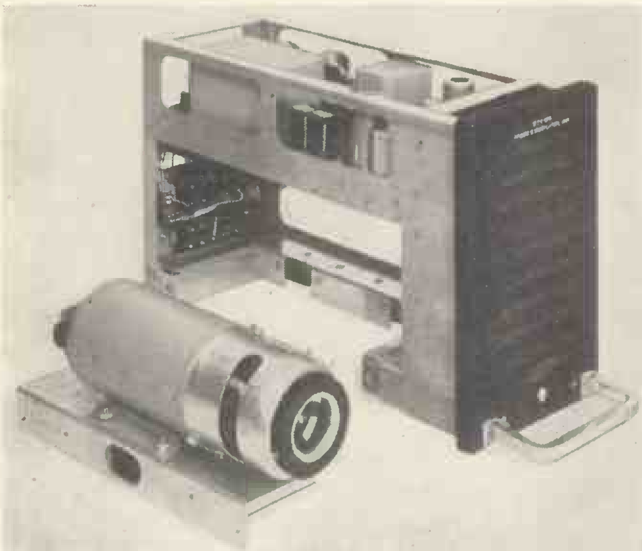


Fig. 2. Radio unit with blower removed
(By courtesy of S. T. & C.)

Giving brief attention to electroplate coatings, it will be seen that zinc and cadmium are both anodic to iron and steel and that the contact potential of cadmium is much closer to that of steel than is that of zinc. The radio industry prefers cadmium as a protective finish for iron and steel, not only because it is less extensively attacked itself in many corroding environments, but also because it does keep the contact potential down towards the centre of the table, easing matters where the non-ferrous metal components have to be assembled to it. Thus the contact potential of cadmium is closely the same as that for the aluminium alloys, and only about 0·3 volts removed from those for tin and tin coatings, and soft solder. Zinc and cadmium do not really provide sound coatings on the copper-rich alloys, zinc on account of wide difference of contact potential, and cadmium for the same reason, as well as on account of its propensity for diffusing into copper at normal temperatures. Tin provides a satisfactory metal coating for these metals and, with its own contact potential of about 0·5 volts, which is not widely different from those for cadmium and aluminium, it provides a reasonable compromise as an electroplate or hot dipped coating for use in contact with cadmium or aluminium. When greater precision is necessary the copper-rich metals may be given a dual plating of tin followed by cadmium. The tin prevents diffusion of cadmium into copper as well as bridging the wide gap between the potentials of copper, brass and bronze, and those of cadmium or aluminium. There are of course instances when it is more appropriate to tin plate the aluminium for contact with a tin-coated copper-rich alloy, and this emphasizes the flexibility of approach to the problem. Again, if silver is insisted upon as the coating for the copper-rich metal, and contact has to be made with aluminium, there is no alternative to coating the latter with silver as well.

Zinc (as electroplate, metal spray, or hot dipped coating), of course, serves as the general purpose protective coating for iron and steel, and chromate passivating does prevent rapid whitening under damp conditions; tin/zinc alloy is an alternative. The other commonly deposited metals, viz. tin, nickel, and silver, are cathodic to steel, so that coatings of them must be continuous and thick enough to be non-porous to the environment in which employed, otherwise they accentuate corrosion at any discontinuities.

In the finishing of copper and the copper-rich alloys, tin is the logical choice for corrosion protection, being anodic without the contact potential of it being too widely different. On the other hand, nickel has been employed for years for telecommunications apparatus and actually still is specified in the Crown Agents specification for this purpose for export equipment. The reason for the use of nickel is really to preserve a white or pale coloured finish and to prevent the black sulphide tarnish that would otherwise occur on brass, copper and bronze. The nickel itself is well resistant to corrosion because of passivity, but it should be noted that, under severely corroding conditions, it can accelerate corrosion of the copper rich alloys because it is cathodic to them.

TABLE 2

Electrode Potentials of Aluminium Solid Solutions and Constituents*

SOLID SOLUTION OR CONSTITUENT	POTENTIAL VOLTS 0 IN. CALOMEL SCALE†
α(Al−Mg) (Mg_5 Al_8)	−1·07
Al+Zn+Mg (4% $MgZn_2$) Solid Solution	−1·07
β(Zn−Mg) ($MgZn_2$)	−1·04
Al−4% Zn Solid Solution	−1·02
Al−1% Zn Solid Solution	−0·96
Al−4% Mg Solid Solution	−0·87
α(Al−Mn) ($MnAl_6$)	−0·85
Aluminium (high purity)	−0·85
Al+Mg+Si(1% Mg_2Si) Solid Solution ..	−0·83
Al−1% Si Solid Solution	−0·81
Al−4% Cu Solid Solution	−0·69
α(Al−Fe) ($FeAl_3$)	−0·56
Al-Cu ($CuAl_2$)	−0·53
Silicon	−0·26

* *Data from Aluminium Research Laboratories.*
† *Measured in an aqueous solution of 53g $NaCl$+3g H_2O_2 per litre.*
(From A.S.M. "Metals Handbook.")

Silver and the precious metals are similarly cathodic to the copper rich metals. Fortunately, silver plate throws very well and is dense, and the copper rich metals are relatively corroding resistant themselves, so that the same heavy thickness is not required upon them as would be necessary upon iron and steel, and as is very essential on aluminium or zinc, when these metals have to be silver plated.

The zinc alloys and aluminium alloys need electroplating for radio communications equipment in many cases. Often a surface coating of high frequency conductance is essential and this means that silver, or copper plus silver, has to be applied. Again, many components of brass or copper which are already plated with either silver or tin have to be assembled to aluminium, and consequently it is desirable to have the same plating on the aluminium in order to eliminate the effect of contact potential. The chief finishes on aluminium for these radio applications are therefore tin and silver, and the general procedure is to apply approximately one mil of copper followed by one mil of tin or silver as the specific case dictates. Under conditions of the damp tests normally specified for services and civil contracts, a total coating thickness of one mil will satisfy the conditions, but a thinner deposit will generally blister and promote rapid attack of the aluminium beneath the blisters. Under salt spray conditions the two mil thickness is generally found to be necessary to give immunity from attack.

The determination of contact potentials uses simple equipment, but in itself is complicated by subsidiary chemical reactions which may occur, so that to obtain stable reading of assured accuracy is somewhat difficult. The Royal Aircraft Establishment in this country have performed most work on the subject, and the values in Table 1 are largely based on their work. Other authorities have used other conditions, including different electrolytes. A recognized standard procedure is sought and research to establish values to an accuracy of perhaps 0·01V; those given to 0·05V are not always adequate when limiting a maximum difference of potential to 0·25V. Data upon the influence of alloying constituents would also be useful on the same basis, particularly in view of the disparity between alloys in the same group, e.g. duralumin and aluminium/managanese alloy.

are produced. To add to the complications, physical influences arise resulting from the history of the particular metal and its form, i.e., from rolling or drawing, casting or extrusion, and the influence of heat treatment, and finally there is the possibility of passivity being developed to some degree. All these factors have some influence which will vary according to the nature of the corroding environment.

The solders are eutectic mixtures and their contact potential lies between that of tin and of lead, the values of which are quite close together. Tin/zinc alloy is also a eutectic type, and in this zinc is the predominating factor giving a contact potential almost the same as that of zinc, but widely different from that of tin.

The number of aluminium alloys employed today is almost legion, and, as the electroplater is fully aware from experiences in the finishing of them, they have a number of peculiarities as shown by their response to cleaning and plating treatments. As a matter of interest, Table 2 shows data from the work of the Aluminium Research Laboratories of America showing the electrode potentials of some of the actual constituents in these complex alloys. These were measured in an aqueous solution of 53 grams

TABLE 3

Electrode Potentials of Aluminium Alloys in 3 Per Cent Sodium Chloride Solution at Room Temperature against Saturated Calomel Electrode

ALLOY	COMPOSITION—PER CENT								POTENTIAL VOLTS
	Cu	Si	Mn	Fe	Mg	Ni	Ti	Zn	
High Strength	—	0·3	1·0	0·2	3·0	—	0·1	7·0	−0·94
Castings 3L5	2·8	0·7	—	0·8	—	—	0·2	13·5	−0·91
Airscrew Alloy X765	0·6	0·5	0·5	0·3	1·4	—	0·1	7·5	−0·89
7% Magnesium Alloy	—	—	—	—	7·0	—	—	—	−0·81
Castings D.T.D.424	2·0	4·5	0·7	0·8	0·1	0·3	—	0·2	−0·80
3½ Magnesium Alloy	—	—	—	—	3·5	—	—	—	−0·77
Wrought RR.77	2·1	0·3	0·5	0·4	2·8	—	—	5·0	−0·77
Aluminium Sheet L16	—	—	—	—	—	—	—	—	−0·76
Castings L33	—	11·5	—	—	—	—	—	—	−0·75
Sand or Die Casting D.T.D.133 ..	1·4	2·1	—	1·1	0·2	1·3	0·1	—	−0·73
Aluminium-coated Dural ..	—	—	—	—	—	—	—	—	−0·73
Wrought RR.56	2·1	0·9	—	0·9	0·9	1·0	0·1	—	−0·70
Duralumin	4·0	0·7	0·6	0·7	0·6	—	—	—	−0·60

TABLE 4

Potential Differences (in volts) between Various Copper Alloys in Dilute Synthetic Sea Water*†

	RED BRASS	70–30 BRASS	MUNTZ METAL	ALUMINIUM BRONZE	30% CUPRO NICKEL	ALUMINIUM BRASS
Copper	+0·031	+0·047	+0·086	+0·048	+0·030	+0·053
Red Brass	—	+0·038	+0·043	+0·005	−0·012	+0·013
70–30 Brass	—	—	+0·013	−0·033	−0·011	0·00
Muntz Metal	—	—	—	−0·030	−0·042	−0·016
Aluminium Bronze	—	—	—		−0·017	+0·010
30% Cupro-Nickel	—	—	—	—	—	+0·027

* *H. L. Burghoff, "Corrosion of Metals,"* p. 100 (1946), *American Society for Metals.*
† *Solution one-sixth the usual strength of sea water.*

In the case of alloys, it can be rather loosely stated that one of the alloying elements largely dictates the behaviour of the alloy and that generally speaking the electrode-potential of the alloy lies somewhere between those of the constituent metals. This is perhaps a dangerous statement to make on account of the complex metallurgical and physical problems which enter. It is to be remembered that in an alloy the constituents may lie side by side as an eutectiferous mixture. On the other hand, they may form a solid solution or a number of solid solutions, or again complications may arise because a series of chemical compounds

of sodium chloride and 3 grams of hydrogen peroxide per litre at room temperature. From the point of view of the present subject, it will be noted that with high purity aluminium at −0·85V, a magnesium constituent raises this appreciably and that zinc does the same. On the other hand the aluminium manganese constituent gives a value the same as aluminium and it is significant that the 1¼ per cent manganese aluminium alloy is well known in industry as being the one aluminium alloy that has a corrosion resistance equal to that of aluminium itself. On the other side of the scale, silicon itself has the very low value of

−0·26V and the copper solid solutions and compounds are appreciably lower than aluminium itself.

These points do explain the corrosion behaviour and other phenomena experienced with the aluminium alloys. They give the reason why low magnesium alloys such as the Birmabright series have quite good resistance to corrosion, and why those having appreciable copper contents, such as Duralumin are relatively poor. They also explain why the 11-13 per cent silicon alloy which is a eutectiferous mixture can fail by "pitting" corrosion. These data also help to explain to some extent why in the electroplating of aluminium such wide divergencies of performance are encountered in passing the work through the pre-treatment solutions (caustic, acid, sodium zincate, etc.), and why differences of behaviour occur here not only with differing compositions, but also with forms of the same composition differing with respect to temper or heat treatment.

In regarding the values quoted in Table 2 it must be remembered that these have been determined in a rather different solution from that used for the electrode potentials in Table 1, which does affect the actual value but would not affect the relationship from one to another. In Table 3 more detail is given for the aluminium alloys from some of the work by R.A.E. and others, to further illustrate the points just discussed.

The dominating influences of a highly anodic element is also shown to some degree in the copper/rich alloys, i.e., by comparing copper with the brasses. The value for copper itself is − 0·18 and the 60/40 copper zinc brasses about − 0·30 with the lower zinc brasses of the order of −0·25.

TABLE 5

Electrode Potentials of Irons and Steels in 3 per cent Sodium Chloride Solution at Room Temperature against Saturated Calomel Electrode

METAL	COMPOSITIONAL—PER CENT			ELECTRODE POTENTIAL VOLTS
	CARBON	NICKEL	CHROMIUM	
Mild steel ..	0·23	—	—	−0·70
Grey cast iron	3·0	—	—	−0·70
Stainless steel	—	—	12·0	−0·45
Stainless steel	—	—	18·0	−0·35
Stainless steel	—	8·0	18·0	−0·20

Again in relation to the influence of zinc as an alloying element and the relative position of copper and the various brasses, Table 4 is reproduced from "Metals Handbook," p. 897 (1948). It shows the potential difference in volts between copper and various copper alloys measured in sea water diluted to one-sixth of the usual strength. Examining the figures along the first horizontal line, it will be seen that copper shows an increasing positive potential to red brass (85/15 or 90/10), 70/30 brass and Muntz metal (60/40), the zinc content increasing from 10 or 15 per cent in the first to 40 per cent in the third of these alloys. The influences of aluminium in aluminium bronze in the fourth column should also be noted, and the similarity of the aluminium brass in the last column with 70/30 brass.

With respect to the stainless steels a number of peculiarities arise from bimetallic junctions in service probably due to the varying passivity of these metals under changing conditions. It is difficult to determine the contact potential of these metals in practice and to obtain a "steady value." Table 5 gives some figures for the steels. The cast irons and plain carbon steels are quoted as − 0·70 which again is rather a difficult figure to establish due to varying passivity in the initial stages of the test. The 12 per cent chromium alloy is given as − 0·45, the 18 per cent one as 0·35, and the 18 per cent chrominum 8 per per cent nickel alloy as − 0·20. The influence of the high nickel content in rendering the latter more noble should be noted. This particular alloy is thus closely similar to copper and the copper/rich alloys for contact potential, but appreciably removed from the aluminium and aluminium alloys rendering performance doubtful if used in contact with the latter.

Fig. 3 shows stainless steel strips, fixed with aluminium rivets to aluminium, after three days' salt spray test. The attack on the aluminium is more severe than if there were no contact with stainless steel and its is particularly concentrated around the rivets and along the junction between the dissimilar metals. There is little to choose between the two samples, if anything the 12 per cent chromium steel A being a little superior to the 18 per cent chromium eight per cent nickel alloy B.

The diaphragm assembly of the telephone transmitter is one illustration of the possible devastating effect of high contact potential. Fig. 4 shows the effect of salt spray conditions. A is the aluminium seven per cent magnesium alloy diaphragm against nickel plated brass clamping ring and case. It shows the heavy corrosion of the diaphragm from the bimetallic junction, this occuring in five days. B is the same kind of diaphragm assembled against chromate passivated zinc, showing very little deterioration after ten days of the test. These artificial results coincide with experience from practice under severe service conditions.

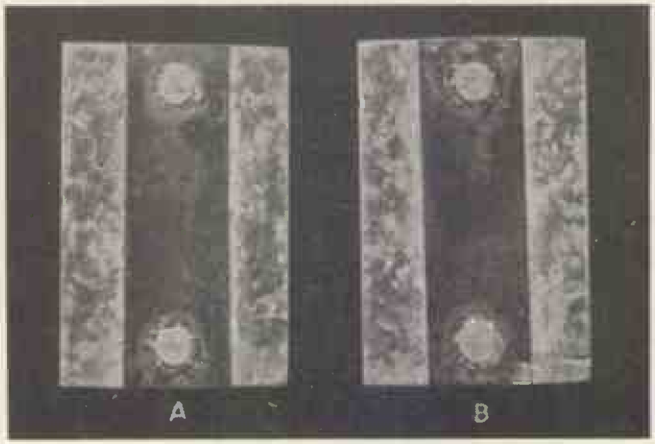
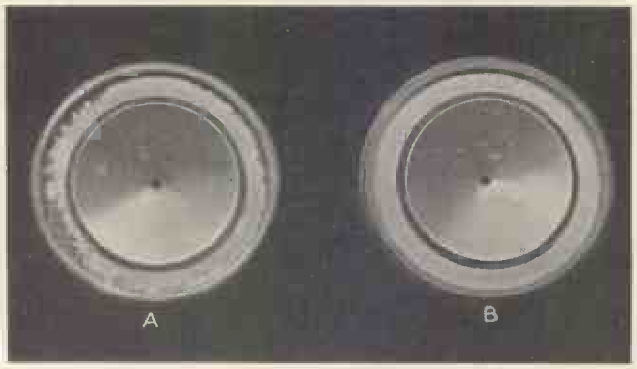


Fig. 3 (above). Stainless steel in contact with aluminium after salt spray test

Fig. 4 (below). Bi-metallic junctions between aluminium diaphragm and metal case after salt spray test. A. Nickelled brass case. B. Chromated zinc case



Unlimited test results could be quoted and many experiences from practice. From the design angle, the sound procedure is to avoid excessive potential differences. Metal finishes provide the practical aid in this direction, but the quality of the finish in all respects must be assured. From the manufacturing angle, process control must be established to ensure the latter.

Pulse Duration Modulator Circuit

By F. Butler, B.Sc., M.I.E.E., M.Brit.I.R.E.

A circuit for the production of duration modulated pulses is described, employing a hard valve generated developed by D. A. Levell.

The pulse duration and repetition rate may be varied over wide ranges. The circuit includes a trigger pulse generator and shaping circuit, the complete equipment being designed for single channel voice frequency communication purposes.

IN 1952 a description was given by D. A. Levell[1] of a new type of hard valve pulse generator. The present note shows how the original circuit may be adapted to produce duration-modulated pulses suitable for single channel voice communication purposes. The requisite modifications are simple and straightforward and the performance of the pulse generator is not impaired by the provision of facilities for modulation.

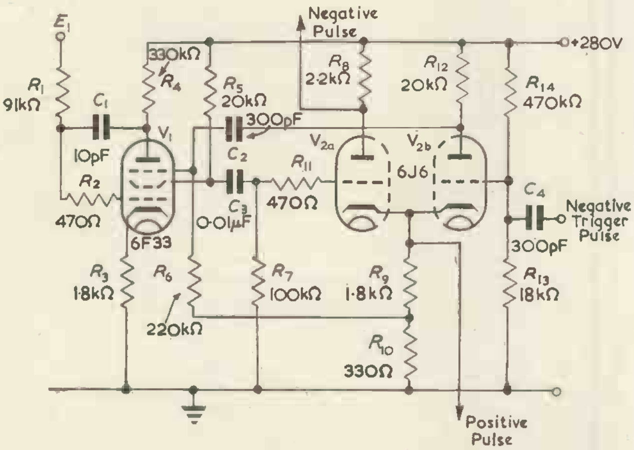


Fig. 1. Basic pulse generator circuit due to D. A. Levell

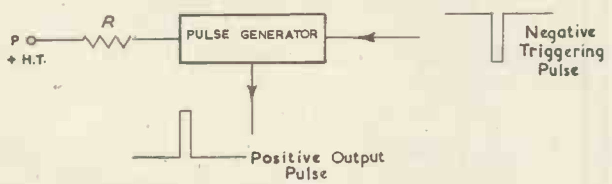


Fig. 2. Block diagram of the pulse generator

The circuit, as already described, is shown in Fig. 1.

Reference to the original article will make clear the mode of operation of the generator, which for the present will be regarded simply as a box which produces positive pulses at its output terminals in response to a recurrent negative triggering pulse, the time duration of each output pulse being dependent on the direct voltage E_1 applied to the free terminal of a high-value resistor connected to the pulse generator. The arrangement is shown schematically in Fig. 2. The resistor R is of the order of 100kΩ and on varying the potential of the point P between 15 and 280V the pulse duration changes smoothly from 12·8 to 0·7μsec.

Fig. 3 shows the relationship between the pulse duration and the potential of P. The characteristic curve is a rectangular hyperbola for which the average value of the product of voltage and pulse duration is numerically equal to 206.

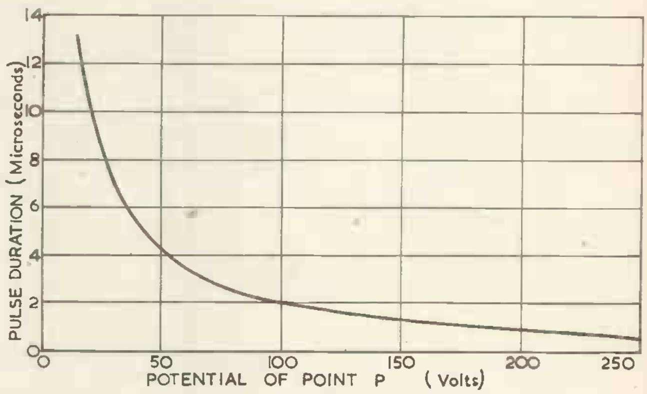


Fig. 3. Pulse duration characteristics

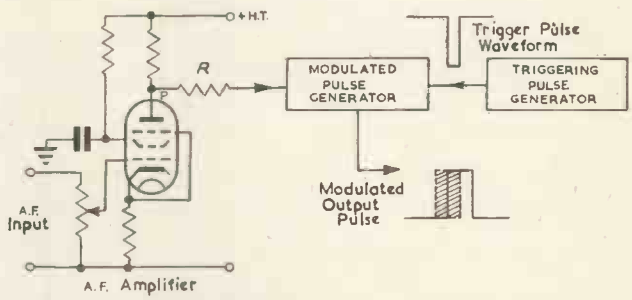


Fig. 4. Schematic diagram of pulse modulator circuit

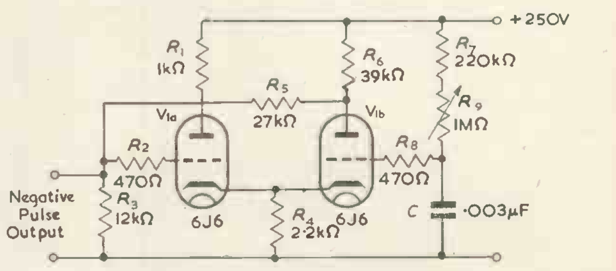


Fig. 5. Trigger pulse generator

Audio-frequency modulation of the pulse duration can be achieved by connecting the point P to the anode of a suitable amplifier valve. The simplest possible arrangement is shown schematically in Fig. 4. The complete pulse modulator requires only the addition of a triggering pulse generator of conventional design. For this part of the equipment a twin triode valve is used in a cathode-coupled multivibrator circuit in preference to the possible alternative of a self-running transitron. Fig. 5 shows the circuit arrangement finally chosen.

Practical Pulse Modulator Circuit

A complete circuit diagram of the equipment is given in Fig. 6. It consists of the original pulse generator, an audio frequency amplifier and a trigger pulse generator, together with a few additional circuit components designed to

One valuable feature of the system is that overmodulation of the pulse is virtually impossible. In cases where low distortion is of importance, a simple palliative may be applied without further complication of the circuit. The principle is to make use of deliberate distortion in the pentode audio frequency amplifier by choosing a load resistance and by setting the electrode voltages so that a non-linear modulating voltage is applied to the pulse generator. The principle of the method is illustrated in Fig. 7. This shows a family of pentode characteristics with an operating point and a load line so chosen as to produce distortion of the opposite sense to that which is introduced

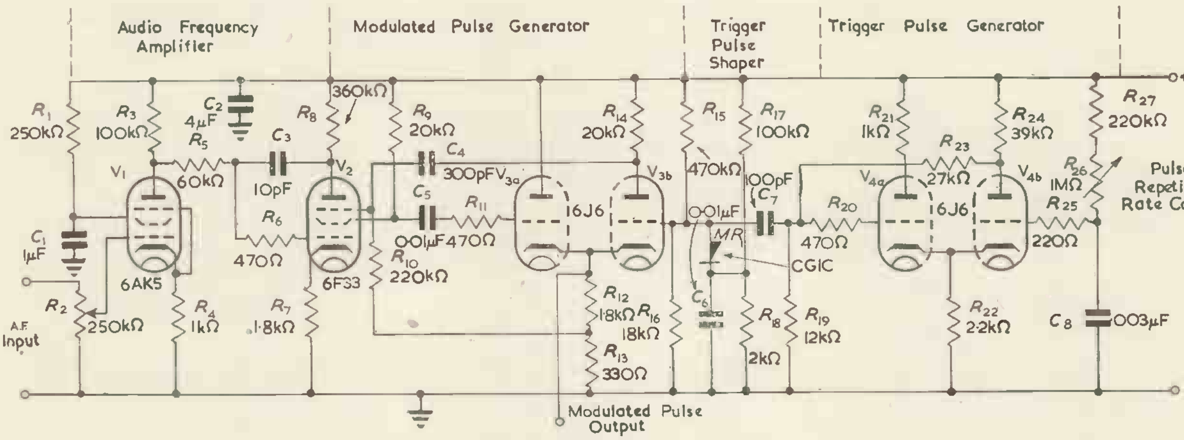


Fig. 6. Complete circuit diagram of the modulated pulse generator

improve the triggering characteristics. A few minor changes have been made in the primary pulse generator circuit. One is the omission of a valve anode load resistor, since negative output pulses were not reguired.

The trigger pulse generator is required to produce a train of short negative pulses having an amplitude in excess of 5V and with a recurrence frequency at least twice as great as the highest modulation frequency which is to be used. This is a fundamental requirement of all pulse modulation systems.

With the component values shown in Fig. 6 the recurrence frequency is variable over the range 9-14kc/s. The control is normally set for operation at 12kc/s, which permits the use of modulation frequencies up to 6kc/s. This is adequate for any normal communication purposes. The output pulse is rather too wide for good triggering and after differentiation by the short *CR* circuit consisting of C_7 and R_{16} two narrow pulses of opposite polarity are produced. The positive pulse is undesirable, since it causes a spurious response in the output from the modulated pulse generator. Its effects are entirely removed by the diode clipper circuit consisting of R_{17}, R_{18}, C_6, and the crystal rectifier *MR*I which is a B.T.H. germanium diode type CG1C.

Except for a few minor circuit changes, some of which have already been specified, the modulated pulse generator is as described in the article by D. A. Levell.

The remaining part of the equipment is an audio frequency amplifier which is D.C. coupled to the pulse generator. The greatest permissible depth of modulation calls for negligible power from this amplifier.

Inspection of Fig. 3 reveals that the modulation characteristic is decidedly non-linear except along the asymptotes of the hyperbola, which correspond to very long or to extremely short pulse durations. It might be expected that deep modulation would be accompanied by strong second harmonic distortion, but experience shows that with voice signals fed at high level into the modulator there is little obvious degradation of quality.

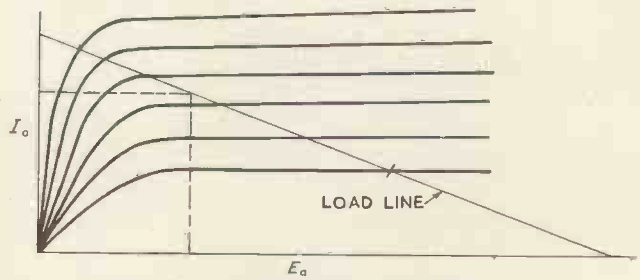


Fig. 7. Production of non-linear modulation voltage

in the modulation process. Subterfuges of this type are inadmissible in high fidelity working, but are entirely satisfactory in communication practice.

Experimental Results

The equipment was set up to produce pulses of 5μsec duration at a recurrence frequency of 12kc/s. The pulse amplitude was 80V peak and the rise and decay times were each about 0·5μsec. Application of a D.C. signal to the amplifier valve varied the pulse duration over the expected range. Similar checks were made at other pulse widths between the limits of 1 and 10μsec. They were repeated for recurrence frequencies between 3 and 15kc/s, the lower frequencies calling for a change of capacitor in the trigger pulse generator, no change being required in the main pulse unit.

To extract the audio frequency from a duration-modulated pulse train it is sufficient to apply the pulses to a low-pass filter. An integrator circuit can also be used to increase the output signal level, but the efficiency varies with the modulating frequency. Distortion is caused and equalization becomes necessary. For experimental purposes, the unit shown in Fig. 8 was constructed. It consists of a cathode-follower feeding a low-pass filter, the output of which is amplified to a level high enough to operate a loudspeaker. The tuned circuit in the cathode lead of V_2 is set to reject the pulse repetition frequency.

With the output of this unit connected to an oscilloscope and with a range of audio frequency tones applied to the pulse modulator, examination of the waveform showed little trace of distortion over the whole frequency range. Lack of suitable equipment precluded an attempt at distortion measurement, but a check with a broadcast programme fed into the pulse modulator showed little difference between the quality of reproduction when the loudspeaker was changed over from the radio receiver to the output of the pulse detector. Some low-level heterodyne interference was caused by radio-frequency harmonics of the pulse output from the generator. Physical separation of the pulse generator and the receiving aerial eliminated this effect.

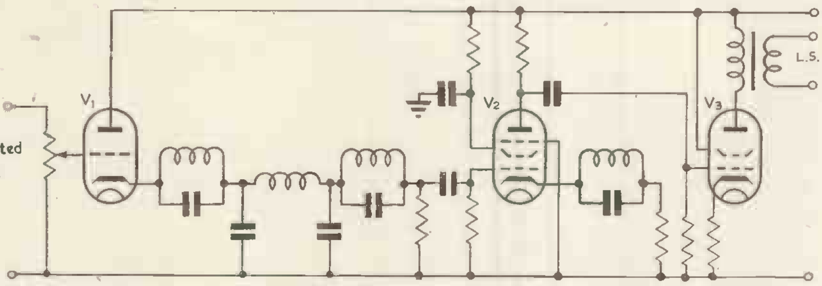


Fig. 8. Pulse demodulation circuit

Conclusion

The unit described produces a train of modulated pulses of whch all the parameters can be varied over an extremely wide range. Its components are non-critical in value and the pulse shape is extremely good. The current consumption is 30mA at 250V and the performance is scarcely affected by normal changes in supply voltage. A high-level output pulse is available from a low-impedance source. In its simplest form the non-linearity of the pulse modulator characteristic might be objectionable, but correction of this fault is not unduly difficult and it can be achieved without additional circuit complication.

The pulse modulator is only suitable for single-channel working and there is no simple way of providing for multiplex operation.

Acknowledgment

The writer is indebted to J. D. Storer for designing the trigger pulse generator and for conducting initial tests on the finished equipment.

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A Simple Analogue Divider

By J. L. Douce*, M.Sc.

A simple circuit is described with an output voltage proportional to the ratio of two input voltages. The device is accurate to 5 per cent over a wide range of inputs.

MANY occasions arise where it is desirable to compare the amplitude of two voltages, with a fair degree of accuracy. One particular application is in the construction of an automatic Nyquist diagram plotter for a feedback system, where the open loop gain is most easily found by comparing two variable signals, the output amplitude and the error signal. The usual method of performing this operation is to use an electromechanical servo system[1]. This can give results of high accuracy, but suffers from two disadvantages. In many cases the cost and complexity of such equipment may not be justified, and the maximum frequency of operation is limited to about 10c/s.

The electronic method to be described uses standard components only, including three pentodes and three diodes. The device is effective for positive input signals only, and for input frequencies from zero to a pre-determined maximum.

Principle of Operation

Let the two input voltages be v_a and v_b such that the desired output is given by

$$v_{out} \propto v_a/v_b \quad \text{(1)}$$

The above relationship is fulfilled by deriving a pulse of duration inversely proportional to v_b and using this pulse to gate the input v_a, so that an output pulse is obtained of amplitude v_a and of duration proportional to $1/v_b$. This process is made repetitive, the repetition rate being much higher than the maximum input frequency. The final output is obtained by smoothing the pulses obtained, using a simple *RC* filter. The time-constant of this filter is made large compared with the repetition period.

The variable width pulse is obtained by using the basic

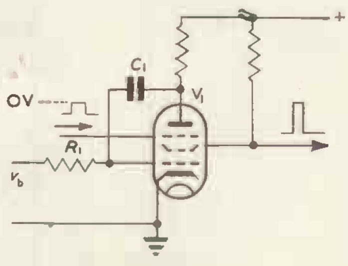

Fig. 1. Basic circuit of the pulse generator

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circuit of Fig. 1 which is a suppressor switched Miller integrator[2]. The rate of run down is given by

$$-dv_1/dt = v_p/C_1R_1 \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

It follows that the run down time, and hence the time during which the screen current is small, is inversely proportional to the voltage v_b. The complete circuit of the divider used is shown in Fig. 2.

The Practical Circuit

Referring to Fig. 2, the input network R_2R_3 provides apropriate bias for V_1 so that with the input earthed the anode potential falls very slowly. The voltage level of the pulse appearing on the screen grid of V_1 is changed by R_4R_5 so that the lower level of the waveform at the junction of R_4 and R_5 is several volts negative. While the

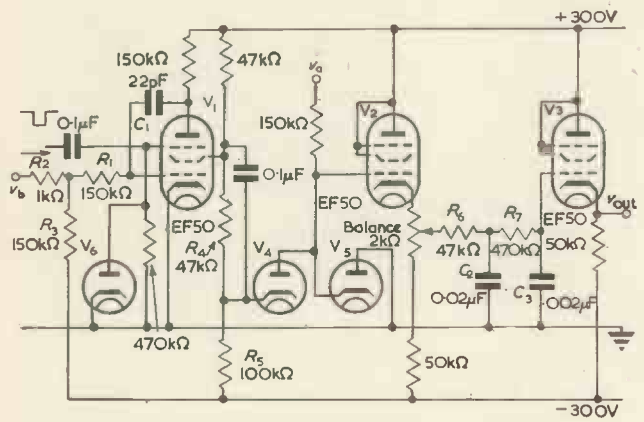

Fig. 2. The divider circuit

anode of V_1 is falling, the screen current is small, hence the cathode of V_4 is positive, and both V_4 and V_5 are non-conducting. Thus v_a is applied to the smoothing circuit R_6C_2, etc. When the screen grid potential of V_1 is low, that is when either the anode is bottomed or anode current is cut off by the suppressor voltage V_4 and V_5 conduct, so that v_a now has no effect on the outut voltage, which tends to zero. It follows that the output voltage is proportional to v_a/v_b, as required.

Permissible Range of Inputs

The permissible range of v_b is limited by two factors.

(a) v_b must be sufficiently large to ensure that V_1 bottoms before anode current is cut off by the suppressor, and must be of several volts amplitude to give a linear run down of anode voltage.

(b) v_b must not be so large that the duration of the pulse appearing on the screen grid is comparable with the rise and fall time of this pulse.

A suitable range for v_b is found to be from 5 to 100 volts.

The only limitation on the voltage v_a is that it must not exceed the positive voltage appearing on the cathode of V_4. A safe margin is provided if v_a is not allowed to exceed 60 volts.

The behaviour of the unit is illustrated by Fig. 3 which gives the input-output relationships for a wide range of D.C. input voltages. From this series of graphs, it can be shown that the error of the output voltage is not greater than ± 5 per cent ± 0·1 volt, whichever is the larger.

The frequency response to an input of the form

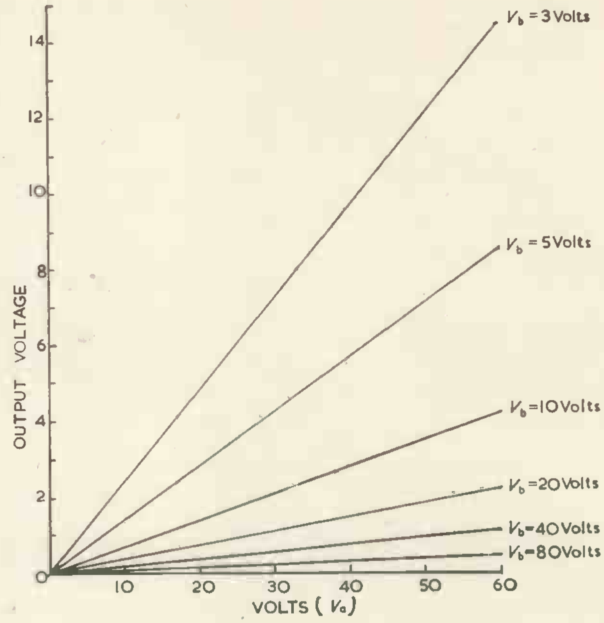

Fig. 3. Experimental response of the unit

$v\,(1 + m \sin \omega t)$ for $|m| < 1$ is shown in Fig. 4, with either v_a or v_b varying with time. In each case the response is 3db down at about 100c/s. This is due to the gating of the waveforms, which takes place at 1 000c/s and the unit could be modified to handle higher input frequencies by increasing the switching frequency.

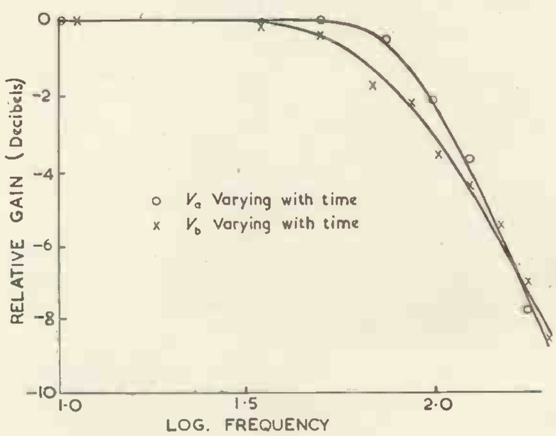

Fig. 4. Frequency response of the unit

Conclusion

A simple circuit has been presented which gives the ratio of two voltages with an accuracy sufficient for many practical purposes. Standard components are employed, and the method has considerable advantages over the servo-mechanism type of divider. The unit has proved reliable in operation and retains its calibration over a long period of time.

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An Industrial Batching Counter

By R. W. Brierley*

A counting equipment is described which controls the batching of mass-produced articles into small pre-determined quantities. The design is based upon a cold-cathode trigger tube, the Hivac XCII, and illustrates the simple "carry-forward" and reset circuits which may be used with tubes of this type.

The individual circuits are discussed in detail.

ONE of the many industrial uses of electronic methods of counting is the batching of mass-produced articles into small quantities either for further processing or for final packing. Electronic counters, using thermionic valves and based upon the various well-known scale-of-two-circuits, have already been used for this purpose but their capabilities, particularly in relation to counting speed, have been usually far in excess of the actual requirements. The newly developed cold-cathode tubes, however, have now made possible the design of an equipment which is considerably less complex than its thermionic counterpart yet whose maximum counting rate is still adequate for the majority of applications. It is the purpose of this article to describe such an equipment.

Cold-cathode tubes, in general, are admirably suited for industrial counting equipment; in addition to the obvious advantage of not requiring a heater supply, they are self-indicating and, by virtue of their two stable states, readily formed into counting rings with but few additional components. The single triode type is particularly advantageous in that it can be used to form not only counting rings of any desired scale but also a wide variety of pulse-forming circuits. Thus, in the batching counter to be described, all tubes, with the exception of a VR150 stabilizer and a 6J5GT triode, are of one standard type.

General Description

The exterior and interior appearances of a complete counter are as shown in Fig. 1 and 2. Looking from right to left in Fig. 2, the four vertical panels contain respectively (a) the power supply, together with the input, batching and reset circuits, (b) the units counter, (c) the tens counter and (d) the hundreds counter. The units and tens panels are both equipped with the full complement of 12 tubes and, reading upwards, these are (a) the start tube, which fires automatically each time the unit is switched on or reset, (b) a decade counter and, (c) the carry-forward tube. This latter tube fires momentarily at each tenth pulse and drives on the succeeding counter by one step.

The unit illustrated is intended to count up to 199, to cover batches of a gross, and the hundreds panel, in consequence, has only two counting stages. Substitution of a standard, fully-equipped panel increases this total to 999 and when a still further increase is required, additional decades can be added without any circuit modification.

Each panel, in addition to the tubes already referred to, has a rotary selector switch with which the batch quantity can be set; if, for instance, a batch of 175 is required, the hundreds switch is set to 1, the tens switch to 7 and the units switch to 5. When this quantity has been counted, the upper relay on the power supply panel operates and its contacts are used, via suitable ancillary gear, either to stop a feed mechanism, swing a gate across a conveyor or otherwise control the machine as required. Resetting, after the clearance of a completed batch, is accomplished either by a built-in push-button or, more

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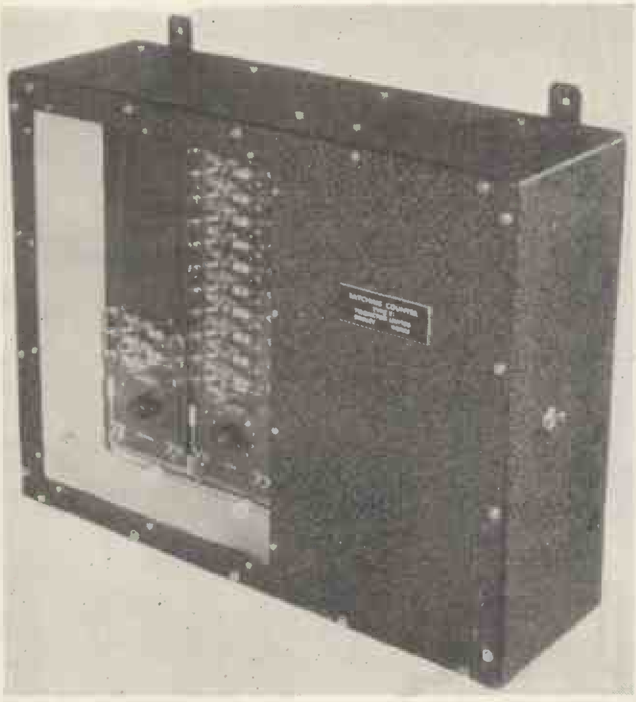


Fig. 1 (left). Exterior view of batching counter

Fig. 2 (below). View of counter with front cover removed

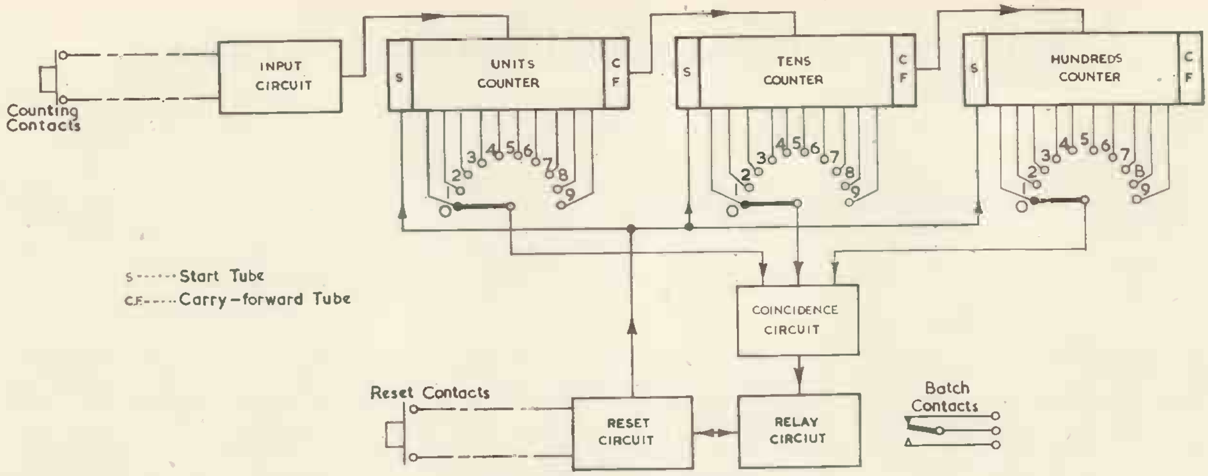


Fig. 3. Schematic Circuit of Batching Counter

usually, by a remote contact operated by the machine.

The three selector switches, mentioned earlier, are mounted within the unit and are adjustable from outside by a screwdriver inserted through bushes in the Perspex panel. When these bushes are sealed off, after setting the required batch quantity, the entire unit is completely dustproof.

Operational Details

In order that the equipment should, as far as possible, be a standard unit and, as such, readily applicable to a wide range of both plant and product, it was designed to operate from the closing of a pair of contacts or, alternatively, from a positive voltage pulse of not less than 50 volts amplitude. Dependent upon the product to be counted, the contacts referred to may be either a simple buffered spring-set operated directly by the passage of the articles, a microswitch similarly used or, the relay contacts of, say, a photo-electric unit or other standard detecting device. False counting, which would result from the presence of contact bounce, is eliminated by fixing the resolution time of the input pulse-forming circuit at 40msec, equivalent to a maximum operating speed of 25 counts per second. While this speed is low in comparison with that of counters using thermionic valves, it is, nevertheless, adequate for the majority of industrial processes. In many instances, when photo-electric pick-ups are used, it is usual to dispense with the relay and to feed the batching counter with pulses derived directly from the photo-cell amplifier. Relay life is not then a limiting factor and the whole equipment, of course, can be operated at a much higher speed than would be possible with a standard type of relay.

The batching relay, which operates when the required number of articles has been counted, is fitted normally with one change-over contact, capable of switching 5A at 250V A.C., and, as previously explained, is used to control the batching mechanism. Both solenoids and solenoid-actuated air-valves are commonly used in this connexion.

In arranging for automatic reset after a batch has been counted, provision is made for a light-duty contact, conveniently, a micro-switch, to be operated by some suitable motion of the machine. This contact energizes momentarily the lower relay on the power supply chassis and so resets all counting tubes to zero. The batching relay which, meanwhile has been energized since the completion of the count, now releases and initiates a further batch. While the period for which the reset contact is held closed is in no way critical, it must be re-opened before the next batch is complete. In addition, the reset circuit is so arranged that it cannot operate until the set quantity has been counted; the final total, therefore, is protected against any accidental operation of the reset contact.

Cold-cathode tubes of the coated-cathode type, such as used in this equipment, should not be operated in complete darkness. Without any incident light, their characteristics become very variable and, for this reason, and to make the equipment independent of external lighting conditions, the counting tubes are illuminated by a small 15 watt lamp mounted within the unit.

Details of the Circuits

A schematic diagram of the complete circuit is shown in Fig. 3.

INPUT CIRCUIT

The circuit shown in Fig. 4 is of the self-extinguishing type and provides the driving pulses for the units counter.

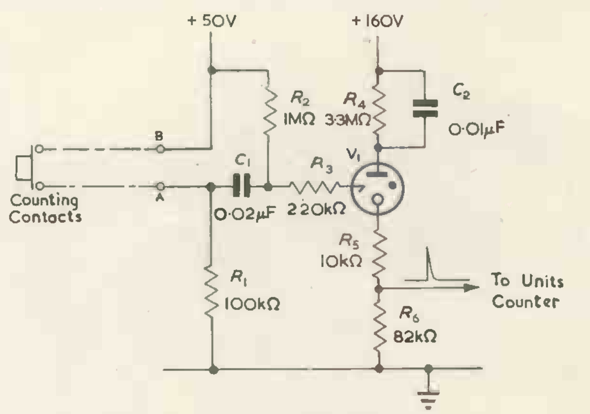


Fig. 4 Input circuit

To strike V_1, a positive pulse of approximately 100V amplitude is required at the trigger. This could have been obtained by returning the counting contacts to a +100V source, but, in order to keep the potential at these contacts to the lowest practical value, a fixed bias of +50V is applied to the trigger via R_2. The contacts have now to develop only a +50V pulse which is then superimposed on the bias.

The time-constants of the trigger circuit have been so chosen that V_1 cannot be fired unless at least 40msec has elapsed since the last closing of the contacts. As already explained, this paralysis period eliminates the false count-

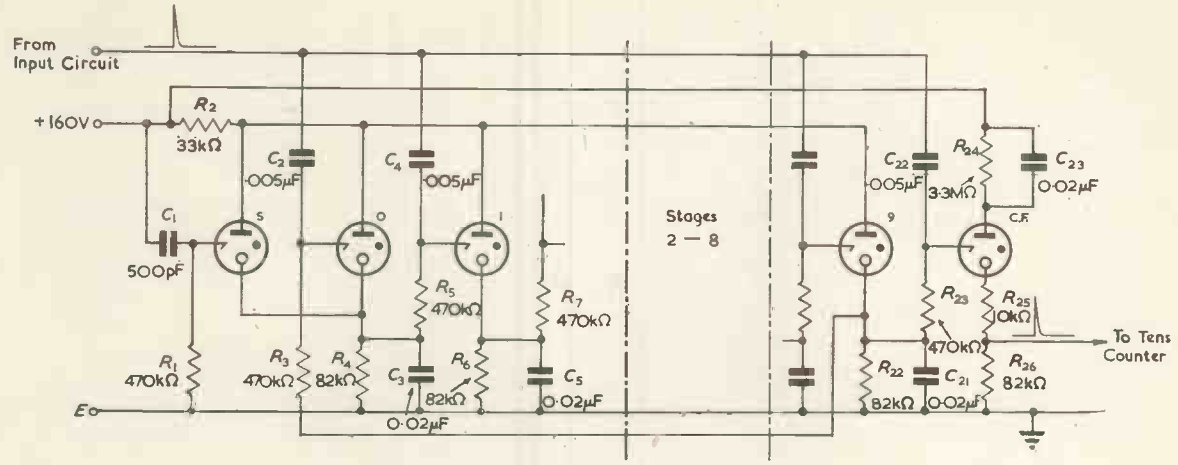


Fig. 5. Counting circuit

ing that would result from bouncing of the contacts after the initial closure. It is effective for a wide variety of contact arrangements.

At each firing of V_1, the main gap discharges C_2 into the cathode resistor, consisting of R_5 and R_6. R_4, in the anode circuit, is of adequately high value to ensure that, once C_2 is discharged, there is insufficient current available to the main gap to maintain ionization; the tube therefore extinguishes. As a result of this action, there is produced across the cathode resistor a positive pulse of approximately 85V amplitude at each closing of the contacts or, alternatively, for each application of a +50V pulse at the point A. Only +60V pulses are required for the counting circuits and the output is taken, therefore, from the junction of R_5 and R_6.

Counting Circuits

The equipment illustrated has three counting circuits conected in cascade to record units, tens, and hundreds. All three are identical in operation and only one need be described here in detail. Fig. 5, therefore, will be taken to represent the units counter and, as such, will receive driving pulses from the input circuit.

On the application of H.T., the start tube *S* is struck automatically by the +160V pulse applied to its trigger by C_1. With a nominal anode-cathode tube drop of 75V, approximately 60V is developed now across R_4, which is common to both tubes *S* and *O*, and this potential is fed via R_5 as a bias to the trigger of tube 1. Being so primed, tube 1 thus strikes on receipt of the first +60V pulse from the input circuit and, because of the presence of the cathode capacitor C_5, reduces the common anode potential, at the instant of firing to approximately + 75 volts. At the same instant, C_3 is holding the cathode of tube *S*, at +60V and with now only 15V across anode and cathode, tube *S* is forced to de-ionize. One input pulse, therefore, has fired the primed tube and extinguished the preceding one.

This process continues progressively throughout the circuit with tube 9 being so connected as to prime tube 0 and, in addition, the carry-forward tube, *CF*. This latter tube, as reference to Fig. 5 will show, is employed in a self-extinguishing circuit which, at each tenth input pulse fires momentarily and drives on the tens counter by one step. The carry-forward tube of the tens counter operates in exactly the same manner and, at each hundredth input pulse, the hundreds counter is driven forward.

Coincidence and Relay Circuits

To signal the completion of any particular batch quantity, it is now necessary to detect the coincidence of three separate +60V potentials; i.e. the cathode potentials of one particular tube from each of the three counting circuits. As will be seen in Fig. 6, a three-rectifier coincidence circuit is employed and it will be apparent that until all three rectifier cathodes are lifted to +50V or above, V_{38} grid is held virtually at earth potential. Since its cathode is at +25V, V_{38} is thus completely cut off and relay *A*, in its anode, is unenergized. When, however, the particular counting tubes to which the rectifiers have been switched by S_1, S_2, and S_3 are all burning simultaneously, i.e. when the required quantity is reached, then all three rectifiers block and V_{38} grid is allowed to rise to +50V. V_{38} now conducts and energizes the batching relay *A*.

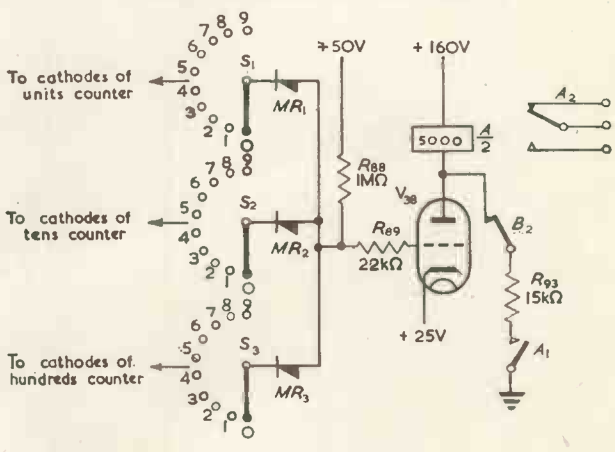
No attempt is made to render the counters inoperative when relay *A* is energized since, if this were done, there would be no check on whether or not the machine had actually cut off at the required quantity. Overrun can quite easily occur in the first designs of fast-feeding mechanisms, but by arranging for relay *A* to hold-on via contact B_2, R_{93} and its own contact A_1, any such overrun is immediately apparent as a difference between the pre-set and the recorded quantities. Without the hold-on circuit, of course, relay *A* would release on the overrun and allow feeding to continue.

Reset Circuit

Resetting, either by the built-in push-button or a remote "make" contact, is effected by removing and then reapplying the H.T. to the counting circuits. Whichever tubes are burning are thus extinguished and as H.T. is restored, the three start tubes strike automatically.

Referring to Fig. 7, it will be remembered that when the

Fig. 6. Coincidence and relay circuits



batch quantity has been counted, relay A is energized by V_{38}. On closing the reset contact, it is now possible to energize relay B, via R_{93}, and its own contact B_1 removes H.T. from the counters. Simultaneously, contact B_2 releases relay A, A_1 opens and thus de-energizes relay B. This sequence of events is quite rapid and the H.T. is interrupted only for a period equal to the sum of the release times of the two relays. Since neither V_{38} conducts nor A_1 is closed until the batch is complete, relay B cannot be energized and hence, the unit reset, by any premature operation of the reset contact.

Power Supply

This follows conventional lines and consists of a selenium bridge rectifier followed by smoothing and a VR150 stabilizer. The H.T. of +160V is taken from a tapping on the anode resistor of the VR150, and while this does not give complete stabilization, it is, nevertheless, adequate for the present equipment.

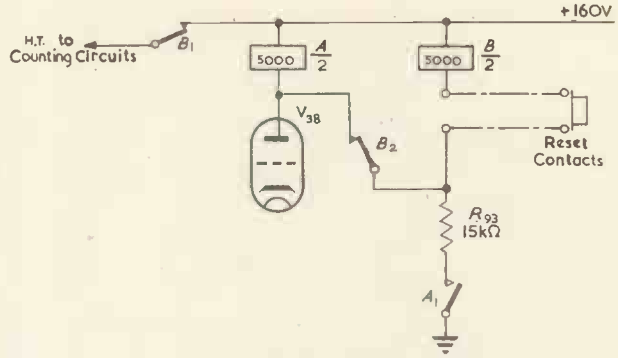


Fig. 7. Reset circuit

Acknowledgments

The author wishes to thank the Directors of Teledictor Limited for permission to publish this article.

A Cold Cathode Batching Counter

By P. E. Tooke*

FOR industrial use, a counter for batching steel components in pre-selected batches, was required to operate at a speed of up to 200 per second. The transfer mechanism used to separate the batches had already been proved satisfactory, but due to the necessity of having to weigh the components against a standard batch, it was decided to develop a faster method of batching.

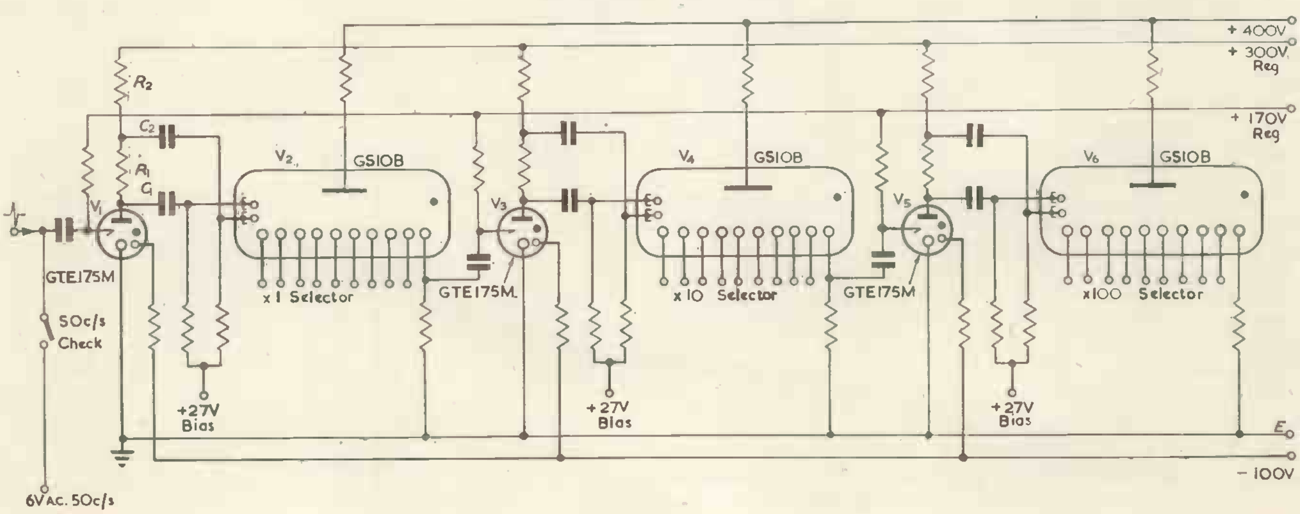
The initiation of the transfer mechanism was simple, a solenoid operating a small clutch was pulled over for a time period of not less than 0·1 sec. During this time however, the counter was required to reset itself and continue counting, as the components were fed at the same rate during the actual separation of the batches, merely being finally fed into different trays.

A design using double triode counters, and several relays was discarded owing to the complexity of the circuit, and its unreliable operation under industrial conditions. A metallic dust laden atmosphere, together with vibration, were two factors that had to be considered. It was necessary for the equipment to be sealed, but in so doing the problem of heat dissipation had to be overcome. It was decided that cold-cathode valves with their rigid electrode structure, and low heat radiation would be advantageous and were, therefore used throughout. The final equipment will run for eight hours continuously, with only a 10° C. rise in temperature.

Three GS10B Dekatron tubes were used, coupled with GTE175M trigger tubes. As these tubes have a maximum counting rate of 550 per second this easily covered the requirement. A 1 267 cold-cathode thyratron was used as the final valve with a relay in the cathode to switch mains for the outpulse. Metal rectifiers, and paper capacitors were used throughout. Selection of the batch number was by means of three front panel switches, each 1-9, with one blank position. These switches were arranged to select units, tens and hundreds, so that a direct reading could be obtained of the number selected. A reset button for manual zeroing, and a mains button for feeding 50c/s

* The Electronic Machine Co., Thornton Heath.

Fig. 1. The counter circuit



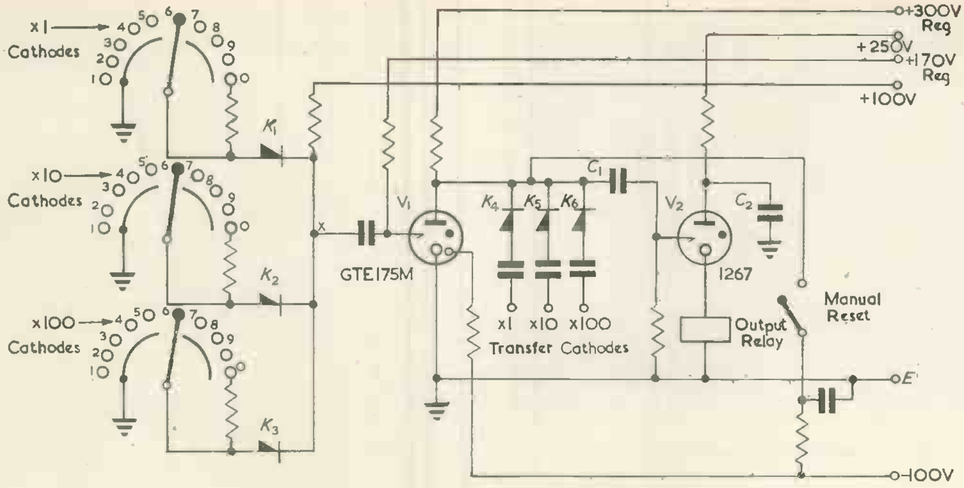


Fig. 2. Selector and reset circuit

into the counter for checking purposes, were all the controls that were thought necessary. The whole unit was contained in a gasket sealed steel case.

The Counter Circuit

Fig 1. shows the counter circuit. The input pulse is fed via a 0·001μF capacitor to the trigger of a GTE175M (V_1). The 170 volt bias on this tube ensures that it will trigger with a positive going pulse in excess of 5 volts, and a duration of not less than 100μsec. The anode of this tube is coupled to the first guides of the Dekatron selector (V_2) through a small capacitor (C_1). The second guides are fed from a tapping on the anode load (R_1 R_2) via a larger capacitor (C_2). When V_1 triggers, both capacitors discharge, and due to the tapped anode load, the negative pulse passed to guide one, is larger in amplitude than that to guide two. Therefore, the glow transfers from V_2 cathode to guide one. On discharge of the capacitors C_1 and C_2, V_1 resets, due to the insufficient current passed by the anode load, which unless supplemented by the discharge of the capacitors, will not maintain the burning voltage. The charging of C_1 and C_2 causes guide 1 of V_2 to become more positive than guide 2, owing to the difference in the time-constants; thereby causing the glow to invest guide 2 until that becomes sufficiently positive with respect to the cathodes, when the glow transfers, completing one count. This occurs until the output pulse from V_2 triggers V_3, which then drives V_4, and so on. Should any cathode of the GS10B's be made negative to all the others, the glow will jump to this cathode. This will then reset the counter to zero if a negative voltage is applied to all the transfer cathodes.

The Selector and Reset Circuit

Fig. 2. shows the coincident gate and reset circuit. The three sliders of the selector switches having been switched to the appropriate cathodes, are each connected to blocking rectifiers MR_{1-3}. A bias is applied to the positive side of these rectifiers, which are also connected to the trigger of the gating tube. Under normal working, the rectifiers pass current via the Dekatron loads R_1, R_2, R_3 However, when the glow rests on a cathode which has been selected, the Dekatron current passing through that cathode load, causes a voltage drop across it which is sufficient to block the rectifier. As there are two other rectifiers passing current, the voltage at point x does not rise until all the selected cathodes have a glow resting on them, then the positive rise at x fires the trigger tube V_1. To give counts of less than 100 or 10, the cathode loads R_1, R_2, R_3 are returned to the blank pin on the selector switch, which in all other positions is earthed by the earthing slider, but open circuits its own rectifier, so allowing only two or one rectifier block before V_1 is triggered.

On V_1 triggering, the negative going pulse at the anode is fed via three rectifiers MR_{4-6} to the 10th cathode of each Dekatron. The negative pulse developed across the load is sufficient to reset these if the anode resistor of V_1 is of the order of 1·5MΩ. MR_4, MR_5 and MR_6 prevent the pulse from the Dekatrons from firing V_1 when the glow is passing the transfer cathode.

Another way of reseting when the counting rate is not so high and therefore the reset time can be shorter, is to apply a separate negative 100 volts to the cathodes of the Dekatrons through a pair of contacts on the output relay. This also has the advantage that when the manual reset is operated it does not fire the output 1267, and so actuate any mechanisms worked by the relay.

V_2 is fired by the pulse from V_1, the coupling capacitor C_1 on discharge resetting V_1 ready for the next batch pulse. A large capacitance (C_2) across V_2 ensures the relay being held on long enough to work a small solenoid. The voltage at the anode of V_2 is also arranged so that on discharge of C_2 the anode voltage has fallen below the burning voltage, thereby resetting for the next pulse.

Power Supplies

The power supplies proved to be very simple and straightforward, hardly any smoothing being required. Two VR150's were used to stabilize the anode supply for the trigger tubes. From the 300 volt regulated supply, two GD86W'S further regulated a 170 volt line for the trigger bias. A 100 volt negative supply for the trigger bias and

Fig. 3. Power supply circuit

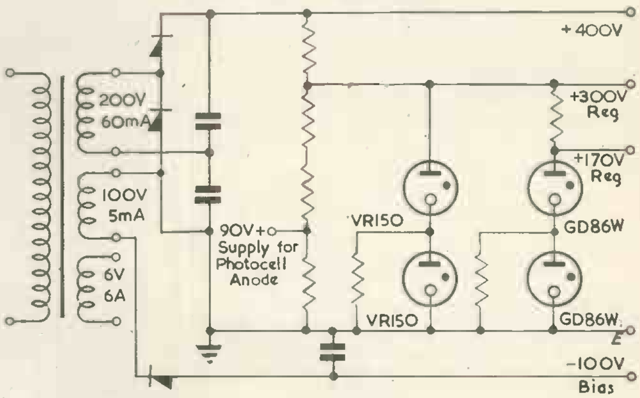


Fig. 4. The batching counter

manual reset was from a separate winding on the transformer, which also had a 6 volt 6 amp winding for the photocell exciter lamp. A bleeder chain across the unregulated 400 volt line supplied the anodes of the 1 267 tubes and photocell. Fig. 3 shows the basic circuit of the power pack.

Performance

In use this counter showed complete reliability, and accuracy of counting. A photocell amplifier, giving a short output pulse, was found to give freedom from jumping and missing counts. The counter input circuit is insensitive to hum pick-up, therefore, a long input lead can be tolerated without elaborate screening. The complete instrument is shown in Fig. 4.

Acknowledgments

Thanks are due to The Electronic Machine Co., of Thornton Heath, for their permission for this article to be published.

LEO

Lyons Electronic Office

An automatic digital calculator has been designed, built and installed for their own use by J. Lyons & Company, Ltd., at Cadby Hall, W.14. It was designed specifically for commercial clerical work and is believed to be the first of its kind in regular use for this purpose. A section of the payroll and cost accounting and stores control jobs are being done regularly each week, and several other jobs are in the preparatory stages. A considerable amount of scientific calculation has also been done over the past two years on contract for Government departments and other bodies.

The original proposal to use an electronic calculator in the office was made in 1947 by a member of Lyons own staff, and in 1949 it was decided to build one based on the Cambridge EDSAC[1]. Dr. M. V. Wilkes, the designer of the EDSAC, made available details of its design. As compared with that machine the principal differences are an increase in the capacity of the store to hold 2048 numbers or orders, and the provision of multiple high speed input and output channels for data and results. Two other minor improvements have previously been described in these pages[2]. Between September 1949 and Christmas 1953 when the installation was finally completed, about 18 months was spent on designing, testing and installing on site the units which were manufactured by Wayne Kerr Laboratories. The rest of the time was spent in designing and testing the input-output circuits and finding ways for making the machine thoroughly dependable.

The calculator itself is seen in the photograph; on the other side of the room are two Ferranti Mark I photo-electric readers for punched tape, and a Hollerith card reader used for data inputs. Output is recorded by a Hollerith type printer and card punch. All wiring to these mechanical units is concealed in under floor ducting. The arrangement of the circuits linking the mechanical units to the calculator cannot be fully described here, but it enables the various data and result channels to operate independently up to their maximum rate if necessary. In this way the machine can deal efficiently with office work, in which the volume of data and results is always large in relation to the arithmetical calculations required, in contrast to scientific work in which the number of data and result figures is much smaller. In fact, the machine can tackle any clerical work which can be reduced to a series of precisely determined arithmetical operations, with provision for wide variations in the procedure to suit the circumstances of particular cases.

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The 220 electronic units of the calculator itself are mounted in 21 enclosed racks. Built-in air ducts at top and bottom remove the heat generated by over 5,000 valves; the cold air duct and the power wiring run under the false flooring. In the background is the monitor desk used for fault-finding. The input and output machinery is in another part of the room.

Slotted Line Impedance Measurements

By E. G. Hamer*, B.Sc.

THE use of slotted lines either of the coaxial or slab types to measure unknown impedances at V.H.F. and U.H.F. is a well-known technique. A measurement of the standing wave ratio, and the shift of the position of a voltage minimum on the line is made when the unknown impedance is connected. The following formula may then be used

$$Z' = R_0 . \frac{1 + K}{1 - K} \quad \text{.................. (1)}$$

where Z' = Unknown impedance.

R_0 = Characteristic impedance of the measuring line.

$K = k \angle \phi$ = Reflexion coefficient.

All the above being complex quantities although for a well-made measuring line R_0 is assumed resistive

$$\text{now } k = \frac{\text{S.W.R.} - 1}{\text{S.W.R.} + 1}$$

$$\phi = 2\Theta$$

where S.W.R. = standing wave ratio,

Θ = Shift of a minimum position.

If the position of a minimum shifts towards the load, when the load is connected, the angle of the reflexion coefficient is negative, and the load is capacitive.

To avoid the constant manipulation of the formula of equation (1), which is somewhat laborious unless a vector slide rule is available[1] a graphical solution may be obtained by the use of Smith charts[2]. These charts give answers of the same or a better order of accuracy than the measurement except in certain instances. Graphical plotting errors are likely to be large if:

(a) The angle of the reflexion coefficient is nearly equal to 0 or ± 180° and the standing wave ratio is greater than 5, particularly in the former instance.

(b) The standing wave ratio is less than 1·4.

These errors may be avoided if the sections of the Smith chart involved are available to a much larger scale (e.g., an expanded chart of the centre of the normal Smith chart).

A small shift of the position of a minimum ($\phi \simeq 0$) usually occurs when measuring impedances whose resistive component is greater than $5R_0$ and which are shunted by a large reactance. An approximate shift of 90° of the minimum position (i.e. $\phi \simeq 180°$) will occur when measuring impedance whose resistive component is less than $R_0/5$ and shunted by reactance.

The former problem is often encountered as the characteristic impedance of measuring lines is low, usually between 50 and 150 ohms. Low standing-wave ratios are encountered when matching unknown impedances to transmission lines or waveguides.

To avoid large errors likely to occur when using the standard Smith's charts in the above quoted instances, and yet avoid the use of the vector equation (1); approximate formula involving scalar quantities only may be employed and these are as follows:

Measuring High Impedances

$$r \simeq R_0 \text{ S.W.R.} \quad \text{.......................... (3)}$$

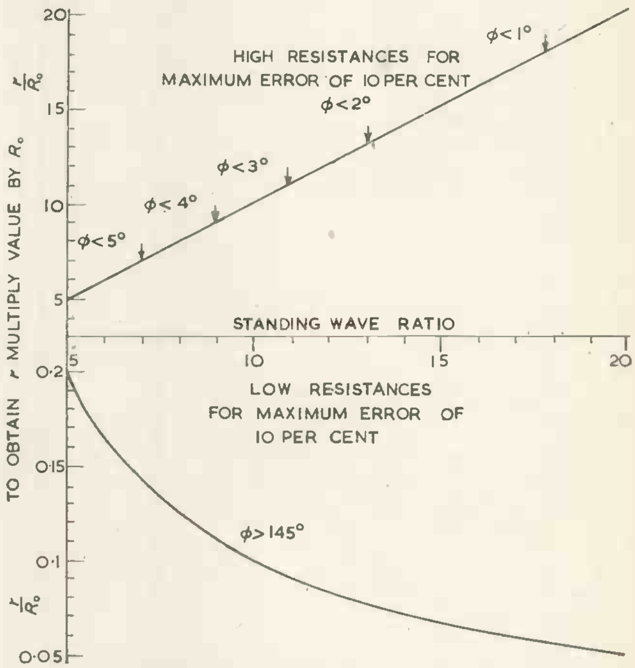
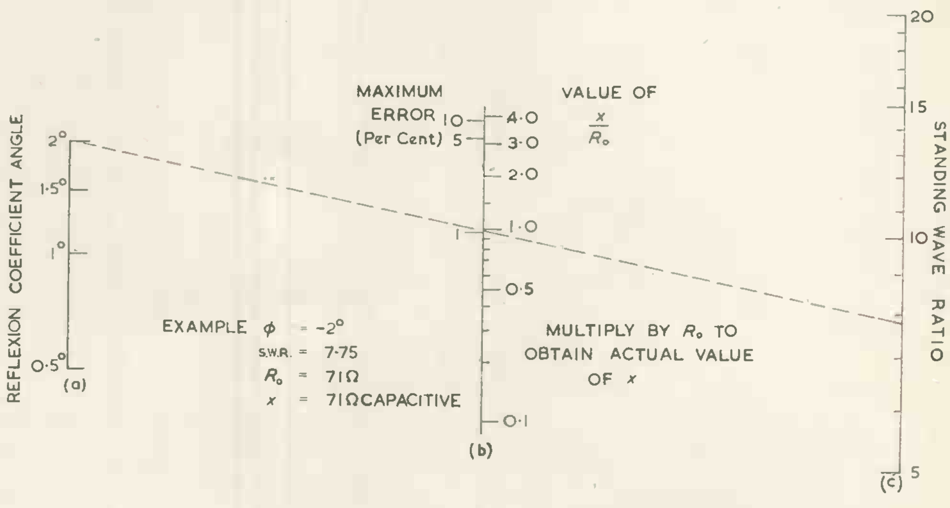


Fig. 1 (above). Graph for obtaining r when S.W.R. is large

Fig. 2 (below) Nomogram for series reactance of high impedances



* *The General Electric Company, Limited, Wembley, England.*

$x \simeq R_0 \sin\phi(\text{S.W.R.}^2 - 1)/2$ .... (4)

for S.W.R. >5 $\phi<2$

Measuring Low Impedances

$r \simeq R_0/\text{S.W.R.}$ .... (5)

$x \simeq R_0 \cdot \frac{1}{2} \cdot \sin\phi$ .... (6)

for S.W.R. >5 $\phi>140°$

Measuring Impedances nearby equal to R_0

$$r \simeq R_0 \frac{\text{S.W.R.} + 1}{(\text{S.W.R.} + 1) - 2(\text{S.W.R.} - 1)\cos\phi} \quad (7)$$

$$x \simeq R_0\, 2 \sin\phi \left(\frac{\text{S.W.R.} - 1}{\text{S.W.R.} + 1}\right) \quad (8)$$

for S.W.R. $<1{\cdot}3$

Where r and x are the series components of resistance and reactance.

The derivation of these formulæ and the limitations on their use are discussed in the Appendix and graphical or nomographic solutions are given in Figs. 1 to 4. In all these graphs and charts the values have been normalized with respect to R_0 the characteristic impedance of the measuring line, and to obtain the actual numerical value of r or x the value obtained from the chart should be multiplied by R_0.

In Fig. 1 the maximum error will be less than 10 per cent if the value of ϕ is less than shown in the various regions for high resistances, and if ϕ is greater than 145° for the low resistance section of the graph.

The nomogram of Fig. 2 is for the evaluation of the series reactance when the total series impedance is large compared to R_0.

The reflexion coefficient angle (scale A) is joined to the standing wave ratio (scale C) and the intersection on scale B gives the value of x/R_0. The intersection on scale B also gives the maximum magnitudes of the error which could be encountered. In the example shown an angle ϕ of 20°, and a standing wave ratio of 7·75 gives a value of $x/R_0 = 1$ with a maximum error of 1 per cent. The maximum error occurs for the larger value of ϕ; and for smaller values of ϕ the error is less for the same intersection on scale B.

For all the nomograms a negative reflexion coefficient (i.e., minimum moves towards load) corresponds to a capacitive reactance. Figs. 3 and 4 are nomograms for S.W.R. less than 1·3 and are used by joining scales A and C and obtaining intersections on scale B. The errors are as shown on scale B for Fig. 3, and the error has a maximum value of 25 per cent and occurs for a S.W.R. of 1·3 and $\phi \simeq 0°$ or 180°.

It must, however, be remembered that at these low S.W.R. unless precision calibrated and corrected equipment is being used the inherent errors of measurement may be greater than 25 per cent.

Again it must be emphasized that the range of the nomogram scales has been selected to keep the errors to a reasonable order of magnitude, and the scales must not be extended in any direction.

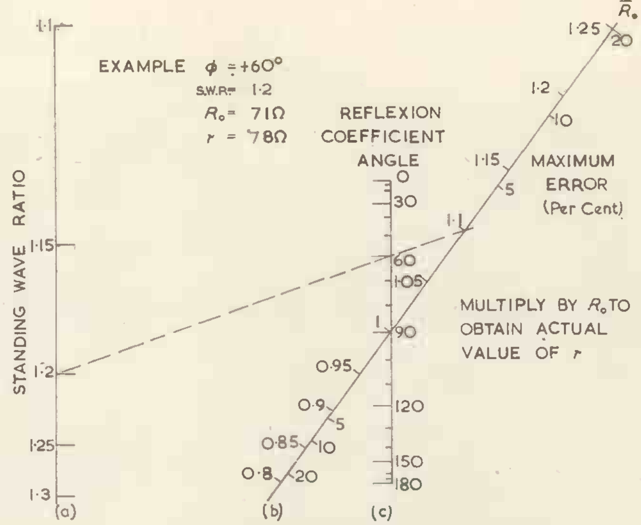


Fig. 3. Nomogram for series resistance for S.W.R. < 1·3

Appendix

$$Z' = R_0 \frac{1 + K}{1 - K} = R_0 \frac{1 + k\,\angle\phi}{1 - k\,\angle\phi}$$

$$= R_0 \frac{1 + 2\,j\,k \sin\phi - k^2}{1 - 2\,k\cos\phi + k^2} \quad (2)$$

High Impedance Case

here we assume $\phi \simeq 0°$ and hence $1 - 2\,k\cos\phi + k^2$

$\simeq 1 - 2\,k + k^2$

$r \simeq R_0\,(1 + k)/(1 - k) = R_0$ S.W.R. .... (3)

$x \simeq R_0\; 2\,k \sin\phi/(1 - k)^2$

$\simeq R_0 \sin\phi \,.\, (\text{S.W.R.}^2 - 1)/2$ .... (4)

Now these approximations are only justified for certain values of ϕ and k and the nomograms and graphs must not be extended or these limits will be exceeded. The maximum value of the error is shown on the appropriate range of the charts.

Low Impedance Case

Here we assume $\phi > 140°$ and hence $1 - 2\,k\cos\phi + k^2$

$\simeq 1 + 2\,k + k^2$

$$r \simeq R_0 \frac{1 - k}{1 + k} \simeq \frac{R_0}{\text{S.W.R.}} \quad (5)$$

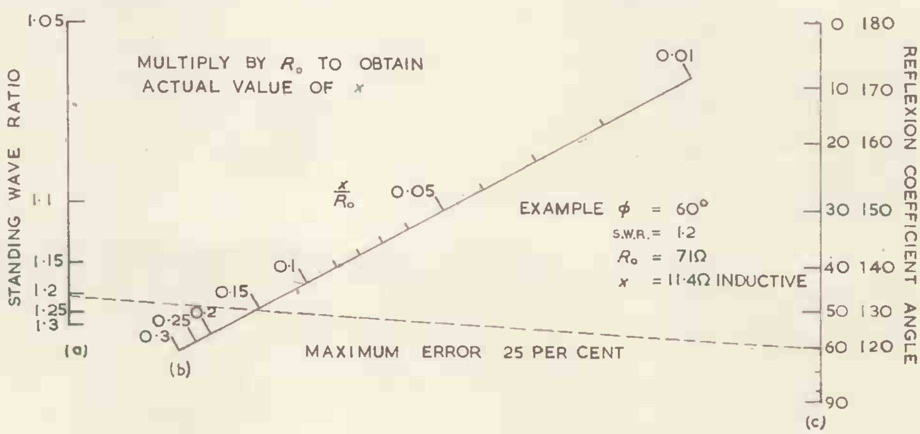


Fig. 4. Nomogram for series reactance for S.W.R. < 1·3

$$x \simeq R_0 \frac{2k \sin\phi}{(1+k)^2} \simeq R_0 \frac{\sin\phi}{2}\left[1 - \frac{1}{\text{S.W.R.}^2}\right]$$

and if S.W.R. > 5 we may neglect the $1/\text{S.W.R.}^2$ term

$$x \simeq R_0 \frac{\sin\phi}{2} \quad \ldots\ldots\ldots\ldots\ldots (6)$$

The maximum error is of the order 20 per cent.

LOW STANDING WAVE RATIO CASE

If S.W.R. < 1·3 the k^2 term may be neglected and

$$r \simeq \frac{R_0}{1 - 2k\cos\phi}$$

$$\simeq R_0 \frac{\text{S.W.R.} + 1}{(\text{S.W.R.} + 1) - 2(\text{S.W.R.} - 1)\cos\phi} \quad \ldots (7)$$

for the evaluation of x the $k^2 + 2k\cos\phi$ term may be neglected, and the maximum error will be 25 per cent over the range considered. This error may seem large from a mathematical viewpoint; but considering the practical difficulties of measuring accurately low standing wave ratios, and shifts of minimum at these low S.W.R., the mathematical errors are likely to be less than the errors of measurement.

Then $x \simeq R_0 2k \sin\phi$

$$\simeq R_0 2 \sin\phi \left(\frac{\text{S.W.R.} - 1}{\text{S.W.R.} + 1}\right) \quad \ldots\ldots\ldots\ldots (8)$$

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The Noise Performance of Television Receivers

By T. S. McLeod*, M.A., A.M.I.E.E.

Noise in television receivers is due to man-made interference, cosmic noise, and circuit noise, in that order of importance. Consequently performance depends chiefly upon the position and directivity of the aerial used, and input circuits are of secondary importance.

THERE are at present a great many television receivers in areas where the field strength of the signals is between 50μV/metre and 200μV/metre, and the quality of entertainment which they provide depends largely upon the aerials and input circuits that they use. The noise performance of high frequency receivers has received considerable attention in the last decade, a recent treatment being that of Hamer[1], and the purpose of this article is to discuss the points that in particular apply to the television receiver. This suffers seriously from man-made interference, to some extent from aerial or cosmic noise, and in some cases from receiver noise, and the object of design must be to reduce to a minimum the ratio of the total of these three to the received signal.

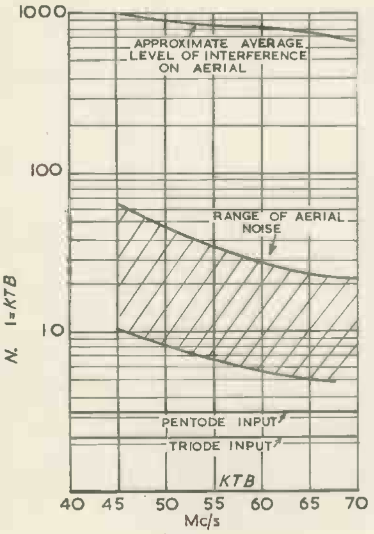

Fig. 1. Comparative noise power

The levels of the pentode and triode inputs shown in the diagram are 4·2 and 2·2

Man-made Interference

The most important single source of man-made interference is motor car ignition. This produces a wide band of radiation, part of which is picked up directly on the television aerial. The remedy is to mount an aerial of good directional properties as far as possible from a main road, and as high up as possible so as to increase the strength of the wanted signal. Buildings may provide a measure of screening, and it sometimes helps to turn the aerial slightly away from the transmitter if this also turns it away from the road. This is because the directional pattern is flat around its centre and the sides fall away sharply. Interference from domestic electrical appliances may be reduced in the same way.

Fig. 1 shows the comparative noise power due to the three sources mentioned. The level of interference shown is 10 to 15db below that described by Hamer[1] as being exceeded for one minute in every hour on average in England. The fluctuations in interference level are very large, and it seems reasonable to assume that for much of the time, particularly in the evening, levels will be at least as low as this, and that they will sometimes be much lower. It is clear, however, that this type of noise is much more

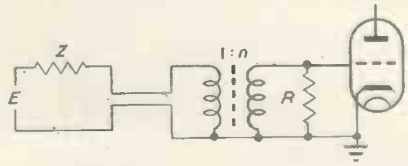

Fig. 2. Standard Input Circuit

* *Cottage Laboratories Ltd.*

serious than the others, and the essential problem of long range television reception is to reduce it to a minimum.

Aerial Noise

This consists of high frequency radiation believed to come from the stars, and it varies considerably with time, season, and the part of the universe at which the aerial is pointing. It will be seen from Fig. 1 that it is more important at the lower end of the television band, and at all frequencies varies by 7 or 8db.

The only protection is to use an aerial of good directional properties: any other means of reducing cosmic noise reduces the desired signal by the same amount.

Input Circuit

Standard British practice is to use an aerial with an impedance of 50 to 100Ω connected to the set by a cable of similar impedance[2], and to feed it to the grid of a high slope pentode through a step-up transformer[3]. Such an aerial may be represented as a constant voltage source in series with its characteristic impedance[4], so that the circuit can be represented as shown in Fig. 2. It may be shown that the voltage developed across the grid:

$$E_g = \frac{nER}{n^2Z + R}$$

(neglecting cable losses)

In practice it is difficult to achieve a value for n greater than 2 or 3, and under these conditions the greatest voltage is developed across the grid for the highest value of R. When R is infinite the voltage gain is 6db greater than that when the cable is matched, and it will presently be seen that the receiver noise figure will also be 6db better. It will be shown that this improvement will rarely have any appreciable effect upon overall performance, and will simply make it unnecessarily difficult to achieve an adequate input bandwidth. Most manufacturers compromise with a value of R of about $4n^2Z$, say 3 300Ω, which gives a gain and noise figure within 2db of the open circuit values, and yet provides a moderate match to the cable and makes it fairly easy to get an adequate bandwidth.

Receiver Noise

The noise produced in the receiver comes from four separate sources. The resistance R acts as a noise source of power kTB, k being Boltzmann's constant, T the absolute temperature, and B the receiver bandwidth. This will be developed across the transformed aerial impedance n^2Z, and will be small compared with valve noise. The valve noise is made up of shot noise due to fluctuations in cathode emission, partition noise due to random partition of the current between screen and anode, and transit time noise due to induction of voltages in the cathode grid circuit by fluctuations of the current between them. The effect of shot noise may be represented by a resistance of

$$R_s = 2{\cdot}5/g_m$$

in series with the grid lead, producing a voltage

$$E_s = \sqrt{4kTR_sB}.$$

Partition noise may similarly be represented by a resistance:

$$R_p = \frac{20i_{sg}}{g_m{}^2} \times \frac{i_a}{i_a + i_{sg}}$$

where i_a and i_{sg} are anode and screen currents of the valve. Transit time noise is effectively damped out by the transformed aerial impedance, and may be neglected.

To quote an example a valve of the CV138(8D7) type will have equivalent noise resistances of 400Ω for shot and 800Ω for partition noise, so that its total equivalent noise resistance is 400Ω when it is used as a triode and 1 200Ω as a pentode.

Moxon[5] has shown that the noise figure of a valve in the circuit shown is:

$$N_r = 1 + r_a/R + R_n/r_a\ (1 + r_a/R)^2 \quad \ldots\ldots (1)$$

where R_n is the equivalent noise resistance of the valve, and r_a the transformed impedance presented by the aerial at the grid. For $n = 3$, $Z = 75$ ohms and $R = 3\,300\Omega$ we have:

$N = 4{\cdot}2$ for a pentode
$N = 2{\cdot}2$ for a triode.

Overall Noise Figure

It is convenient to express both interference noise and cosmic noise in the same way as receiver noise by the multiple by which each exceeds the value of kTB, the theoretical minimum noise power to be found in a circuit at normal temperature. Then it may be shown that the overall receiver noise figure:

$$N = N_I + (N_A - 1) + LN_r \quad \ldots\ldots\ldots\ldots (2)$$

where L is the loss factor in the aerial feeder expressed as the ratio of available signal power at the aerial to that at the receiver, and N_I and N_A are the interference and aerial noise figures. It must be remembered that while receiver and cosmic noise are continuous, interference is intermittent, and its importance depends upon the duration as well as the amplitude of the bursts in which it comes. Circuits which clip peaks and cannot be paralysed, and synchronization that is hard to upset, reduce the disturbing effects on the viewer of occasional interference, and the figure taken for N_I should therefore be well below its peak value.

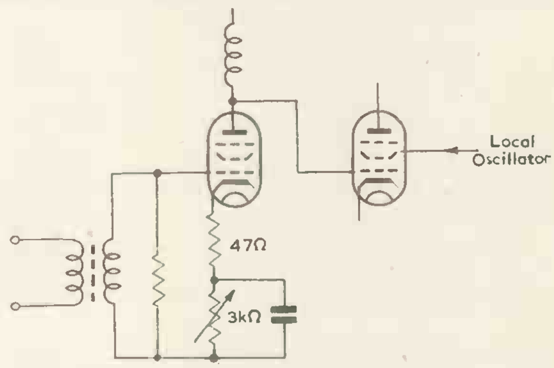

Fig. 3. Typical early stage of television receiver

Fig. 1 taken from values given by Hamer[1] and Moxon[5] for N_I and N_A shows that they will normally be much larger than LN_r, so that the input circuit of the receiver will be unimportant. Even in positions exceptionally free from interference N_A will usually be as high as 20 at 45Mc/s, and with a feeder loss of 2 (100ft of Uniradio 32) the difference between a pentode and a triode input will only be 28·4 against 24·4; less than 1db. At 66·75Mc/s aerial noise is appreciably lower, say $N_A = 10$, and the advantage of a triode over a pentode will be nearly 2db.

It is now possible to see how much feeder attenuation can be increased before receiver noise compares with interference, and thus to determine how far it is possible to reduce total noise by moving the aerial to a good position. Suppose that the receiver is close to a main road and that the interference noise level is about a figure of 1 000. If the aerial can be moved to a point some distance from the road, and screened from it by buildings, the interference level may well fall to a tenth of its previous value. If this requires 300ft of cable with a loss of 10db the contribution of receiver noise will be increased accordingly, and in place of:

$$N = 1\,000 + (N_A - 1) + 4{\cdot}2$$

we have:

$$N = 100 + (N_A - 1) + 42$$

The improvement will be 8 or 9db.

It will be noticed that the only effect of a pre-amplifier close to the aerial will be to decrease the value of L in equation (2), and that this will only be useful when L is exceptionally high or N_I and N_A exceptionally low. In all cases the use of a triode instead of a pentode input is equivalent to the improvement due to moving a pentode input 100ft closer to the aerial.

Unnecessary Noise Sources

The early stages of a typical British television receiver[3] are shown in Fig. 3. The following points should be noted.

1. The 47Ω resistor in the cathode lead, placed there to reduce the effect of valve changing on the input circuit tuning, will increase the noise factor of the valve by 1db.
2. Reduction of the valve gain by the biasing control will further increase its noise factor, probably by about 3db for a gain reduction of 6db.
3. Unless the first stage has a gain of 16db or more the local oscillator noise will contribute appreciably to the overall receiver noise figure. This point may seem elementary, but the writer has experience of a popular commercial receiver in which the gain control precedes the local oscillator, and in a good service area the first stage acts as an attenuator. Local oscillator noise can always be seen on the screen.

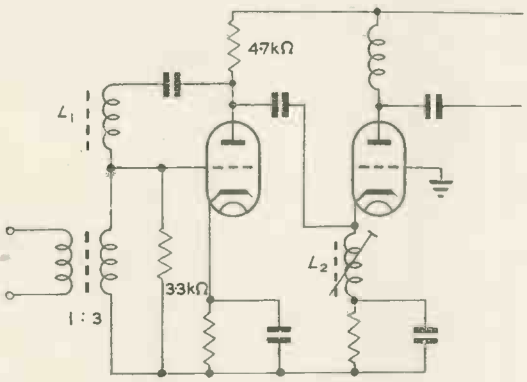

Fig. 4. Low noise input circuit
(L_1 and L_2 tune parallel strays at carrier frequency)

A Low Noise Input Circuit

It will be appreciated from what has been said that a special low noise input circuit is only justified when interference is low and feeder attenuation high. In these circumstances it may give an improvement in performance of 2 or 3db, and the circuit shown in Fig. 4, designed for use in Newcastle (for reception from Holme Moss), has received favourable reports.

Conclusion

1. The noise performance of a television receiver depends chiefly upon the position and directional properties of the aerial.
2. A pentode input is satisfactory, but it should be used at full gain in areas where the signal is weak, and should feed the mixer stage at a level adequate to swamp local oscillator noise.
3. Pre-amplifiers and special low noise circuits are of value only under exceptional conditions.

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New V.H.F. Broadcasting Transmitters for B.B.C.

In connexion with their plans for the introduction of V.H.F. sound broadcasting in this country, the B.B.C. have placed an order with Standard Telephones and Cables Ltd., for their latest type of Frequency Modulated Very High Frequency Broadcasting Transmitters. The order calls for twelve 10kW Transmitters type C.F.4 and twelve 1kW Transmitters type C.F.2.

These transmitters embody all the latest principles and practices of modern design. An important feature is an entirely new approach to the system of transmitter control ensuring the high standard of reliability essential to unattended Remote Controlled operation.

At each station, twin transmitters will be used for each programme so that either transmitter can be switched off without interrupting the service.

The B.B.C. has also placed an order with Marconi's Wireless Telegraph Co., Ltd., for the construction of 26 V.H.F. Frequency Modulated transmitters.

These transmitters, of Marconi design, comprising 24 of 4½kW power and two of 10kW, will form part of the B.B.C.'s plan to provide a powerful reinforcement to the coverage of its present medium and long wave stations, by the use of V.H.F. F.M. stations.

As envisaged, the 4½kW transmitters will operate in parallel pairs, each pair handling one programme. Thus, six of these transmitters will be used on each three-programme station. The two 10kW transmitters will be used in parallel at the B.B.C.'s existing V.H.F. station at Wrotham, where there are already two 25kW Marconi transmitters.

Nine Marconi station monitors have also been ordered by the B.B.C. for use on this project.

The Marconi transmitters, comprising units of basically similar design, but suitably arranged to provide the various output ratings, operate on the frequency-band 87·5-108Mc/s.

Air-cooled valves are used throughout, leading to a simplification of equipment, with reduced installation and maintenance costs.

The F.M.Q. drive unit used on these transmitters, employs a frequency-modulated quartz crystal, and supplies an output at the carrier-frequency. This signal is then amplified to raise it to the required output level, the number of amplification stages used depending on the rated power-output of that particular type of transmitter.

The initial R.F. amplification stages consist of a double tetrode stage, capacity coupled to a pair of tetrode valves, the anode circuits of which take the form of quarter-wave balanced lines magnetically coupled to a 50 ohms line, from which the output is taken at 250W.

A third amplifier stage is added (in this case a triode), for the 1kW equipment. The input is fed via the 50 ohm line to the cathode, the two cathode leads being at the same R.F. potential and forming the inner member of a tuned unbalanced line. The grid is grounded, and the anode circuit takes the form of a concentric line whose electrical length is varied by moving an R.F. short-circuit along the line. A tuned inductive coupling takes power from the anode line and feeds to the aerial termination.

For the 4½kW transmitter a further identical triode amplifier stage is added, while for the 10kW case yet another amplifier stage is used, employing two such arrangements in parallel.

A Time Base Oscillator

By C. H. Banthorpe*

MOST sawtooth voltage generators, or time-bases, have some particular merit, and it is sometimes difficult to decide which type is best for a particular application.

The sawtooth voltage generator for the line time-base of a television receiver should generate a voltage increasing linearly with time, have a short flyback time, be adjustable in frequency without a change of amplitude, lock readily to sync pulses, be unaffected by interference, and be reliable, simple and cheap.

A circuit which fulfills most of these requirements to a very high degree has already been described[1], but seems to have been little used so far.

Fig. 1 shows the basic circuit, the action of which is as follows:

When the circuit is switched on C_1 will have no charge, therefore g_1 of V_1 will be at earth potential. g_1 of V_2 will be at a positive potential with respect to earth, and its cathode potential will rise until it is just above g_1. Because the cathodes of V_1 and V_2 are connected together V_1 will be biased well beyond cut-off. As C_1 is connected to H.T.+ by means of R_1 it will become charged and the potential across it will rise exponentially, the rate of rise being determined by C_1, R_1, and the H.T. potential. At some instant the potential on g_1 of V_1 will be sufficiently high to cause V_1 to take some anode current. When it does its anode potential will fall, causing g_1 of V_2 to fall also.

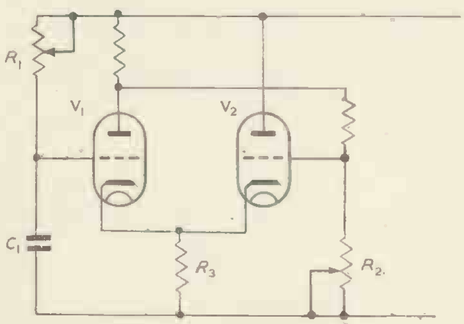

Fig. 1. Basic time-base circuit of Webb and Morgan

As V_2 takes less current, its cathode potential will fall, also the cathode of V_1, which is thus made to take much more current. This action is cumulative, the switch of current from one valve to the other being very rapid indeed. At this point g_1 of V_1 is positive with respect to its cathode and it will therefore take grid current which will discharge C_1. When C_1 is sufficiently discharged, V_1 will take less anode current, its anode potential will rise, g_1 of V_2 will rise and the potential of both cathodes will rise. V_1 will thus take still less current, and its anode potential will continue to rise. This action is also cumulative and the original state is reached with V_1 cut off and V_2 taking current. On the second and all subsequent cycles, however, C_1 does not commence to charge from a fully discharged state, as V_1 does not completely discharge C_1. R_2 is a convenient amplitude control and R_1 will control the frequency without a change of amplitude.

A negative pulse can be obtained across R_3 and a positive pulse can be obtained from the anode of V_2 if a resistor is connected in the anode circuit.

These pulses are useful for trace brightening or flyback blanking.

This circuit has already been used successfully as part of a divider chain[2], and has also been used by the author in a line time-base for a considerable time, with satisfactory results. Like the blocking oscillator and self drive line time-bases, it is remarkably free from the effects of noise and provides a picture with clean vertical edges.

If a time-base is adjusted so that it requires a large sync pulse, then it will be practically free from the effects of noise or interference from sync source, but the free running speed will be very much slower than when locked and the amplitude will be greatly increased. This can cause serious trouble if a television receiver is operating with no signal due to station breakdown or shut down, or aerial or receiver failure, particularly if the E.H.T. is obtained from the flyback.

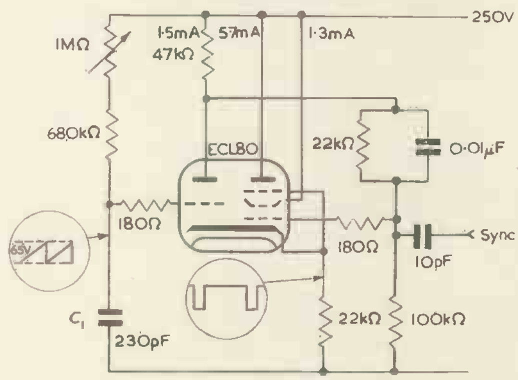

Fig. 2. Final circuit of line time-base oscillator

In the oscillator described the change of frequency and amplitude when the sync is removed is very small; less than 10 per cent. Fig. 2 shows the final circuit used as a line time-base oscillator. A standard modern valve is used for the purpose, and it is operated well within its ratings.

If other frequencies are required they may be obtained by changing the value of C_1 only, and the amplitude will remain constant. This feature is extremely desirable in oscilloscope time-bases and the circuit would appear to be particularly suitable for this purpose. It will operate over a very large range of frequencies and is easily locked.

* (*Derwent Television*), (*Central Equipment Ltd.*)

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Short News Items

The Royal Society of Arts have issued a list of the successful candidates in the Society's Industrial Art Bursaries Competition for 1953. In all 232 candidates entered from 60 schools and industrial establishments. A record number of 18 bursaries was awarded amounting in value to £2 400, which compares with £2 225 in 1952, and brings the total sum awarded in these competitions since 1946 to £11 740. In addition to their bursaries 9 winners will also be eligible for Associate Membership of the Society.

The German Industries Fair will be held in Hanover from 25 April to 4 May. Full details may be obtained from Schenkers Ltd, Shipping and Forwarding Agents, 27 Chancery Lane, London, W.C.2, who are the official agents in the United Kingdom.

The Scottish Committee of the Council of Industrial Design is holding a Design Congress on 26 and 27 May in the Assembly Rooms, Edinburgh. The theme of the Congress will be the promotion of design as a high level responsibility in industry, commerce and the public services, and a distinguished panel of speakers will be presented.

The Institution of Electrical Engineers held their annual dinner at Grosvenor House on 25 February when the President, Mr. Harold Bishop, was in the chair. The principal guest, Field Marshal the Rt. Hon. the Earl Alexander of Tunis, Minister of Defence, proposed the toast of "The Institution," to which the President replied. The toast of "Our Guests" was proposed by Colonel B. H. Leeson (immediate past-president), and the reply given by Sir Ian Jacob (Director-General, BBC).

EMI announce that, following his election as their representative on the Council of the Radio Communication and Electronic Engineering Association, Mr. S. J. Preston has now been elected Vice-Chairman of the Council.

The Swiss Post Office recently ordered three Emitron microwave links and these are to be augmented by a further three complete units. They will be used in connexion with the Anglo-European interchange of television programmes recently announced. Emitron links, which are employed by the BBC, are used to relay outside television broadcasts from location to the main transmitter.

Marconi Instruments Ltd, St. Albans, have increased the productive capacity of their Longacres works by the opening of a new factory wing. Several sections have been reorganized and a new design centre provides improved facilities for the company's engineers.

The BBC announces that the contract for the first stage of the building work at the new London Television Transmitting Station at the Crystal Palace has been placed with Higgs & Hill Ltd, Crown Works, South Lambeth Road, London, S.W.8. They also announce that contracts for the provision and erection of the masts for the transmitting aerials at the permanent medium power television stations at Rowridge (Isle of Wight), Pontop Pike and North Hessary Tor (South Devon), have been placed with British Insulated Callender's Construction Co. Ltd. Similar contracts for the provision and erection of masts for the permanent and medium power television stations at Divis (Northern Ireland) and Core Hill (near Aberdeen) have been placed with J. L. Eve Construction Co. Ltd.

The Joint Commission on Electron Microscopy is sponsoring an International Conference in its subject. At the invitation of the Electron Microscopy Group of the Institute of Physics, this will be held in London from 16-21 July this year. The Inaugural Meeting will be held at Senate House, University of London and the scientific meetings will be held at the London School of Hygiene and Tropical Medicine, Malet Street, London, W.C.1. The registration fee will be £2 for full members, £1 for friends accompanying them and for research students. All communications should be addressed to the Conference Joint Secretaries, Dr. C. E. Challice and Mr. F. W. Cuckow, c/o The Institute of Physics, 47 Belgrave Square, London, S.W.1.

The Council of The Institution of Civil Engineers announce that they have appointed Mr. Alexander McDonald as Secretary of the Institution, to succeed Mr. E. Graham Clark, C.B.E., who will be retiring this year.

Pye Ltd. have provided Keith Prowse with a mobile radio booking office, the first of its kind in the world. It is a 25cwt van, equipped as a ticket agency and is connected with the company's central clearing house by two-way V.H.F. radio. This mobile radio booking office will be going daily to markets, race meetings, sporting events and other similar gatherings.

Erratum. On page 131 of the March issue, in the description of the Capacitor Power Factor Measurement manufactured by Viduna Instruments, "150 to 150pF" should read "150 to 1 500pF".

PUBLICATIONS RECEIVED

READERS' GUIDE TO BOOKS ON RADIO AND TELEVISION is number 22 of a new series of select bibliographies now being published by the County Libraries Section of the Library Association. Each Guide is compiled by a librarian in co-operation with a recognized authority on the particular subject concerned. They may be purchased from the Honorary Secretary of the County Libraries Section of the Library Association, County Library, Widemarsh Street, Hereford, at 10d. a copy, plus 2d. postage. If over three copies are ordered, the price is 5d. a copy.

A HANDBOOK ON DIE CASTINGS has been prepared at the request of, and is issued by, the Advisory Committee (Die Casting) of the Ministry of Supply. While the publication was intended primarily as a Service handbook, the Committee considered the contents would be of considerable interest to industry. Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2, price 6s.

HOW TO TROUBLESHOOT A TV RECEIVER discusses how to find the cause of trouble in a television receiver in the shortest time. Part of the presentation includes lists of the equipment, tools and accessories required for receiver servicing. John F. Rider Publisher, Inc., 480 Canal Street, New York 13, N.Y. Price $1.80.

THE STRUCTURE AND MECHANICAL PROPERTIES OF COPPER-MANGANESE-TIN ALLOYS is a booklet recently issued by the Tin Research Institute. It describes a range of new alloys which may be useful in the fields hitherto served by nickel silver. The publication gives detailed information on the properties of a wide range of compositions and indicates how compositions and methods of treatment may be varied to give strength, colour or deformability, etc., as may be required. International Tin Research and Development Council, Fraser Road, Perivale, Greenford, Middlesex.

SUPPLEMENT NO. 1 TO RAGOSINE MOLYBDENISED LUBRICANTS describes new grades of molybdenum disulphide lubricants covering dispersions in water, volatile fluids and lubricating oils. The leaflet also mentions for the first time "Molysil" greases which combine the stability of silicone with the low coefficient of friction of molybdenum disulphide. Ragosine Oil Co. Ltd., Ibex House, Minories, London, E.C.3.

WIGGIN NICKEL ALLOYS NO. 22 contains articles on precision casting of the Nimonic alloys, uses of Monel in electric motors, fine bore tubing in nickel and high-nickel alloys, uses of Inconel in a submerged combustion device, exhaust valves in Nimonic 80 and fusion cutting of high-nickel alloys. Copies of this journal are obtainable, free of charge, from Henry Wiggin & Co. Ltd., Wiggin Street, Birmingham, 16.

ALDEN'S HANDBOOK gives the overall designs and components to build electrical or electronic equipment using plug-in unit construction. Alden Products Company, 117 North Main Street, Brockton, Massachusetts.

COURS PRATIQUE DE TELEVISION is a booklet for all technicians, engineers and students who are interested in the workings of a televisor and its installation. Editions Techniques et Professionnelles, 18 bis, Villa Herran, Paris 16.

BULGIN COMPONENTS is a catalogue of electrical and electronic components of interest to traders, factors, manufacturers and amateurs. This edition has been completely revised and redesigned to facilitate the location of components and the reading of data. Price 1s. post free. A. F. Bulgin & Co. Ltd., Bye Pass Road, Barking, Essex.

R.E.C.M.F. EXHIBITION PREVIEW

A description of selected exhibits at the Exhibition of the Radio and Electronics Component Manufacturers Federation to be held in the Grand Hall, Grosvenor House, Park Lane, London, W.1, from April 6–8.

(Figures in parenthesis refer to Stand Numbers.)

Advance Components Ltd. (11)

ON this stand will be shown the company's range of signal generators, attenuators and constant voltage devices.

The items that are of particular interest this year will be a Signal Generator Type D.1/D which is a new version of the existing instrument Type D.1 and has now been modified so it is directly calibrated, showing also for the first time will be a U.H.F. Piston Attenuator Type A.57 which is the same as that used in Signal Generator Type L.1.

The attenuation range is 126db. The attenuator drive spindle rotates through 270° between extreme attenuation settings.

A crystal diode is built into the output of the attenuator together with a non inductive capacitor, so that the output voltage can be read directly if a calibrated microammeter is connected to the tags provided. A 75 ohms resistor (non-inductive) is inserted between the output socket and the crystal diode, so that for practical purposes the output presents a source impedance of 75 ohms.

Advance Components Ltd,
Shernall Street,
London, E.17.

Avo (111)

THE range of this Company's products is today so wide, that it is impossible to show very much more than the latest developments.

Of particular interest this year is the new "AVO" High Voltage D.C. Multiplier, and the "AVO" Valve Tester Type 160, a new pan-climatic, simple-to-use Valve Tester. This is illustrated above.

The Automatic Coil Winder & Electrical Equipment Co. Ltd,
Douglas Street,
London, S.W.1.

Bulgin (46)

MANY or all of the standard products of this company are now specially made in materials and finishes to special specifications (such as RIC/1000, RCS/1000, etc.) where such is called for and also in general "Tropical" versions, civil grade.

The wide range of components has been extended and among the new products are the Bulgin "PolyMicrO" units, groups of up to 12 standard Bulgin Miniature Micro-Sensitive Switches ganged between brackets, with rotary-cam operation by shaft, and with or without indexing of positions, for manual or mechanical drive. These provide robust mains selector-switches of high rating, small size, for a life of ½-million or more operations.

A. F. Bulgin & Co. Ltd,
Bye Pass Road,
Barking, Essex.

Cosmocord (76)

THE main feature of the Acos stand will be the latest "Hi-g" series of pick-ups and pick-up cartridges which are designed to track with ease any modulation that is ever likely to be engraved on a gramophone record. A complete series of cartridges and pick-up heads will be shown including cartridges suitable for incorporating into any of the latest, and most of the older, types of gramophone units. Illustrated above is the Acos HGP.35-1 pick-up head.

Also on show on the Acos stand will be the latest addition to the new range of microphones for use with tape recorders, public address systems, etc.

Cosmocord Ltd,
Enfield, Middx.

Daly (105)

THE Daly range of electrolytic capacitors has been further extended in the three main fields of Television and Radio, Specialized Electronics and A.C. Motor Starting. In all three, sizes have been reduced and characteristics improved particularly as regards operation at extreme temperatures. (−40°C. to +85°C.)

Many new types have been added to the Television class offering capacitance values up to 300μF in single compact units. The Daly Twist Prong single and multiple miniature units with international standard fixing, now cover a large variety of capacitance and working voltage values.

Daly (Condensers) Ltd,
West Lodge Works,
The Green, Ealing,
London, W.5.

Dawe (73)

TWO new instruments will be exhibited by Dawe. They are:

(1) Type 1408 Sound Level Indicator. This is a very compact model, covering the range 40 to 130db. and provides a simple means of comparing the intensity of similar sounds and making preliminary investigations—for example, determining the best siting of P.A. loudspeakers in difficult locations, etc.

(2) Type 1101 Ultrasonic Thickness Gauge (*illustrated above*). Demonstrations will be given of this new model gauge used for the measurement of thickness of materials by means of high frequency sound waves. It has been especially developed for application where one surface only is accessible.

The range of measurement is from 1/16 in. to 12 in. of steel with an accuracy of ±3 per cent.

Special crystal units can be supplied to improve the accuracy of measurement on curved surfaces.

Dawe Instruments Ltd,
99 Uxbridge Road,
Ealing, London, S.W.5.

Dubilier (69)

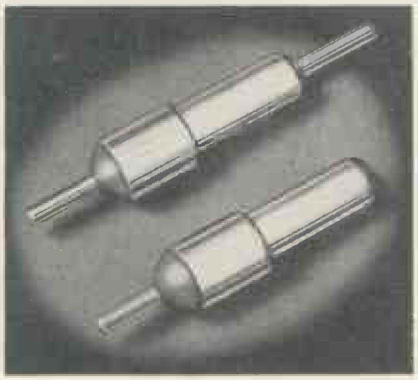
IN addition to Drilitic, Electrolytic, Nitrogol Paper, Moulded Stacked and Silvered Mica Capacitors, the following will be exhibited.

1. An entirely new range of High K ceramic dielectric varnish protected tubular capacitors for general radio frequency application and a new type of fully-sealed metal encased tubular High K ceramic capacitor in both stand-off and bushing forms, which at frequencies even in excess of 150 Mc/s still act as capacitors. This latter form is suffi-

ciently well sealed to meet Class H.2 requirements of the Joint Service Specification.

Illustrated are stand-off and bushing capacitors in this range.

2. Super tropical paper tubular capacitors—4800C range—capable of meeting Joint Service Specification Grade A (100°C.) Class H.1 (84 days' tropical



exposure) and R.I.C. Specification Red Grade. These capacitors have sustained without failure an endurance test exceeding 3 000 hours at 100°C. with working voltage applied.

3. Duconol Capacitors for A.C. application, fitted into aluminium containers, which are sealed by a special process novel in capacitor manufacture. The design and manufacturing process of these capacitors has enabled substantial reductions in weight and dimensions to be made whilst providing for a higher working temperature than has been possible hitherto.

Dubilier Condenser Co. (1925) Ltd,
Victoria Road,
North Acton, London, W.3.

Electrothermal (88)

ELECTROTHERMAL Engineering Limited are exhibiting their range of Valve Retainers to which a number of new types have been added. Noteworthy are the new Valve Retainers Cat. No. VRA.6 and 7 for miniature valves without anodes, and a Valve Retainer to be used with the new Top Cap Connector Cat. No. TC/4 for miniature valves with anode.

The "Precistor," a high stability wire-wound resistor with the unique stability of 0·1 per cent, is also on show, together with the new wiring jigs for B7G and B9A valve holders.

Electrothermal Engineering Ltd,
270 Neville Road,
London, E.7.

AB Metal Products (33)

ON this stand will be exhibited the Clarostat Range of Composition Element Potentiometers incorporating the Clarostat Stabilized Element.

New, also, will be Clarostat Series KS "Standee" above-chassis mounting power resistors, mounted vertically by one fixing above the chassis. The heat is allowed to dissipate in a harmless manner and the terminals protrude through the chassis for ease of wiring.

A comprehensive range of rotary switches in standard and miniature sizes, with ceramic and S.R.B.P. insulation will be displayed together with the Minibank Switch which still holds pride of place as the smallest Multi-Pole Switch in the world.

AB Metal Products Ltd.,
16 Berkeley Street,
London, W.1.

Belling-Lee (55)

THE "Belling-Lee" range of components and accessories for the Electronics, Radio and Electrical Industries has been further strengthened by the introduction of new lines and the redesign of some established lines. Hard gold plating has been added where appropriate.

The general purpose instrument fuse-link, L.1055 is now manufactured by an entirely new technique which bonds caps, glass and filament into one unit, caps being so securely held that they will not come off unless the glass is broken. Average ratings are from 60mA to 25A.

A new range of six fuseholders for Inter-Service use has been developed, and in addition to the existing types of sealed and neon indicating versions, forms a very comprehensive range.

Screened plugs and sockets with 4, 6 and 12-way assemblies have been introduced. Assemblies are interchangeable with existing screened coaxial types.

Belling & Lee Ltd.,
Gt. Cambridge Road,
Enfield, Middx.

Berco (28)

THREE new components of outstanding interest to manufacturers of electronic and allied equipment will be introduced. They are:—

1. The Berco Rotary Regavolt continuously variable transformer, toroidally wound and having a brush rotated by a knob. Made in two sizes, 0·8 and 2 amp rating, they will be the smallest variable transformers available in this country and, therefore, can be built into electronic equipment (*illustrated*).

2. A range of five sizes of toroidal-wound power-type Rheostats 20-100

watts rating. The outstanding characteristics are:—

(a) All Porcelain construction.
(b) Windings embedded in Vitreous Enamel.
(c) Use of Silver Graphite as a brush contact.
(d) A wide range of accessories to provide ganged assemblies and ventilated cases are available.

3. A range of three plastic-moulded collet fitting knobs.

The British Electric Resistance Co. Ltd.,
Queensway, Ponders End,
Middlesex.

Erie (15)

THE already wide range of Erie temperature compensating ceramicons has been still further expanded by the introduction of two new sizes of tube, and the introduction of the well-known Erie type-approved phenolic insulation as an optional finish.

The expansion of the existing range of tubular units, together with the introduction of miniature disks, is intended to meet the demands of manufacturers who are designing round the recently announced plans for F.M. and multi-channel television at very-high- and ultra-high-frequencies.

Allied to the above, and to meet the demands for top-end coupling, oscillator-coupling, and similar functions calling for small values of capacitance with very close tolerances, Erie have introduced the "Gimmicon" and the Type K.A. ceramicon, of which the common features are a capacitance range of 0·5pF to 10pF, and a standard tolerance of ±0·1 pF to ±0·2pF. The prices of these units, by virtue of highly mechanised production, are considerably lower than any other close tolerance ceramicon hitherto produced. The "Gimmicon" is fully insulated and extremely small in size, and, the Type K.A. ceramicon is non-insulated, but slightly larger; both having relatively large diameter axial leads.

Erie Resistor Ltd.,
The Hyde,
Hendon, London, N.W.9.

Ferranti (16)

AMONG the new products on this stand is a range of 3cm and 10cm TR cells. Their characteristics are as follows:

TTR.31. A tunable Q T.R. Cell for use with ⅞in. diameter circular waveguide. Frequency Range 9 100-9 900 Mc/s. Band width 5Mc/s. Handling Power 50kW peak.

TTR3.31MR and TTR.31MC. Tunable medium Q T.R. Cells for use with standard American waveguide (TTR. 31MR) or ⅞in. diameter circular waveguide (TTR.31MC). Frequency Range 9 100-9 900Mc/s. Band Width 25Mc/s. Handling Power 50kW peak.

Ferranti, Ltd.,
Hollinwood, Lancs.

Goodman (12)

A NEW type of Permanent Magnet Focusing Unit will be on show. This unit, which employs new features in picture focus and shifts, is being used by British Television manufacturers and is now available to the home constructor.

There are three constructions applicable to this design, type 12/44, 14/44 and 16/44, all of which utilize the new Ferroxdure magnetic material that has the advantage of high resistivity, enabling the units to be positioned close to the deflector coil without affecting the performance of the set.

Goodmans Industries will also be showing an omni-directional sound diffuser Model C.D/77. This unit houses a high flux permanent magnet 10in. loudspeaker and has provision for an internal line transformer.

A small version of the C.D./77 type C.D./66, has been developed and will also be on show. This unit houses a high flux permanent magnet loudspeaker.

Goodman Industries Ltd.,
Axiom Works,
Wembley, Middlesex.

Hunt (44)

RECENT developments include a range of Electrolytic Capacitors of high-ratio anode construction, approved to new Inter-Service standards RCS134 issue 3 and RCL134 Addendum Issue 2; special types for Television applications; for High Temperature operation and miniature Electrolytic tubulars for diminutive apparatus.

In miniature metallized paper capacitors the midget W99 is now available for use up to 85°C. Thermetic-cased midgets are for operation from −100°C to +120°C.

New developments in Mica construction are Miniature Stacked Foil and Silvered types.

A. H. Hunt (Capacitors) Ltd.,
Bendon Valley,
Garratt Lane,
Wandsworth, London, S.W.18.

L.E.M. (42)

IN addition to the range of L.E.M. protected silvered mica from 1pF up to 2μF, there is now the new "Catacon" range of moulded silvered mica capacitors. These are fully Inter-Service approved to the 40/100 H1 Specification. Types CMM1-G and CMM3-Y cover the Ministry Specification RCL.132 up to 10 000pF and a range of moulded filter extends the range up to 250 000pF.

The Type 1106 sub-miniature "sintered" type silvered mica has been designed to meet stringent requirements of stability in circuits where small size and high performance are essential.

The range of F.E.C. ceramic capacitors now covers temperature compensating types for 1pF to 500pF and in tolerances as low as $\pm\frac{1}{4}$pF, and a range of High K Tubes and Disks for up to 200Mc/s. These are especially suitable for inclusion in television receivers.

London Electrical Manfg. Co. Ltd.,
Beavor Lane,
Hammersmith, London, W.6.

Mullard (65, 108, 109)

A RANGE of AM/FM valves for VHF broadcast receivers will be shown for the first time. Included in the range are VHF double triode, type ECC85; a triple-diode-triode EABC80, for use in ratio detectors; a versatile triode-heptode, type ECH81; and a high-slope (6·5mA/V) variable-mu, RF pentode EF85. These valves lend themselves to a variety of circuit arrangements, thus making possible the efficient and economical reception of both AM broadcasts, on the lower frequencies, and FM broadcasts on the very-high frequencies (i.e. 87·5-100Mc/s).

Junction triodes will be shown for the first time. The OC10, OC11 and OC12, are intended for circuit experiments, while the OC70 and OC71, which are hermetically sealed in glass, are high-gain, high-stability types. Two point-contact transistors, the OC50 and OC51, will also be shown. In these, the contact spacing has been varied to give markedly different characteristics.

New hermetically sealed germanium diodes include the OA71 and CV448, with high back resistance, and the high efficiency RF detector OA73/CV442.

The new OA70 television detector and the OA61 D.C. restorer and pulse clipper will also be shown.

Mullard Ltd.,
Century House,
Shaftesbury Avenue,
London, W.C.2.

Multicore (66)

A NEW exhibit on this stand will be an automatic soldering head designed for repetition soldering processes of small parts.

Solder drawn from a 7lb. reel is automatically fed above the components to be soldered and an electrically-heated iron automatically descends and solders the components concerned. The standard iron supplied has a long-life 80 watt element and a minimum temperature of 300°C at the end of a 2in. long (adjustable) bit, $\frac{3}{8}$in. diameter. Alternative size bits and irons can be supplied to special order.

The machine will accommodate any diameter of Multicore Solder between 13 and 19 s.w.g. and feed any length of solder between 1/32in. and $\frac{3}{4}$in. per movement. This new machine, designed and produced by Multicore Solders Ltd., Hemel Hempstead, Herts, can be supplied in three models. One model is supplied with no motive power so that it can be linked with an existing manufacturing process. Another is supplied complete with a bench and a foot-operating pedal (*illustrated*), whilst the third model is a motorized version which will make joints at the rate of up to 3 000 per hour.

It should be emphasized that these machines are intended for manufacturing processes involving soldering and are not suitable for radio servicing.

Multicore Solders Ltd.,
Maylands Avenue,
Hemel Hempstead, Herts.

Mycalex (86)

"MYCALEX" is the trade name for patented Glass Bonded Mica insulation manufactured from glass and mica compounded under heat and pressure. It is supplied either as a finished article moulded to shape, or in sheets and rods machined to requirements.

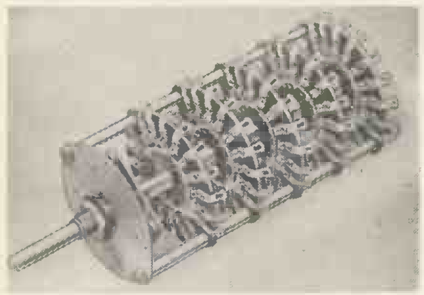
Recent developments have resulted in an insulator with greatly improved electrical qualities. This will be marketed under the name of "Mycalon." The power factor has been reduced to 0·001.

Illustrated is a range of moulded components made from "Mycalon."

Mycalex Co. Ltd.,
Cirencester, Glos.

NSF (61)

NEW products include the 18 position type DL (*illustrated*) and the nylon type NDH wafer switches, a tandem dual



concentric spindle carbon track volume control type CP3 and miniature pre-set carbon potentiometer type CP9. Both these latter items have been specially developed for television receivers.

NSF Ltd.,
9 Stratford Place,
London, W.1.

Painton (27)

AMONG the 1954 New Range of Painton Components are the following units.

The New PW2 Series of Midget 2-watt Wirewound Potentiometers. Generally for RCL121 Type approval, with the progressive feature of a split collet spindle locking device which is integral with the mounting bush.

The full "Bembridge Series" of Knobs is shown for the first time, the design based on the already proven studio control knobs as used by the B.B.C.

Extending the existing range of Painton Push-Button Switches is the introduction of a heavy duty push-button switch with provision for panel sealing if required.

Painton & Co. Ltd.,
Kingsthorpe,
Northampton

Plessey (67)

A NEW and interesting television component is the Multi-Channel Tuner, designed to cover frequency bands I and III. This tuner, of the turret type, can be used to select any number of channels, up to a maximum of 12, within the two bands, covering the International television channels for export television requirements and also the proposed home commercial TV range. It thus makes adequate provision for any future increase in Channel availability in Band III for home use.

Among television components a new development in high insulation scan coil technique is the polythene insulated high impedance coil which is of particular value in "direct drive" circuits. In conjunction with this component are two designs of E.H.T. transformers of the "direct drive" type giving a range of 9-14 kV EHT. The application of the Schade type of linearity control to direct drive circuits has resulted in the attainment

of a horizontal linearity figure of the order of 5 per cent, and the development of a new frame circuit design has resulted in a similar order of linearity in vertical scan.

The illustration shows Line-EHT Scanning Transformers with the conventional auto-transformer design on the right and a new design for direct drive on the left.

The Plessey Co. Ltd., Ilford, Essex.

Steatite (54)

NEW materials shown include Faradex H, a stable high permittivity ceramic (K=3200), for by-pass capacitor manufacture; this ceramic has a very small variation of permittivity over the whole temperature range called for in Services requirements.

Another new ceramic at present available in limited quantities is Frequentite S, a steatite-type material of extremely low dielectric loss ($\tan\delta < 0{\cdot}0002$). The mechanical properties and absolute freedom from porosity of this material renders it particularly suitable for vacuum applications, e.g., for envelopes of UHF valves, magnetron windows, etc.

Steatite and Porcelain Products Ltd., Stourport-on-Severn, Worcestershire.

Stocko (99)

THE "Stocko" range has expanded over the past years due to the ever-increasing demand for intricate pressed and draw work required by the radio and electronic industries.

Standard items include, eyelets, single and double-ended eyelet tags, flat solder and contact tags, wired caps, end caps, wired eyelets, fluted caps, ferrules, pillar lugs, etc.

Stocko (Metal Works) Ltd., Queensway, Ponders End, Middlesex.

Stratton (10)

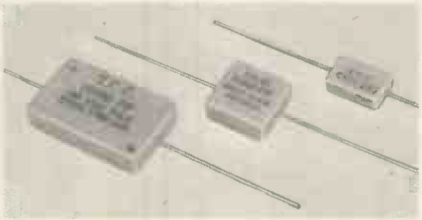
A NUMBER of new components have been introduced, and attention is drawn to the Cat. Nos. 551, 552 and 553 Miniature Microdensers which will undoubtedly have many applications in compact VHF equipment. There is also a new range of I.F. and Discriminator Transformers, whilst the range of Knobs has been increased.

Stratton & Co. Ltd., Alvechurch Road, Birmingham 31.

T.C.C. (17)

IN order to comply with the requirements of Inter-Services Specification RCS.132 Category 40/100, H.1, Moulded "Plimoseal" Silvered Mica Capacitor has been introduced. This method of protection not only prevents the ingress of moisture, it also improves the insulation resistance and power factor, without impairing the inherent stability of the capacitor unit. This series, which is illustrated, conforms in every way to RCL.132 and will ultimately be available in all capacitances and sizes quoted therein.

The latest addition to the Hi-K Ceramic Group are the Miniature Lead-Through Capacitors which will be of especial interest to designers of TV receivers for Bands III/IV. They have a capacitance of 1 000pF, and are in-



tended for soldering on to a chassis or sub-assembly.

A new range of Metallized Polystyrene Capacitors is now available in Tubes and Metal Cans which has considerably enlarged the scope of these condensers.

For capacities of $0{\cdot}005\mu F$ up to $0{\cdot}5\mu F$, a tubular construction is usually adopted: above that metal cans with glass terminals are used.

The Telegraph Condenser Co. Ltd., North Acton, London, W.3.

TMC (26)

AN innovation this year will be a display of capacitors covering the complete equipment requirements of a portable Radar station. Among the various types shown will be, at one end of the range, H.T. capacitors for 7kV D.C. working, housed in welded steel cases, while at the other end will be so-called "Blister" types for circuit de-coupling, bulking no larger than a cubic inch.

Polystyrene capacitors, continuing to find new fields of exploration, will be represented by specimens of the standard range and of a new range developed for A.C. working. New case styles and mounting methods, that keep pace with the new circuits that go with Polystyrene, will be shown including samples of the "Potted Circuit" technique and its application to composite Polystyrene capacitor blocks.

Telephone Manufacturing Company Ltd., Hollingsworth Works, Dulwich, London, S.E.21.

Telcon (78)

TO the well-established range of Telcon helical membrane coaxial cables has now been added a duplicate series of 50 ohm coaxials, together with a new 75 ohm cable of 1¼in. diameter—the HM.7.A1.

Further work has been carried out on the design and development of screened quad cables for television relay systems and other new exhibits include a cable with a corrugated outer conductor and another showing an extruded screen of resistive material.

Telegraph Construction & Maintenance Company Ltd., Telcon Works, Greenwich, London, S.E.10.

United Insulator (8)

U.I.C's range of products has been added to this year by some unique designs in chassis furnishings which offer scope for new applications, saving space and money. Other new items include an I.F. Transformer Former in low loss ceramic, and several additional ranges of Fuses.

Two new materials will be on show: "Unilite" the new low-loss insulator especially produced for R.F. applications and "Unilain" the new high-grade porcelain, particularly suitable for high stability resistor formers.

Also on show is U.I.C's range of metallized terminals which are now being produced by a recently developed nickelizing technique.

United Insulator Co. Ltd., Oakcroft Road, Tolworth, Surbiton, Surrey.

Welwyn (58)

NEW components on this stand will include the following:

(1) "Panclimatic" range of cracked carbon resistors which have an improved protective lacquer, giving an excellent performance under tropical conditions.

(2) A resin encapsulated form of cracked carbon resistor which provides an insulated component.

(3) Metal film resistors in the conventional tubular form.

(4) Toroidally wound Potentiometers for power applications.

(5) Ceramic Terminal Seals in the Inter-Services range of approval sizes.

(6) Resin Encapsulated Precision Wire Wound Resistors.

Welwyn Electrical Laboratories Ltd., Bedlington Station, Northumberland.

BOOK REVIEWS

Circuit Theory of Electron Devices

By E. Milton Bone. 483 pp., 120 figs. Demy 8vo. Chapman & Hall Ltd. 1953. Price 68s.

SO many books have been written on radio engineering and electronics that there is a tendency to say "What, another!" and to look to see whether a new book gives a fresh approach to established theory or contains new material. The chief recommendation for this book is that it contains a 50-page chapter on transistors though this does not go beyond the scope of popular articles in the technical press. The rest of the book deals with telecommunications component circuits in no new way, and covers much the same ground as many well established American textbooks.

Chapter I, on diode and triode valves, contributes a somewhat verbose introduction and some sentences have to be re-read to get the real meaning. For example on page 5, di_b/de_b is constant and equal to the variational conductance of the element. It would be preferable to substitute "A.C." for "variational." On page 10, surely the third electrode does not permit the "free passage of the electrons through the spaces between the grid wires"; its potential controls and restricts the number passing through. The student may find the introduction of $\sqrt{2}$ in expressions on page 29 confusing; if it is felt necessary to refer to maximum values a special symbol is available and recognized. Fig. 1.21 does not agree with the text, the A.C. peak voltage is 4 volts in the diagram and 2 volts in the text. The load eclipse should be shown as tangential to the negative peak grid line and not cutting it. Apart from the equivalent circuit and load line treatment of the triode valve, there are two pages on photosensitive devices. Tetrodes and pentodes are the subjects of Chapter II. Little need be said about the next two chapters on voltage and power amplifiers. Push-pull operation and negative feedback are examined; there is also a section on video frequency amplifiers. For the chapter on "Gas filled tubes" the author very wisely starts from the high vacuum diode and points out in the text that the diode has a saturation current for a given value of heater voltage; unfortunately this is in conflict with the valve characteristic (Fig. 5.1) used to illustrate it. Some reference to the indeterminate action of oxide coated cathode would have put this in perspective. Single and three phase rectifiers are dealt with next, and again we find evidence of carelessness in preparation of diagrams. Fig. 6 1 c. and d. look much the same apart from the delay time of the "gas tube" and yet the i_b, e_b characteristics are quite different. The scale of Fig. 6.1e has been made to fit the diagram after the latter was drawn so that O to π is about 30 per cent greater than π to 2π. The analysis of the power efficiency of the half-wave rectifier would have appeared much simpler had the author used the fact that power input is the product of the R.M.S. input of secondary voltage and the R.M.S. fundamental component of current, i.e. $(E_m/\sqrt{2})$ $(I_m/2\sqrt{2})$.

Tuned R.F amplifiers (narrow and broad band) are considered in Chapter VIII. It is important to avoid confusing critical coupling with the coupling (sometimes called optimum) giving maximum voltage output from coupled tuned circuit. The two are not identical when primary and secondary Q factors are unequal and critical should be reserved for the coupling just avoiding double peaked response. Passing mention is made of wide band coupled circuits and to their improved frequency response and gain, but there is no reference to their greater overshoot to a transient. Chapters IX and X are concerned with R.F. power amplifiers and oscillators. Fig. 10.5 is another example of badly executed diagram I_p and I_L vectors are repeated and the lengths changed in the process.

After modulation and demodulation have been dealt with, we come to the last chapter on transistors.

K. R. STURLEY

Kempe's Engineers' Year Book 1954

1345 and 1413 pp. Crown 8vo. Two volumes (in case). 59th Edition. Morgan Bros. (Publishers) Ltd. Price 75s.

THE fifty-ninth edition of this book which has just made its appearance is noteworthy in that the whole of the book has been rewritten and reset in a new type face.

Every chapter except one, which is waiting further deliberations by the British Standards Institution on the particular subject, has received a major revison and a vast amount of additional matter has been introduced so that many of the existing chapters are virtually new.

There are eight new chapters, bringing the total number up to 79, and with every justification the publishers can claim that every aspect of mechanical, civil and electrical engineering is covered in these two volumes.

It is, of course, beyond the capabilities of a single reviewer to comment on the book as a whole but "Kempe" has been so long with us—it was first published in 1894—that as a source of reference it is a "must" for the engineer's bookshelf. It is a remarkable tribute to its longevity that at least three generations of engineers have been brought up on "Kempe."

The chapter entitled "Radio Communication" in the earlier editions has been completely revised and now appears under the heading "Electronic Engineering" which is more in keeping with the times and is indicative of the way in which this particular branch of engineering is expanding. The reader will find much that is missing in this chapter but this is in no sense a criticism for electronic engineering is now such a vast subject that to give adequate treatment would take up the whole of the available space in Kempe and no doubt this applies equally well to the other principal subjects dealt with.

The best possible use is made of the 24 pages allocated to electronic engineering, but no more than a brief survey can be made with a pause here and there to emphasize a particular facet.

Methods of Theoretical Physics

By P. M. Morse and H. Feshbach. Part 1, 998 pp., 153 figs. Part II, 980 pp., 75 figs. Royal 8vo., McGraw-Hill Book Co., Ltd. 1953. Price £12.

THIS magnificent treatise has been in preparation for over eight years and represents the achievement of two professors of physics in the Massachusetts Institute of Technology. The primary purpose of the work is to present a detailed exposition of the mathematical processes which have proved to be most effective in the calculation and analysis of the many kinds of fields encountered in modern physical theory. It provides an extensive account of the methods available to physicists for finding the particular solutions of certain partial differential equations of field theory which correspond to prescribed boundary conditions.

The work occupies two volumes. The first volume begins with a discussion of the properties of scalar and vector fields and their representation in various coordinate systems. This leads to a comprehensive treatment of the mathematics of field theory. The subjects introduced include vector analysis, tensor calculus, dyadics, quaternions, spinors, and the spacetime manifold of special relativity. In the second and third chapters the more important partial differential equations of theoretical physics are derived. These include the wave equation, the Laplace, Poisson, Helmholtz, Klein-Gordon, Schroedinger, and Dirac equations and the equations of Maxwell. Special consideration is given to the process of abstracting the most important interrelations from physical phenomena and representing them in the form of differential equations. The technique is introduced by way of a one-dimensional problem which is thoroughly investigated before the reader is exposed to the more difficult cases of wave-motion in elastic media, the motion of fluids, and the electromagnetic field. The equations of quantum mechanics are discussed in detail and the connexions between various phenomena in classical and quantum physics are outlined. The third chapter indicates the relation between the equations of field theory and the variational principle of Hamilton.

The following six chapters are devoted to the strategy of analysis. Beginning with an account of function theory and transformation calculus they proceed to an elaborate study of the differential equations previously introduced and the analytical properties of their solutions. The emphasis of these chapters is on the determination of the particular combination of solutions, from all possible solutions, which satisfy the boundary conditions of a specific problem. An exhaustive treatment is given of the techniques of separable co-ordinates, expansion in eigenfunctions, and Green's function. The topic of mathematical representation concludes with a discussion of the significance of the integral equation formulation of boundary value problems and a survey of approximate methods.

The remaining four chapters deal with the application of the more advanced techniques to specific problems of modern theoretical physics. The authors' primary concern is that of analytical method; the reader is assumed to possess a reasonable knowledge of the relevant physics.

The work has been executed on a lavish scale and considerable care has been given to details of presentation. Each chapter concludes with a table summarizing the salient results, a group of problems to be worked by the reader, and a list of references. The diagrams employed to illustrate three-dimensional phenomena are presented as stereoscopic pairs. If these are viewed with the eyes relaxed at infinity, they are seen in relief without the need for a stereoscope. A selection of tables for use in numerical computation is given in the appendix. The appearance and quality of the books are of the high standard now expected of the publishing house whence they come.

There can be little doubt that this work will quickly establish itself as a standard treatise on the methods of theoretical physics and become a necessary part of the equipment of those engaged in fundamental physical research.

S. R. DEARDS

Principles and Practice of Radar

By H. E. Penrose and R. S. H. Boulding. 795 pp., 500 figs. Royal 8vo. 4th Edition (revised). George Newnes Ltd. 1953. Price 50s.

IN this revised edition, the introductory chapters on the basic principles of radio practice have been summarized, and now form a single chapter. The space saved has been used to amplify those parts of the book which experience has shown to be of most practical use to students, operators and technicians. The section dealing with actual equipments has been enlarged. In addition to the B.T.H., Sperry, Kelvin-Hughes and Liverpool Harbour radars, sections on the Decca, Cossor and Marconi radars are now included, together with a section on airfield control radar. A new chapter on radar test gear has been added.

Television Antennas and Converters

By Allan Lytel. 118 pp., 65 figs. Demy 8vo. John F. Ryder, Inc., New York. 1953. Price $3.50.

THE purpose of this book is to explain in simple terms the function and operation of U.H.F. conversion systems in America. Emphasis is placed not only on the convertor systems but also on the antenna structures and transmission line systems. No involved mathematics have been included and every effort has been made to use circuits and descriptions that are useful and practical.

Probability and Information Theory, with Applications to Radar

By P. M. Woodward. 128 pp., 20 figs. Post 8vo. McGraw-Hill Book Co., Inc., New York. Pergammon Press Ltd., London. 1953. Price 21s.

THE first three chapters of this monograph deal respectively with Probability Theory, Waveform Analysis and Information Theory, and give remarkably lucid introductions to these subjects. Each of these chapters might well be read for its own sake, though intended as an introduction to the later parts of the book.

Chapter IV applies statistical methods to the problem of reception, and is applicable both to radar and communication. The function of an ideal receiver is to form from the received signal the distribution of probabilities of the set of possible messages, and this process is analyzed. Results are derived which have a bearing on the design of receivers for amplitude modulation. A valuable feature of the treatment is that it takes account of the effect of unknown signal parameters, which would arise, for instance, if the signal underwent an unknown attenuation due to fading. The effect on reception of a noise level differing from that for which the system was designed is also briefly considered.

In Chapter V are derived the characteristics of a radar receiver giving the greatest possible amount of information regarding range and presence or absence of a target. In Chapter VI radar information is analyzed and expressions derived for the information gain of a radar system. Chapter VII deals mainly with the problem of resolving two targets which differ only slightly in range or velocity. Resolution depends on the waveform of the transmitted signal, and the theory Chapter VII might reasonably be expected to yield an expression for an optimum waveform. No such expression has been derived, however, for the problem is a complex one.

Apart from its value to designers of radar systems, the book is of more general interest because it describes an application of Information Theory to observation, as distinct from communication. The idea of information as a measurable quantity lies behind the reasoning in the three chapters dealing with radar, even though it is only in one section of Chapter VI that a measure of amount of information appears as a term in the equations. Elsewhere in these chapters the ideas of Information Theory are used in ensuring that signals are subjected only to information-preserving transformations. It seems likely that Information Theory will prove applicable to other systems of observation and measurement.

The book is mathematical in nature, with 375 equations in 125 pages, but it is remarkably lucid and readable. An understanding of differentiation, integration and some properties of complex numbers is required of the reader. Taylor's Theorem is used on pages 18 and 103, Undetermined Multipliers on pages 25 and 54, and Bessel Functions on pages 77 and 97, but no knowledge of the properties of the last named is needed to follow the reasoning.

A. M. ANDREW.

Soft Magnetic Materials for Telecommunications

Edited by C. E. Richards and A. C. Lynch. 346 pp., 60 figs. Demy 8vo. Pergamon Press. 1953. Price 63s.

THE appearance of this book is somewhat deceptive; it is not, as its format and title might suggest, a general reference book on soft magnetic materials, but contains the papers presented at the Conference on Soft Magnetic Materials held at the Post Office Research Station, Dollis Hill, in April, 1952. Most of the thirty-five papers included are specialist papers and together cover a wide range of subject matter, but the Conference is not distinguished by any paper making a major contribution to the theory or practice of ferromagnetism. As only a few of the papers are likely to be of permanent interest to an individual, the book is not likely to be purchased privately but is mainly for reference libraries.

The problem of classifying the material is very difficult; the publisher's courageously attempt the task by saying "Several papers deal with each of the following topics:—Magnetic after-effects and losses in alternating fields; various observed types of non-linearity, especially in ferrites; use of X-rays in studying the crystal structure of powder cores and grain oriented alloys. Study of surface layers on high-permeability materials; study of rectangular loop materials and their applications; performance at high frequencies of ferrite material."

Some of the papers of more general interest to the engineer include one by Greig and Shurmer on iron losses with two superimposed excitation frequencies; a paper by De Barr and Frost-Smith on instrument transductors, in which they suggest a figure of merit for cores, taking into account permeability, sharpness of saturation and linearity, and also indicate the value of employing a composite core constructed of two different magnetic materials; and Randall and Scholefield's paper on the effect of cold reduction and heat treatment on 50/50 and 80/20 nickel irons. McFarlane and Mole's paper on the properties and applications of silicon-irons contains much useful information, but most of it is readily available elsewhere. The paper by Bates, Davies and Harper deals with the measurement of A.C. iron losses using a calorimetric method—a method likely to be more widely employed in future as a result of the work of this school, now that a way is shown of avoiding most of the difficulties previously associated with calorimetric measurements.

The book also contains a paper by Kersten, who presents a modification and extension of his theory of initial permeability, and a short paper by Néel on the reduction in permeability at high frequencies due to the domain structure.

L. R. BLAKE

Technique de la Television

By A. V. J. Martin. 296 pp., 380 figs. Demy 8vo. Editions Radio, Paris. 1953. Price Fr.1080.

THIS book should prove of value to all those interested in the working and development of television. Written by the Editor of *Television*, the theory and technique of the subject are discussed, together with future plans for the expansion of the French television network.

Microwave Lenses

By J. Brown. 125 pp., 55 figs. Crown 8vo. Methuen & Co. Ltd. 1953. Price 12s. 6d.

THIS recent addition to the list of Methuen's Monographs on Physical Subjects presents a concise survey of a specialized branch of Radio Engineering which has in the last few years been the subject of much interest and controversy on both sides of the Atlantic. This book is a well balanced critical account and will do much to stimulate the interest and may settle some of the controversy.

The author has appreciated that many of his readers will need to revise their knowledge of physical optics before being able to appreciate the finer points of lens design, and the first three chaptors cover the essential principles upon which the behaviour of the dielectrics used in lenses, and the design of such lenses, depend. Chapters IV and V deal with artificial dielectrics of the "delay" and "phase advance" types, and, as well as giving a very readable introduction to the theory of the mechanism of such dielectrics, provide a useful amount of design information in the form of families of curves connecting geometrical parameters with refractive indices. The chapter on "Wide Angle Scanning" illustrates an application in which the advantages of lenses are exploited to the full, and the more specialized chapters covering such topics as the optics of non-homogeneous media and configuration focusing may well point to the direction in which future developments will lie.

The final chapter on "Lens Aerials" suggests approaches to design procedures and also amounts to a very fair summing up of the pros and cons of lenses compared with mirrors. Such an assessment of relative advantages is inevitably controversial, and some engineers may well consider that recent advances in structural techniques have swung the balance further in favour of mirrors for some applications.

The book is very clear and, although thorough, should not strain the mathematical resources of the average reader. A very comprehensive bibliography is appended.

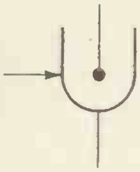
S. S. D. JONES.

LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Transistor Symbol

DEAR SIR,—One of the difficulties of understanding and designing transistor circuits is that the symbol usually employed does not present a visual representation of its electrical properties. In particular, the collector appears to be firmly tied to the base electrode, so that it is hard to imagine that a potential difference could exist between them.



Suggested transistor symbol

If the symbol could suggest not only that a potential difference could exist between the collector and base electrode, but that it could be influenced in some way by the emitter, the symbol could serve as a working diagram for the action of a transistor. Such a symbol might be drawn as shown. In the drawing, the arrow is the emitter which retains the feature of suggesting the rectifier action between it and the electrode possessed by the existing symbol. The wire ending in a blob is the collector.

Yours faithfully,
L. MOLYNEUX,
Newcastle-upon-Tyne.

High Frequency Effects in Germanium Diodes

DEAR SIR,—In connexion with the article by Messrs. Jones and Brodribb in your January issue I would like to report another anomalous effect.

It was observed that a proportion of production television receivers showed on test a "tailing" effect—any large black area being followed by a long white or dark "tail"—and it was found that this could be corrected by changing the crystal used as vision detector. The matter was investigated by applying a

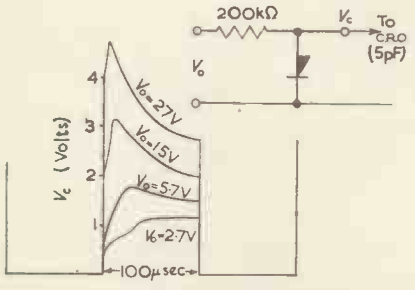


Fig. 1. Voltage V across a "tailing" crystal (T_{10}) for four values of input V_o (on 100μ sec pulse

square wave at various frequencies to the faulty crystals, and results like those in Fig. 1 were obtained: the instantaneous back resistance R_b is seen to be higher or lower (depending on the input) than the normal value for a period after the voltage is applied. In the typical case shown, the peak R_b occurs after 10-30μsec, but other tests with longer pulses have shown analogous effects with time constants up to a millisecond or more. The effect is not dependent upon the application of a positive voltage at some point in the cycle. The phenomena may also be demonstrated by displaying the dynamic V-I characteristic upon a C.R., as illustrated in Fig. 2.

Crystals showing these effects all showed a rather low R_b (order of 10kohms) and were found to exhibit a hysteresis effect in their D.C. characteristic: for example, the current passing with 1V applied in the backward direction became two or three times greater after a higher voltage (say 10V) had been momentarily applied, the crystal returning slowly (in a matter of minutes) to its original condition.

The effect reported here does not seem to have any direct connexion with that

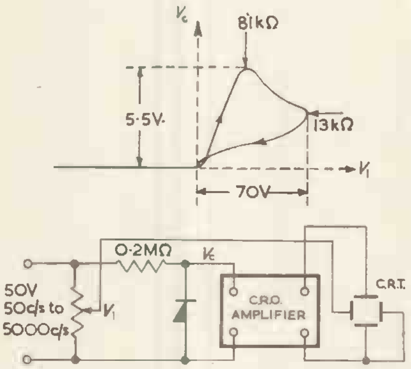


Fig. 2. Dynamic characteristic for a "tailing" crystal (at 50c/s)

considered by Messrs. Jones and Brodribb (which we also have observed) nor with the similar high speed effects, with time constant less than 0·1μsec, reported by several other writers (e.g. WALTZ., *Proc. Inst. Rad. Eng.*, November, 1952).

Yours faithfully,
M. V. CALLENDAR,
E. K. Cole Ltd.
Southend-on-Sea.

The Equivalent Q of R.C. Networks

DEAR SIR,—You have been offered several different numerical values for the Q of the *RC* network. These discrepancies do not arise from any difficulty inherent in the *RC* network. For the in-phase condition, it is not contested that the rate of change of phase with relative frequency is given by A = − 1·3. The difficulty arises in the *LRC* circuit, when the attempt is made to redefine its Q in terms of its A.

The only reason for introducing the *LRC* circuit is to provide a model, which is intended to illustrate the meaning that is to be attached to Q. The choice of *LRC* circuit would have given simpler results. If the parallel *LRC* circuit is regarded as of more practical interest, a simpler result can be obtained by disregarding the total applied voltage, and concentrating attention on the relationship of the voltage across the inductor to the total applied current. (This voltage is measurable as the secondary voltage of a transformer, of which the primary is the *LR* of the *LRC* circuit). It is then found that A = −2Q and that this equation applies for all values of Q. If Q is appropriately defined, the formula also applies if there is loss in the capacitor as well as in the inductor.

The care needed in specifying the exact points between which the voltage must be measured arises because A is a property, not of the circuit itself, but of the particular output that is taken from it. On the other hand, Q can be defined in such a way that it is a circuit property, independent of the particular output that is measured. The definition will apply to many *RC* circuits, but not to ladder networks of three stages or more. The performance of such networks is appropriately specified by A, which is a valuable parameter in its own right.

Yours faithfully,
DAVID MORRIS,
Department of Electrical Engineering,
University College of North Wales.

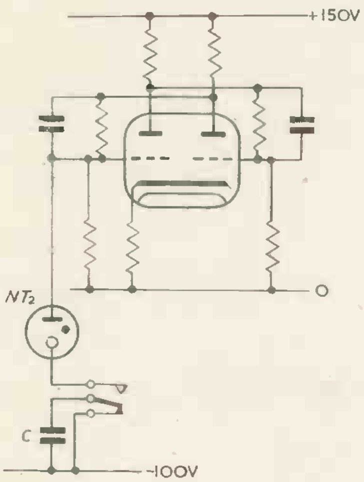
Setting a Trigger Circuit by a Contact

DEAR SIR,—It is frequently necessary in computors and other applications to set a trigger circuit in its appropriate "0" or "1" state by means of a remote mechanically or electrically operated contact. As it may be necessary to repeat this a large number of times, it is desirable to devise a simple circuit to avoid adding a considerable number of valves to the equipment.

At first sight this might appear to be a fairly straightforward problem, but two factors make it difficult in practice. Firstly, it is not possible to connect a long length of wire, which it may be necessary to bind in a cable form, to the grid or anode of a trigger, without upsetting its performance due to the capacitance of the wire to its surroundings. Secondly, a contact rarely makes its connexion cleanly, but usually with a series of short makes and breaks, before coming to rest in the fully made condition. The effect of these short impulses when applied through a small capacitor to the grid or anode of a trigger circuit is occasionally to pulse it on or off several times so that it comes to rest in a random condition.

A simple circuit which has been found to offer a satisfactory solution is shown below. A conventional trigger circuit has one electrode of a small Type NT2 neon diode connected to its grid by short wiring. The other electrode of the neon diode is taken through the cable forms to the make spring of a changeover contact, the centre spring of which is taken through capacitor C to −100 volts. In the non-operated condition the back contact short circuits the capacitor.

When the contact is operated, the discharged *C* is connected in series with the neon tube to the grid of the trigger. As



the voltage applied across the neon tube is greater than its striking voltage it ionizes and a short pulse of current flows through it to charge the capacitor. As the capacitor charges, its voltage rises until it reaches a point where the voltage across the neon is insufficient to maintain the discharge, and the neon deionizes. The reduction of the voltage across the neon is also assisted by the falling in voltage of the trigger grid when it is operated. After the neon tube has de-ionized, the trigger circuit is isolated from the remainder of the circuit except for the capacitance of the neon tube electrodes, until the charge on *C* leaks away, which is negligibly long in comparison with the speed of operation of the machine. The value of the capacitor *C* will depend on the wiring capacities and the de-ionization time required. With a 0·001μf capacitor the neon tube was found to de-ionize in about 1msec.

Yours faithfully,
R. TOWNSEND,
Electronic Laboratory
The British Tabulating
Machine Co. Ltd.

Meetings this Month

THE BRITISH INSTITUTION OF RADIO ENGINEERS

Date: April 21. Time: 6.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: Crystal Valves in Radio and Electronics.
By: B. R. A. Bettridge.

North Eastern Section

Date: April 14. Time: 6 p.m.
Held at: Neville Hall, Westgate Road, Newcastle-on-Tyne.
Lecture: Electroencephalography.
By: Alexander Kennedy and J. W. Osselton.

Merseyside Section

Date: April 1. Time: 7 p.m.
Held at: The Electricity Service Centre, Whitechapel, Liverpool, 1.
Lecture: Logic, Algebra and Relays.
By: E. Williams.

West Midlands Section

Date: April 27. Time: 7.15 p.m.
Held at: The Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.
Lecture: Radio Telephone Equipment.
By: T. C. Howell.

THE BRITISH SOUND RECORDING ASSOCIATION

Date: April 9. Time: 7 p.m.
Held at: The Royal Society of Arts, John Adam Street, London, W.C.2.
Lecture: The Design of Tone Correction Circuits.
By: E. W. Berth-Jones and H. J. Houlgate.

THE INSTITUTE OF PHYSICS

Date: April 1. Time: 10 a.m.—12.30 p.m. 2 p.m.—5 p.m.
Held at: The Cavendish Laboratory, Cambridge.
Series of Lectures: X-ray Analysis.
By: G. E. Bacon, J. A. F. Smith, H. Lipson, W. Cochran, A. F. Douglas, F. Fowweather, P. J. Weakley, D. W. J. Cruickshank.
Date: April 2. Time: 10.15 a.m.—12.30 p.m. 2 p.m.—4 p.m.
Continuation of lectures on above subject.
By: J. M. Robertson, H. P. Stadler, P. J. Black, B. H. Wiebenga and A. F. Wells.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All London meetings, unless otherwise stated, will be held at the Institution, commencing at 5.30 p.m.
Date: April 1.
Lecture: The Possibilities of a Cross-Channel Power Link.
By: D. P. Sayers, M. E. Laborde and F. J. Lane.
Date: April 29.
The 45th Kelvin Lecture: The Physics of the Ionosphere.
By: J. A. Ratcliffe.

Radio Section

Date: April 5.
Discussion: Technical Problems involved in Receiving Alternative Television Programmes.

Measurements Section

Date: April 6.
Lectures: Determination of the Static and Dynamic Elastic Properties of Resilient Materials.
By: R. S. Jackson, A. J. King and C. R. Maguire.
A Method of Using Microwaves for Measuring Small Displacements and a Torque Meter using this Principle.
By: N. C. de V. Enslin. (To be read by Prof. R. Guelke.)
Magnetic Measurement of Mechanical Hardness.
By: D. Hadfield.

Radio and Measurements Sections

Date: April 7.
A Group of Papers on Recent Work on Transistors: A Versatile Transistor Circuit.
By: E. H. Cooke-Yarborough.
The Measurement of the Small-Signal Characteristics of Transistors.
By: E. H. Cooke-Yarborough, C. D. Florida and J. H. Stephen.
A Bridge for Measuring the A.C. Parameters of Type "A" Transistors.
By: A. R. Boothroyd and L. K. Datta.
The Transistor as a Regenerative Amplifier with some Application to Computing Circuits.
By: G. B. B. Chaplin.

Mersey and North Wales Centre

Date: April 5. Time: 6.30 p.m.
Held at: The Liverpool Royal Institution, Colquitt Street, Liverpool.
Annual General Meeting and Lecture: Technical Arrangements for the Sound and Television Broadcasts of the Coronation on June 2 1953.
By: W. S. Procter, M. J. L. Pulling and F. Williams.

North-Eastern Centre

Date: April 12. Time: 6.15 p.m.
Held at: The Station Hotel, Newcastle-on-Tyne.
Annual General Meeting and General Conversazione.

North Midland Centre

Date: April 1. Time: 7.15 p.m.
Held at: The Yorkshire Electricity Board, Ferensway, Hull.
Lecture: Voltage Transformers and Current Transformers associated with Switchgear.
By: W. Gray and A. Wright.
Date: April 12. Time: 7 p.m.
Held at: The Town Hall, Leeds.
Faraday Lecture: Electro-Heat and Prosperity.
By: O. W. Humphreys.

South Midland Centre

Date: April 5. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Great Charles Street, Birmingham.
Lecture: The Development and Application of Nuclear Reactors.
By: R. V. Moore.

South Midland Radio Group

Date: April 26. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Birmingham.
Lecture: The Theory and Application of Transistors.
By: F. F. Roberts and H. G. Bassett.

South Midland Supply and Utilization Group

Date: April 5. Time: 6 p.m.
Held at: The Imperial Hotel, Birmingham.
Lecture: The Electrolytic Analogue in the Design of High-Voltage Power Transformers.
By: D. McDonald.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Date: April 14. Time: 5 p.m.
Held at: The Conference Room, 4th Floor, Waterloo Bridge House, London, S.E.1.
Lecture: Television Receiving Aerials.
By: G. L. Stephens.

THE TELEVISION SOCIETY

Date: April 13 and 15. Time: 7 p.m.
Held at: The University of London Institute of Education, Senate House, London, W.C.1.
Lecture: Colour Television.
By: G. G. Couriet.