BBC

ENGINEERING DIVISION

MONOGRAPH

NUMBER 71: NOVEMBER 1967

The programme effects generator

by

H. DAVIES, M.Eng., C.Eng., F.I.E.E.

(Designs Department, BBC Engineering Division)

BRITISH BROADCASTING CORPORATION

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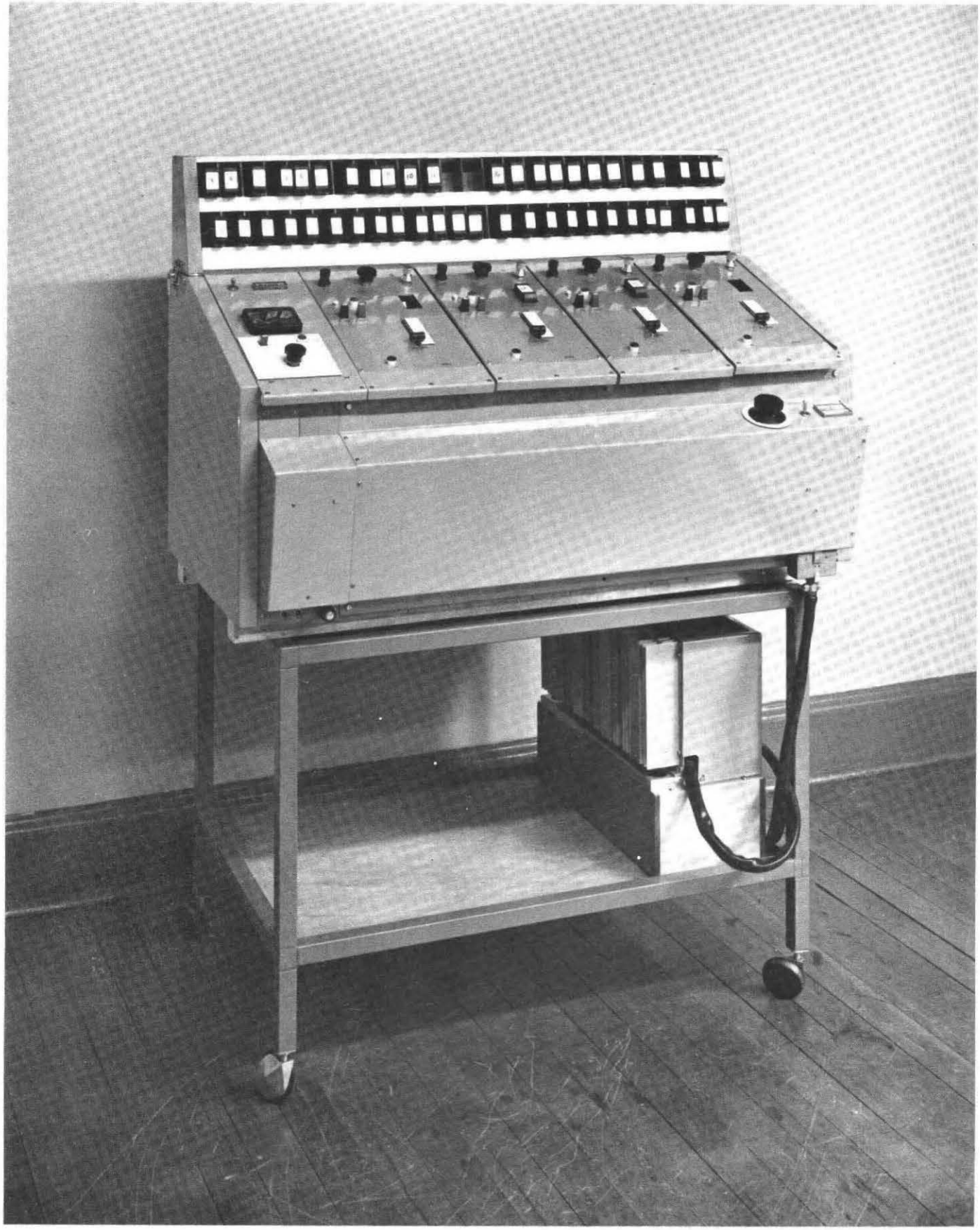
Frontispiece. General view of a four-channel Programme Effects Generator mounted on a trolley



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FOREWORD

THIS is one of a series of Engineering Monographs published by the British Broadcasting Corporation. About six are produced every year, each dealing with a technical subject within the field of television and sound broadcasting. Each Monograph describes work that has been done by the Engineering Division of the BBC and includes, where appropriate, a survey of earlier work on the same subject. From time to time the series may include selected reprints of articles by BBC authors that have appeared in technical journals. Papers dealing with general engineering developments in broadcasting may also be included occasionally.

This series should be of interest and value to engineers engaged in the fields of broadcasting and of telecommunications generally.

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THE PROGRAMME EFFECTS GENERATOR

SUMMARY

The first part of this Monograph outlines the methods usually employed for inserting sound effects and other recorded material into sound and television programmes and sketches the basic consideration which settled the design of a new type of equipment that has been developed for this purpose, the Programme Effects Generator. This is followed by a general description of the device and its use in programme production. The Monograph concludes with some details of the mechanism used.

1. Introduction

1.1 *General*

With the current usage of recorded sound effects it is not unusual for a hundred inserts to be made in a half-hour radio or television programme and, in exceptional cases, many more may be required. There is no basic difficulty in providing a large number of recorded inserts but the conventional methods of doing so impose severe penalties in the time required for preparation and in the cost of the equipment necessary.

1.2 *Former Practice*

In the days when recorded sound effects and similar programme inserts were derived from 78 r.p.m. disk records, the procedure was to lower the pick-up, either by hand or by a mechanical lowering device, on to the rotating disk. A simple scale enabled the correct radial position on the disk to be found with sufficient accuracy and a skilled operator, by observing the rotational position of the label, could pick out a desired point in the recording with considerable accuracy. What he could not do, of course, was to ensure that the required point in the recording arrived under the pick-up stylus at the precise moment when the action in the play required it; if the required point had just passed from under the stylus then almost the time for one revolution, 0·77 seconds, had to elapse before it could be underneath the stylus again. Consequently, when it was important not merely that replay should begin accurately from a particular point in the recording but also that it should begin accurately in time, there was an incentive to avoid the use of recordings by making sound effects 'live' or by other means. For example, in 1954, the BBC introduced an Electronic Gun Shot Generator which enabled various sounds of gun shots, single, repetitive, ricochet etc., to be put into programme very precisely on cue by injecting the appropriate wave-forms into the programme circuits.

1.3 *Current Practice*

With $33\frac{1}{3}$ r.p.m. and 45 r.p.m. fine groove records, there has been an improvement in sound quality but even the rather modest time precision available from lowering a pick-up on to a disk rotating at 78 r.p.m. is no longer attainable since a single revolution takes 1·3 sec in one case and 1·8 sec in the other. With fine groove records it has therefore been necessary to adopt the technique used with magnetic tape, that is to say, to place the pick-up stylus at the correct point on a stationary disk* and then, on cue, to bring the disk up to speed very rapidly. To enable this to be done, rather expensive quick-starting turntables have to be used and on each occasion that the replay of an effect is required, either on transmission or rehearsal, time has to be spent to 'find the place' for the stylus. If a number of 'spot' effects must follow each other closely and with precise timing, it is necessary to have the corresponding number of quick-starting turntables or, if time is available, to have an operator re-load and re-set turntables during the sequence.

Some difficulties can be, and indeed are, avoided by recording individual items on tape and then splicing them together to provide a sequence of all the inserts required in a programme. However, a considerable time is required to prepare such a tape and it can be a source of inconvenience during rehearsal. It is unusual for scenes to be rehearsed in the order of the final transmission and if, after rehearsing a scene from near the end of the programme, the producer wishes to turn to one near the beginning, the actors have only to turn over the pages of their scripts. The tape machine operator, however has not only to run the tape back to near the beginning of the reel, a thing which itself may take some minutes; he has also to find accurately the correct starting point on his tape. During all this time the studio facilities, staff and artists are idle.

Difficulties also arise because modern reproducing equipment, both for disk and tape, runs essentially at a fixed speed; the speed variation on professional disk-reproducing turntables is usually only about ± 5 per cent. A much greater range of speed was available with the turntables that were used for 78 r.p.m. disks and it enabled a limited number of some kinds of stock effects, such as footsteps or engine noises, to be varied to suit a wide range of programme requirements.

Of course, there are many ways in which the conventional processes can be speeded up. Wide-range variable speed facilities can be added to disk† and tape reproducers though this is rather expensive if a first-class technical performance is to be retained. Devices have been developed by means of which a large number of tape-recorded inserts spliced together may be individually numbered and any

* In practice the disk is turned to move the required point away from the stylus by a distance that allows for the short time required for the disk to come up to speed. This need not be more than $\frac{1}{4}$ sec.

† A conversion kit is available for some BBC disk reproducers.

one found comparatively quickly by means of a digital display* or by coded buttons or dialling. However, such equipment tends to increase the already inconveniently long time required to prepare the tape initially and though it can substantially reduce the time spent in the final search for the precise beginning of a particular effect it does not reduce the time taken to run through a long length of tape on the way to it.

Again, for some purposes tape casettes are useful. In the two-reel type, the tape is handled very much as on a normal machine so that, although the time required to load is greatly reduced, the time required to run a given length of tape forwards or backwards or to 'find the place' accurately is not substantially changed. The other type of cassette commonly used contains an endless loop of tape and it can readily be arranged that, once set running, the tape will continue until the starting point has again been reached and will then automatically stop. But with such cassettes the tape cannot be run forwards at high speed and cannot be run backwards at all unless a rather elaborate design of cassette is used. With most cassettes of this type, once reproduction is begun there is no way of returning to the beginning except by waiting for the whole of the reproduction to be completed at normal speed. The usefulness of both types of cassette for this type of work is therefore limited.

For some purposes the Mellotron Sound Effects Console[1,2] has been found to be very useful. This is a keyboard instrument, somewhat similar in appearance to an electronic organ, and contains a $\frac{3}{4}$-in. wide pre-recorded tape for each of its keys. Adjustments are provided that enable eighteen different sound effects to be obtained from each key so that, in all 1,260 effects are available. A recorded sound effect is instantly available on the pressure of the appropriate key and, when the key is released, the tape returns to its starting point in a fraction of a second. A recording of, for example, a single gun-shot or hammer blow can therefore be repeated time after time and each time quite precisely synchronized with action. This feature is of great value when dealing with short recorded inserts or 'spot' effects but it is accompanied by features that are less appropriate to the requirements of broadcasting studios. For example, the machine is not designed to provide long durations of background sound and each recording lasts only for 8 secs. Further, although a very large store of effects is available there are limitations to the ways in which they can be combined and, since the store is an integral part of the machine, it cannot readily be changed.

It was decided, therefore, to develop a machine which would give the quick return facility of the Mellotron with even quicker access to a large store of effects and to do this in a form more convenient for operational use in broadcasting studios.

2. Essential Design Considerations

2.1 *Method of Storage and Loading*

While some effects recordings, such as footsteps or seagull cries, may be regarded as long term 'stock items' there are many others that are of a topical nature. The normal noises of locomotives, motor-cars, and aeroplanes at the present time are different from those of a few years ago and in many radio and television productions sound effects specially produced for the purpose are required. It was therefore thought to be important in new equipment for putting sound effects into programmes that it should be possible for new recordings to be inserted quickly and easily.

If a machine has a built-in store of recorded effects, a new one can be inserted only by replacing an old one. This could be done either by replacing a tape entirely or by erasing and re-recording a tape in situ but in either case the requirement that the operation shall be quick, easy, and safe imposes difficulties and complications of design that become more and more onerous the larger the store. Again, the larger the store the more difficult it must be to provide means of combining any of the stored effects in any sequence or combination.

It was therefore decided not to have a number of recordings built into a machine but instead to put the individual tape recordings into cassettes. The store of recorded effects would then be separate from the reproducing machine and could be made as large or as small as each individual application required. With cassettes there is no limitation to the ways in which the individual items can be combined save only that imposed by the number of reproducing channels available and if recording facilities are added it becomes possible to combine effects from a number of existing cassettes into a single new one.

2.2 *Cassette Design*

With such an approach it was essential that the cassette should be both small in size and cheap to manufacture. The former consideration implied that it should be of the single-reel rather than the two-reel type, the second that it should contain the minimum amount of equipment, that is to say no more than the tape, a spool to hold it, and perhaps a tape guide. The endless loop type of single reel cassette could not give the quick return feature that was sought and it was therefore decided that a new type of single reel cassette was required, designed so that a torque could be applied externally to rewind tape into the cassette. This implied in turn that a mechanism would have to be provided in the reproducing machine for pulling tape out of the cassette and lacing it over the reproducing head and through the drive system. The mechanism developed for doing so is described below.

At an early stage in the design of the cassette, consideration had to be given to the incompatible requirements of long playing time and small size. Both are, of course, bound up with the choice of other design parameters, in particular the tape speed and tape thickness.

So far as the tape itself was concerned, the basic consideration was that a fully professional standard of recording quality must be realized, particularly if advantage were to be taken of facilities to re-record. Another consideration was that a very quick return of the tape to the starting point was required. If this were to be combined with a sub-

* Equipment of this kind was introduced in the BBC in 1962.

stantial running time then considerable rewind velocities must be used and this argued against the use either of narrow or of thin tape.

So far as the tape speed was concerned, there was no overriding requirement to use one of the standard tape speeds but it was thought to be desirable to do so since it would leave open the possibility of loading the cassettes with tapes recorded on standard machines. Moreover, since the internationally-agreed standard speeds lie in a geometrical series with a ratio of only 2:1, no substantial advantage is to be gained by choosing an intermediate, non-standard value. The choice, then, lay between 15, $7\frac{1}{2}$, and $3\frac{3}{4}$ in./sec. The highest of these was unnecessarily high; the lowest would have enabled an adequate standard of quality to be provided but it would have required a closer control of head azimuth, and hence of the tape path, than with a higher speed. This was not a matter to be taken lightly in a design in which the tape, in its cassette, had to be inserted mechanically into the tape drive system and it was therefore decided to use tape of standard width and thickness running at $7\frac{1}{2}$ in./sec. There would then be, in effect, a built-in provision for extending playing time in the future, if it should be found worth while to do so, either by reducing the tape speed or by using thinner tape.

The playing time should, of course, be as long as possible. However, the longer the playing time the longer the tape, the larger the cassette to hold it and, what is operationally worse still, the longer the time required to return to the beginning. In a series of skeleton designs, the playing time was raised from what was considered to be the minimum acceptable figure of 12 secs, firstly to 20 secs, and finally to 30 secs. The tape for this could be accommodated on a spool $1\frac{1}{4}$ in. (3·17 cm) in diameter which implied a cassette approximately $2\frac{1}{4}\times1\frac{5}{8}\times\frac{7}{8}$ in. (5·8 × 4·1 × 2·1 cm). This appeared to be a manageable size and to be compatible with an acceptable re-wind time and a simple mechanism. A small cassette cannot, of course, be counted on to provide long durations of background sound* but it was thought that 30 secs running time would cover over 90 per cent of the requirements for 'spot' effects. This figure could not be greatly improved even by doubling the playing time, though to do so would entail serious penalties in other directions and it was therefore decided to settle on a 30 secs playing time.

2.3 *Machine Design*

At this point then, the new machine was conceived as consisting essentially of a number of cassette-loaded tape reproducers and a basic decision had to be taken as to whether to build a unitary assembly, possibly using a common drive shaft, or whether to build a series of separate reproducers, each complete in itself but suitable for assembly, modular fashion, in whatever numbers might be required. The choice depended greatly on a decision as to how many reproducing channels were likely to be required. With a very large number of channels, as in a Mellotron, a common drive would be almost inevitable but, with cassette loading, a large number of channels would not be required. It has been traditional in the BBC to provide a maximum of six disk reproducing turntables for effects purposes and it was thought that because loading and finding the starting place could be much quicker with the new design of cassette machine, four channels or, at the most, six should suffice.

Sketch designs revealed both the possibilities of, and the objections to, a unitary design for six channels. A single capstan shaft, if directly driven at the convenient speed of 1,500 r.p.m., would be impossibly small in diameter for its length, the more so since substantial side pressures would have to be applied by the engagement of the individual pinch wheels. It would therefore be necessary either to use a larger diameter or else to articulate the shaft making it, in effect, a series of short shafts, each in its own bearings and driven through a constant velocity flexible coupling from its neighbour. This would be a rather unattractive construction for equipment of this kind. On the other hand, if the capstan shaft were large enough in diameter to work satisfactorily with only two bearings, then a low rotational speed would be necessary and this would greatly increase the difficulty of providing first-class speed uniformity, the more so since wow-free operation must be had from any channel while any or all of the other five drives are engaged or disengaged. Again, with such a construction, varying the drive speed must affect all channels at once and its usefulness would be very restricted compared with an arrangement in which the speed of individual channels could be varied. It was therefore decided that it would be better to adopt a modular design in which each channel had its own tape drive and electronics. This would enable a large or a small number of channels to be used according to requirements and each would be independent of the operation or non-operation of the others.

On the basis of these design considerations the Programme Effects Generator described in the next part of this paper has been developed. Perhaps the most difficult part of the development of a novel design of this kind is to decide how far it should be improved by the addition of further desirable features. There are many ways in which the design described below could be elaborated and it may prove useful to do so for particular applications but operational experience in different kinds of work is really required before such proposals can be properly evaluated.

3. General Arrangement Adopted

Fig. 1 gives a close-up view of a four-channel Programme Effects Generator. It consists of a cabinet, 1.1, providing receptacles for four identical channel modules, 1.2, and incorporating under the left hand panel, 1.3, the power supplies and the recording and programme metering facilities for six channels. The power supply to the whole assembly is controlled by the switch, 1.4, with its illuminated indicator 1.5. An assembly of two additional channel modules can be plugged into or detached from the basic four-channel assembly to extend its facilities when re-

* It can do so in some circumstances. cf Part 3 below.

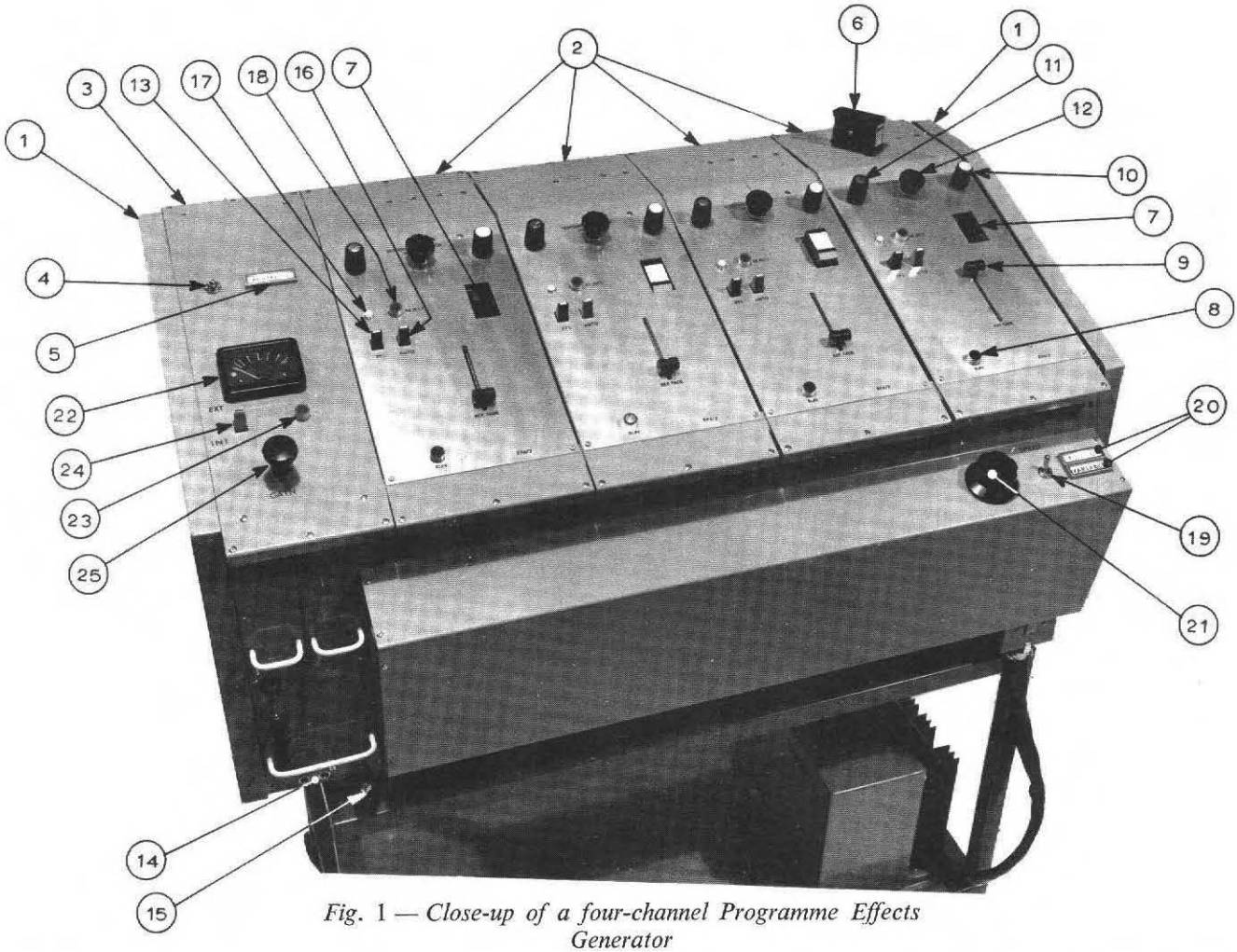

Fig. 1 — Close-up of a four-channel Programme Effects Generator

quired. Fig. 2 shows a two-channel auxiliary unit on its own trolley.

Each channel module is a tape reproducer designed to accept the cassette, 1.6, which is shown to a larger scale in Fig. 3 and is described in detail in the next section of this monograph. As can be seen from Figs 5 and 6, a channel module consists essentially of a vertical structural plate on which the mechanism is mounted and a top panel that carries the controls. When a channel module is inserted into a cabinet, the edges of the structural plate engage in vertical slots in the cabinet frame. The module slides downwards and plugs on its lower edge make all the necessary electrical connections with a set of sockets in the cabinet. There are no retaining bolts or clamps; a module may be lifted out of or inserted into an assembly at any time without interfering with the other modules.

4. Method of Operation

4.1 *Loading*

A channel module is 'loaded' with programme by inserting a cassette into its loading slot, 1.7. In Fig. 1, the left hand (No. 1) and right hand (No. 4) channels have empty loading slots. Channel 3 has a cassette in the loading slot but not pressed home, while Channel 2 is loaded and ready for running.

To complete the loading operation, the cassette is pressed down in the loading slot against light spring pressure until its flat top surface is flush with the panel. The cassette is then automatically latched in place and the tape is drawn out from the cassette, over a replay head and through the tape drive system until it reaches its standby position. This operation takes between 1 and 2 secs and, as soon as it is completed, the green RUN push-button, 1.8, at the bottom of the panel illuminates.

4.2 *Running*

The loaded channel is now set so that, if the green RUN push-button is pressed, reproduction of the tape will start instantly and will continue as long as the RUN button is held down. During this time the light in the RUN button is extinguished. When the RUN button is released, reproduction from the channel is immediately muted and the tape runs back rapidly to its initial, standby position. Im-

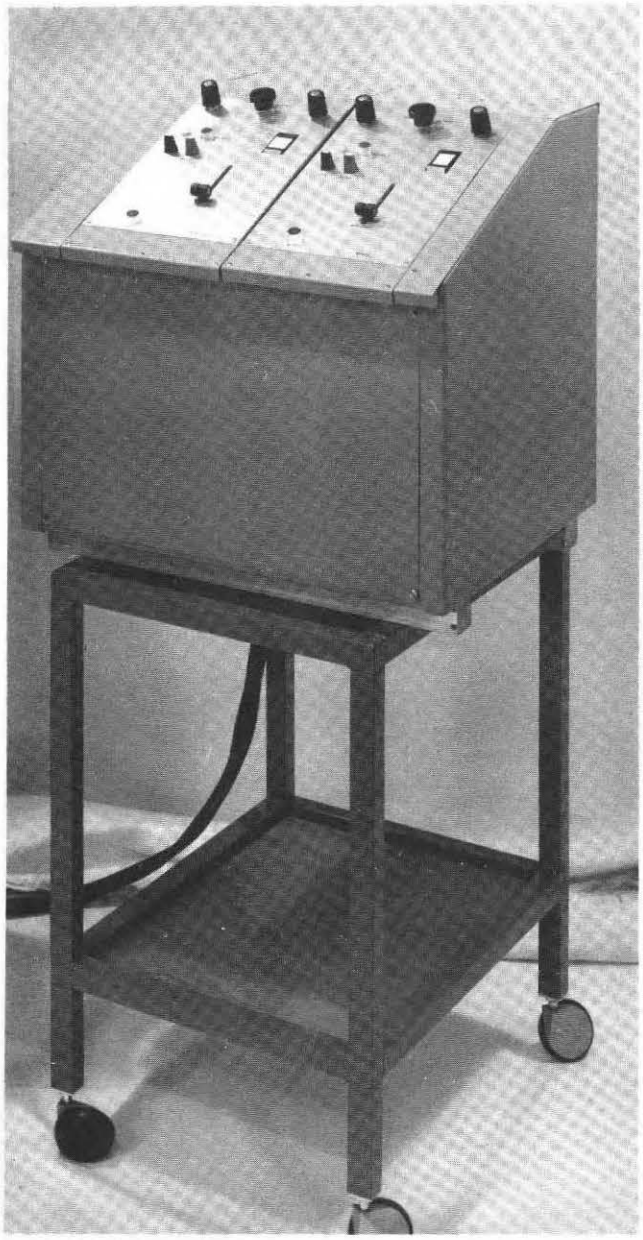

Fig. 2 — Two-channel auxiliary unit mounted on a trolley

mediately it arrives there, the RUN button re-illuminates, showing that the channel is again in the state in which pressure on the RUN button will start reproduction instantly.

The time taken for the tape to return to its standby position is roughly one tenth of the reproducing time that preceded it. Consequently, if reproduction lasts for only a second or two, which is all that is required for a single footstep or hammer blow, then by repeated operation of the RUN button, the same sound may be repeated at close intervals and exactly synchronized with action for as long as required.

Reproduction may be faded in or out or the level adjusted by means of the linear REPLAY FADER, 1.9, and the frequency response may be modified by means of the three controls along the top edge of the panel. The right hand knob, 1.10, controls an increase or decrease of the higher frequencies, the left hand one, 1.11, an increase or decrease of the lower frequencies, the correction being switched into or out of circuit by means of the centre knob, 1.12.

The P.F.L. key, 1.13, provides for pre-fade listening. With this key pressed down, reproduction can be checked on headphones even when the channel is faded out. The headphones are plugged into one of the P.F.L. sockets, 1.14, alongside the associated P.F.L. GAIN CONTROL, 1.15. In Fig. 1 the cover which is normally clipped on to the handles of the power supply and recording amplifier units has been removed to make 1.14 and 1.15 easily visible.

If the key marked AUTO, 1.16, is in the 'down' position, then after a momentary pressure on the RUN push-button, reproduction will continue for 30 secs, though it can be stopped at any time by returning the AUTO key to its normal, 'up' position.

An automatic trip operates at the end of 30 secs reproduction whether this has been reached because the machine has been left running with the AUTO key down or because the RUN push-button has been held depressed. In either case, the output from the channel is muted, the drive is released, and the tape runs back rapidly to its initial position. During the 3 or 4 secs of this process, the white indicator light, 1.17, illuminates. When the tape has reached its initial standby position, the white trip light goes out and the green RUN button illuminates to show that the machine is again ready for a fresh start.

4.3 *Unloading*

To unload a channel, it is only necessary to press the red REJECT button, 1.18. This reverses the lacing operation, causing the tape to be wound back into the cassette, and finally releases the latch that retains the cassette in the fully inserted position. The cassette therefore springs up to the position shown in Channel 3 of Fig. 1 and can readily be removed.

The REJECT button will not work while the tape is running either forwards or backwards, that is to say while the RUN button is not illuminated, and is interlocked with the AUTO key so that it will not work while the latter is in the operative, 'down' position.

5. Variable Speed

The right hand (No. 4) channel in Fig. 1 is equipped for variable speed tape drive. The speed control switch, 1.19, has illuminated indicators, 1.20, marked FIXED and VARIABLE and it connects the tape drive motor either to the mains supply or to a three-phase variable frequency oscillator shown on the lower shelf of the trolley. The frequency of the oscillator, and hence the tape speed, can be increased up to about double or reduced to about one-third of normal by the speed control knob, 1.21. Any number of channels can be equipped for variable speed operation by adding additional oscillators and the corresponding controls but

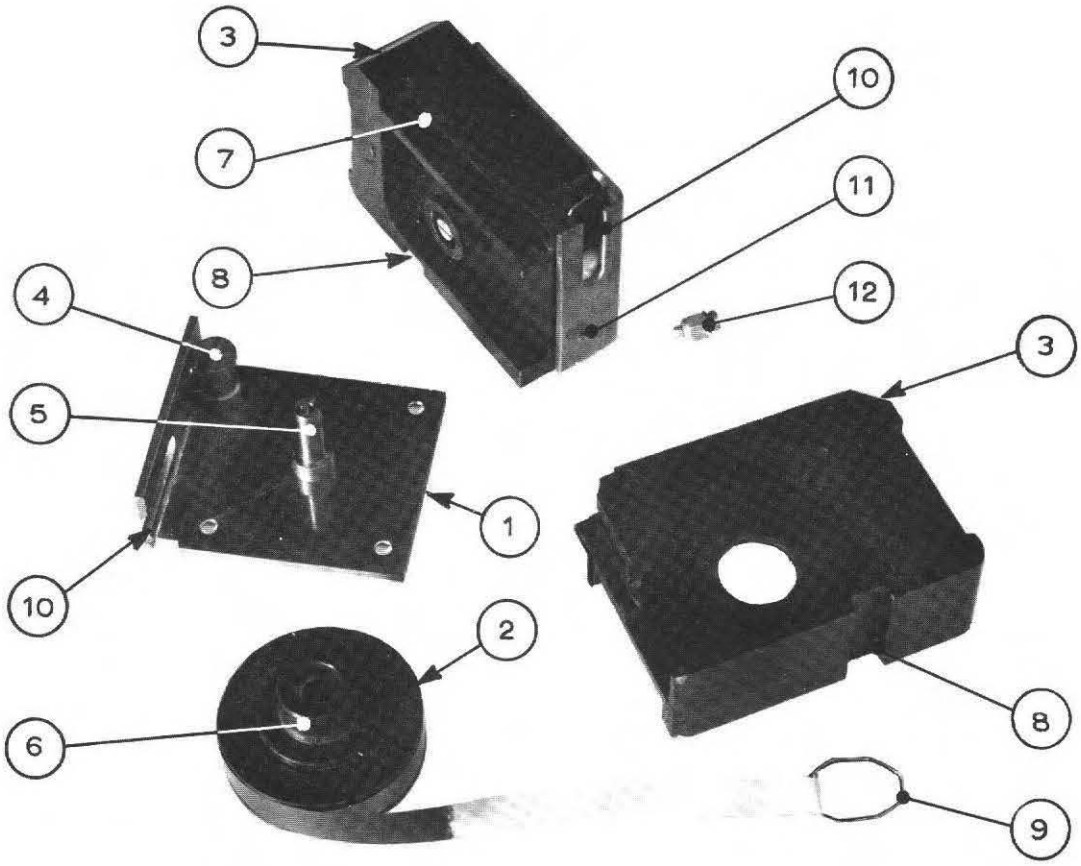

Fig. 3 — Components of the tape cassette

in most assemblies of up to six channels one variable speed control should be sufficient.

Since the speed control is obtained by feeding the tape drive motor from a variable-frequency supply, the facility is associated with a particular position in the cabinet, not with a particular module. Any module that is inserted in the right hand position in the assembly shown in Fig. 1 becomes a variable-speed unit. The use of a high or a low tape speed naturally shortens or lengthens the running time of the cassette correspondingly but it does not affect the time taken by the tape to return to its standby position.

6. Programme Output

The programme outputs from all the channel modules in an assembly are combined into a single output, the programme volume* of which is indicated by the Peak Programme Meter, 1.22. The line-up is arranged so that the output level obtained from a fully modulated tape when the REPLAY FADER, 1.9, is fully 'up' gives zero volume output from the module and a peak indication of 6 on the P.P.M. The contributions of individual channels to a combination may, of course, be reduced to secure proper balance by use of the individual REPLAY FADERS.

* 'Programme volume' is an operational term used in the BBC to describe the level of a sound signal voltage. A programme signal having zero 'volume', when applied to a peak programme meter, produces a maximum deflection 8 dB above that produced by a 1 kHz sinusoidal voltage of r.m.s. value 0·775 volt (corresponding to a level of 0 dBm in 600 ohms). The 'volume' assigned to a programme signal is in fact equal to the level of the corresponding line-up tone.

7. Recording Facility

Recording can be carried out in the following way. A cassette containing blank tape and carrying the stud, 3.12, (see Fig. 3) is loaded into the left hand (No. 1) channel module. The red RECORD push button, 1.23, beneath the programme meter is then pressed. This converts Channel 1 so that it will start recording as soon as its RUN button is pressed and the RECORD button illuminates to show that this conversion has taken place. The RECORD button affects Channel 1 only and only when it is loaded with a cassette carrying a stud.

If the input selector switch, 1.24, is in the EXT position, then Channel 1 will record programme coming from an external source. All that is required is to press the RUN button at the chosen moment in the incoming programme. With the AUTO switch in the down position, 30 secs of recording will then be made after which the mechanism will automatically trip out of the recording condition and the tape will rapidly run back to the standby position. On its arrival there the green RUN button will re-illuminate

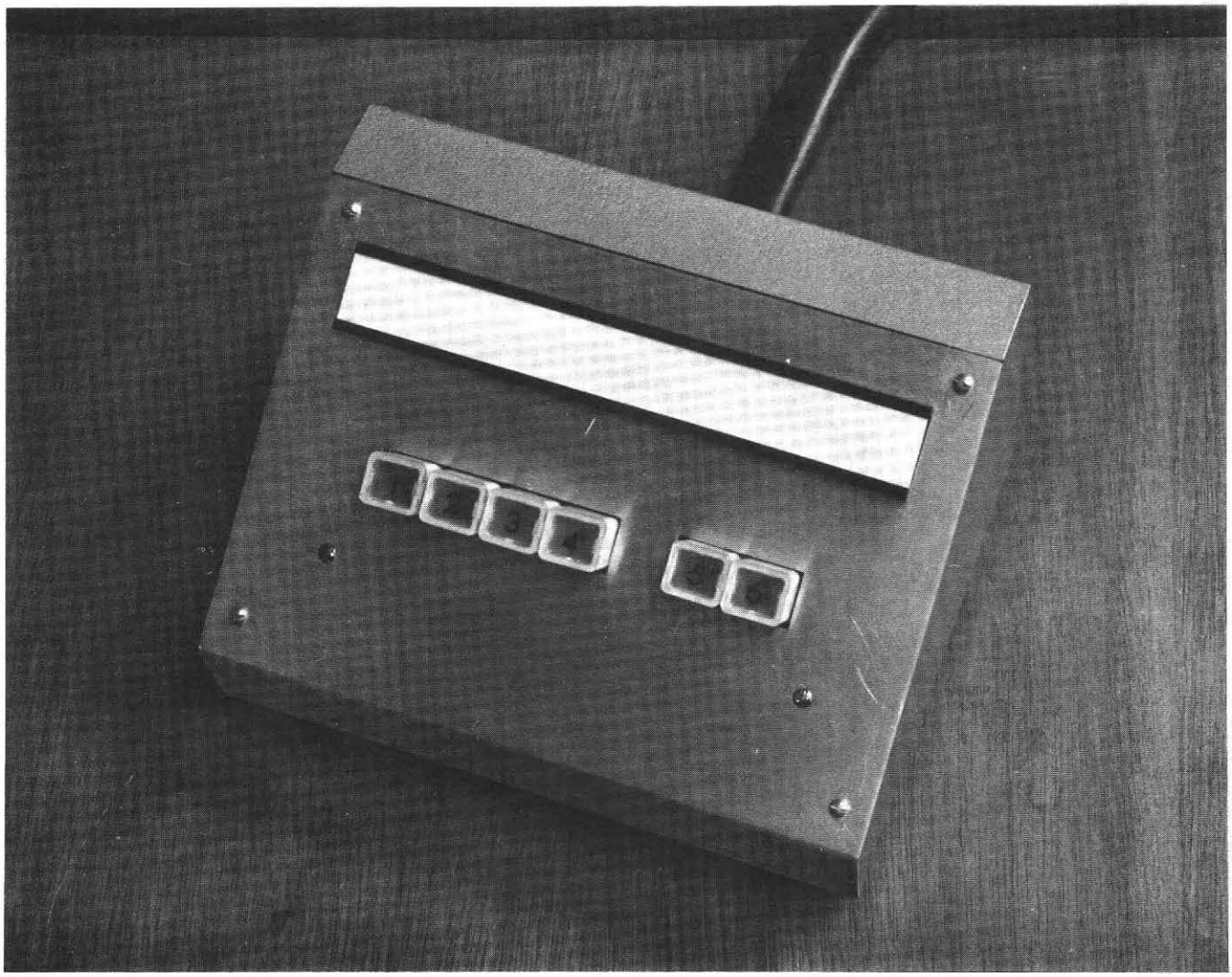

Fig. 4 — Six-channel remote control unit

and the newly recorded programme can at once be reproduced by pressing the RUN button.

If the input selector key is in the INT position, then Channel 1 will record the combined output of all the other channels in the assembly in sequence or in combination. In the centre position of the input selector switch, 1.24, the input to Channel 1 is cut.

When Channel 1 is in the recording condition, the P.P.M. is switched to measure the recording level. Its sensitivity and the gain of the recording amplifier are automatically adjusted so that, when the meter peaks to 6, a tape recorded in Channel 1 is recorded to the proper peak level. The RECORD GAIN control, 1.25, is normally set to a reference mark so arranged that, when recording programme incoming from an external source at zero volume, the P.P.M. peaks to '6' and a proper level is therefore recorded. Similarly, when the RECORD GAIN control is in this position a cassette that is replayed in a channel that is faded fully 'up' gives zero volume at the output of its module and therefore will produce a tape recorded to the same level in Channel 1.

8. Remote Control

Fig. 4 shows a Remote Control Unit for operating six channels made up of a four-channel assembly (as in Fig. 1) and a two-channel assembly (as in Fig. 2). The remote control unit is connected to the four-channel assembly by a multicore cable which may be plugged in and out as required.

The push buttons in the remote control unit duplicate the RUN push buttons on the individual channels and are correspondingly grouped. As with the RUN buttons themselves, each push button lamp in the remote control unit extinguishes while the tape in the corresponding channel is running forwards or backwards and when the channel is

unloaded but illuminates when a tape is loaded and in the standby position, thus giving an unequivocal indication at the remote point when reproduction from that channel is available.

In the remote control unit the push buttons have been placed closely together so that four of them fall easily in the compass of one hand. This will sometimes be more convenient than having the control push buttons spread out on the individual channel modules and the unit may be used to obtain this facility 'non-remotely'. However, with close grouping of the controls it is much easier accidently to press the wrong button and this arrangement is therefore regarded as an alternative to, rather than a replacement for, control from the individual modules.

If operational experience shows that close grouping of the control push buttons is often of value, a set can be mounted in a position corresponding to the speed controls, 1.19, 1.20, and 1.21, but beneath Channel 1, which, because it is used for recording as well as replay, would not normally be equipped with variable tape speed facilities.

9. Operational Facilities

9.1 *Reproducing*

One of the most important features of the Programme Effects Generator is that the time required to put a new recording into the machine and to start reproducing at the chosen point in programme is only 2 to 3 secs. Similarly, the time required to remove a recording, replace it by another, and again start on cue is only 5 to 6 secs. A four-channel assembly, as in Fig. 1, can therefore give reproductions from an unbroken succession of different cassettes going on for as long as desired provided that, after the first, each reproduction is more than 6 secs long. Alternatively, in each sequence of four two may be short, provided that the other two are at least 12 secs long, and so on.

The provision of only four channels is therefore a limiting factor on the number of cassettes that can be replayed in sequence only when, after the first item, three or more reproductions of less than 6 secs length must follow in unbroken succession. However, when a series of reproductions of less than 6 secs are required, it is a simple matter to load Channel 1 with a cassette carrying blank tape and to record into it the required sequence from cassettes in the other channels. If all are less than 6 secs long, it is not possible to reload during the sequence and with a four-channel machine only three items can be re-recorded at a time into a new cassette. However, any number of additional items, within the total running time of 30 secs, can be added by the procedure noted below.

The duration of an effect is not necessarily limited to the 30 sec duration of a single cassette. With background noises having no strongly rhythmic character, a pair of cassettes carrying duplicate recordings may be loaded into two channels and, by starting each a little before the other reaches its end, an indefinite duration of replay may be obtained. The slight increase in level during the time the two channels are operated in parallel is usually not noticeable. Similarly, with impulsive, single sounds such as hammer blows or footsteps a sequence of indefinite length can be obtained from one or two channels.

The very quick 'load-and-start-to-run' time of this equipment is associated, of course, with the acceptance of a pre-selected starting point from each cassette but it is a very simple matter to choose another starting point. All that is necessary is to reproduce the cassette in question and to start Channel 1 recording a new cassette when the desired new starting point has been reached.

9.2 *Recording*

The recording facility enables cassettes readily to be loaded with new programme material. If Channel 1 is loaded with blank tape, set to record, put in the AUTO condition and connected to external programme, then a momentary pressure on its RUN button at the chosen moment automatically produces a new recording 30 secs long which, 4 secs or so after it ends, can be replayed by another touch of the RUN button.

Material which is already in a cassette may be added to material recorded from an external source by moving the input selector switch to INT at the appropriate moment and simultaneously pressing the RUN button on a channel loaded with the existing cassette.

When recording from a number of existing cassettes, it is possible to record more items in sequence than there are replay channels available provided that the duration of the individual items is such as to give time for reloading. A longer sequence than can be done in this way may be had by recording as many as possible in one cassette, and then the rest of the sequence into a second or a third cassette which can then be combined into a master cassette.

Operating in this way, however, the final assembly is a second re-recording of the original cassettes. This may be avoided by the following procedure. Channel 1 is loaded with blank tape and the reproduction from as many cassettes as possible is recorded into it in the normal way. This having been done, the reproducing channels are reloaded with cassettes carrying the additional items. Channel 1 is then run as a reproducer. When the end of the material recorded in the Channel 1 cassette has been reached, the RECORD button is pressed simultaneously with the RUN button of the channel loaded with the next item. Channel 1 will then continue recording whatever is reproduced from the other channels.

It is also possible to 'over-record' in the manner sometimes done with domestic tape machines. To do this, a cassette that contains a recording, say of music, is fitted with the stud usually put only on cassettes that contain blank tape. This cassette is then loaded into Channel 1 which, by operation of the RECORD button, is converted to record. Programme material from an external source or from the other channels may now be recorded on the cassette in Channel 1 superimposed on the original music recording, the level of which is automatically 'wiped down' so that it appears as a background. This procedure can only be used when the quality of the 'wiped down' recording is not important.

10. Design Details

10.1 *The Cassette*

As shown in Fig. 3, a cassette consists of three parts, the back plate, 3.1, the spool, 3.2, and the cover, 3.3.

The metal back plate carries a tape guide, 3.4, and a spindle, 3.5, on which the spool rotates.

The spool, which is large enough to carry 20 ft of standard thickness tape between its flanges, is a plastic moulding and has a self-lubricating bush. It mounts and runs freely on the spindle, 3.5, and has a cylindrical extension, 3.6, to which an external friction drive can be applied.

The moulded plastic cover, 3.3, is attached to the back plate and surrounds and protects the spool. It has a groove, 3.7, to assist location when entering the reproducing machine and a slot, 3.8, in which a retaining latch can engage.

The tape has the magnetic exide removed from both ends or has clear ends spliced on so that the start and finish may be recognized by lamps and photo cells built into the reproducer. The outer end of the tape terminates in a slotted leader tab or wire loop, 3.9. When the tape is fully wound into the cassette, the leader tab or loop, 3.9, lies immediately behind a slot, 3.10, in the back plate. When the cassette is loaded into the reproducing machine, this slot and the loop, 3.9, behind it pass over a hook on the lacing mechanism so that, when the hook moves along and out of the slot, it draws the tape out from the cassette.

Fig. 3 shows a tapped hole, 3.11, in the back plate. The reproducing machine or 'channel module' is so designed that when the cassette is used in this form it is protected against damage by an accidental attempt to record on the tape. Cassettes containing 'library' material which it is wished to retain are in this form. With a small stud, 3.12, screwed in, however, the insertion of the cassette operates an internal switch in the machine which makes it possible to convert the machine from a reproducing to a recording channel.

The way in which this safety feature is arranged is described below.

10.2 *The Channel Module*

The arrangement of the lacing mechanism can be seen from Figs 5a and 5b. In Fig. 5a the module stands with its loading slot, 5.1, 1.7, empty. The lacing lever, 5.2, carries at its upper end the lacing head, 5.3, pivoted at 5.4 and pulled in a clockwise direction by the tension spring, 5.5. This keeps a roller, 5.6, on the end of the lacing head pressed lightly in contact with the cam plate, 5.7.

Attached to the lacing head, 5.3, but not visible in the picture is a small hook, its open end facing to the left and so disposed that when a cassette is pressed down in the loading slot the loop of its leader tab, 3.9, passes over and surrounds the hook.

In Fig. 5b a cassette has been inserted in the loading slot where it is held, pressed sideways against a locating surface by the blade spring, 5.8. If simply dropped into the loading slot the cassette would rest on the spring-loaded plunger, 5.9, and no further operation would take place. If the cassette is pressed down against the spring pressure until it reaches a stop (at which point its central surface is flush with the top panel) then, at the end of its travel, the disk, 5.10, on plunger, 5.9, operates the microswitch, 5.11. This starts up the lacing drive motor (which is mounted on the other side of the plate) thus causing the crank, 5.12, to rotate, driving the connecting rod, 5.13, and moving the lacing lever, 5.2, to the position shown in Fig. 5b.

This leftward motion of the lacing lever, 5.2, permits the spring loaded latch bar, 5.14, also to move leftwards so that the latch on its upper end engages with the slot, 3.8, in the cassette which is then retained in the 'down' position against the pressure of the spring-loaded plunger, 5.9. The leftward movement of the lacing lever also causes the hook on the lacing head to engage with the tape leader tab, 3.9, and draw the tape out from the cassette. The shape of the cam plate, 5.7, is such as to make the end of the tape follow a suitable path, passing over the reproducing head, 5.15, and between the capstan, 5.16, and the pinch wheel, 5.17, which is just visible behind the cam plate in Fig. 5a.

At the end of the leftward motion of the lacing lever a cam, 5.18, on its upper end engages with the bell crank lever, 5.19, and operates a microswitch, 5.20, which switches off the lacing motor. The motion of the bell crank lever also moves the pinch wheel, 5.17, from the retracted position shown in Fig. 5a and brings it nearly into contact with the capstan so that only a small motion need be imparted to it to engage the tape drive.

At the end of the lacing operation, the tape lies in its standby position, its end fixed to the hook on the end of the lacing head, 5.3, and passing through the narrow gap between the capstan and pinch wheel, over the reproducing head and into the cassette. It is kept under tension by an auxiliary drive (described below) to the spool in the cassette.

If the RUN button (5.21; 1.8) is pressed, a relay energizes the solenoid, 5.22, which pulls the pinch wheel firmly into contact with the tape and the continuously running capstan. The tape is therefore drawn out of the cassette and over the replay head at the speed of $7\frac{1}{2}$ in./sec. The end of the tape remains on the hook at the end of the lacing head and a loop is therefore formed which drops into a random store, 5.23, consisting of a metal and a perspex plate separated by a little more than the width of the tape. This store will hold the $18\frac{3}{4}$ ft of tape that pass through the drive in 30 secs.

Release of the RUN button releases the solenoid and hence the pinch wheel. It also increases temporarily the torque applied to rewind the tape into the cassette and the tape is therefore drawn rapidly out of the random store and back into the cassette. When this operation has been completed the tape is back in its standby position and reproduction from the beginning can be started by another pressure on the RUN button.

Pressure on the REJECT button, 5.24, 1.18 energizes the lacing motor which rotates the cranks, 5.12, and, by means of the connecting rod, 5.13, draws the lacing lever, 5.2,

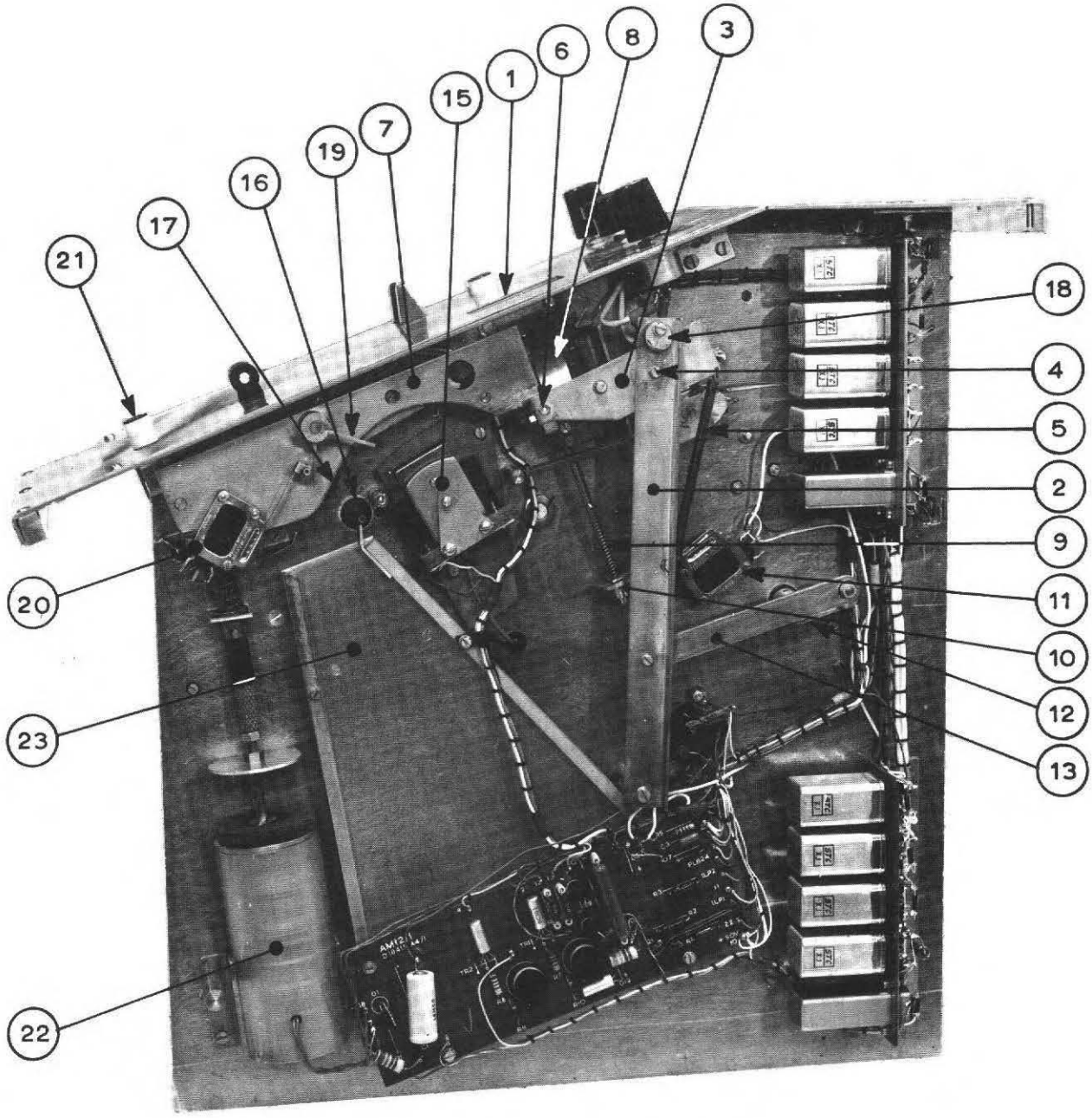

Fig. 5a — Channel module unloaded

back to the position shown in Fig. 5a. At the same time the torque on the rewind motor is increased so as to wind the tape back rapidly into the cassette. At the end of its travel the lacing lever, 5.2, moves the latch bar, 5.14, to the right so releasing the cassette which is raised in the loading slot by the spring-loaded plunger, 5.9. The rising of this plunger disengages the disk, 5.10, from the microswitch 5.11 and switches off the lacing motor so that the mechanism comes to rest.

The microswitch, 5.25, is operated when a cassette that carries a 'stud' is inserted in the loading slot. This switch connects a supply to the switching system that enables operation of the RECORD button to convert Channel 1 for recording.

Fig. 6 shows the reverse side of a channel module. The tape drive motor, 6.1, is mounted on the vertical plate with a magnetic screen, 6.2; its shaft end appears as the capstan 5.16 in Fig. 5a. The lacing motor, 6.3, is a small mains-operated motor with a built-in gear reduction and it drives the crank, 5.13. The mu metal box, 6.4, encloses and screens the tape rewind motor.

The tape rewind motor shaft protrudes through the

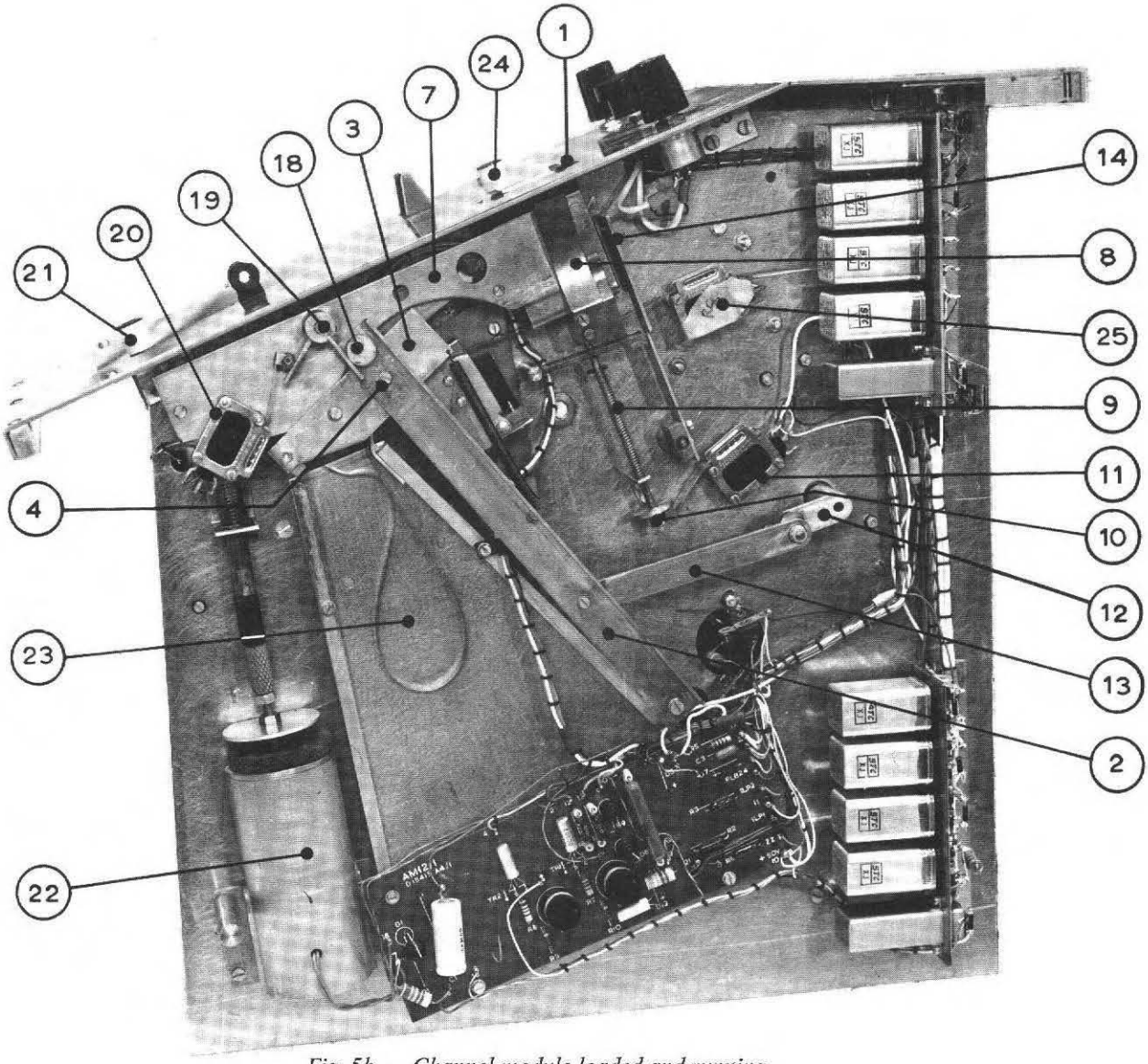

Fig. 5b — Channel module loaded and running

base of the screening box and carries a pulley which, via a circular section endless belt, drives a countershaft carried on a spring-loaded arm. The countershaft protrudes through a slot in the main structural plate into the space below the loading slot and carries on its end a polyurethane sleeve. This is so disposed that when a cassette is pressed down in the loading slot the spool extension, 3.6, presses against the polyurethane sleeve and moves the countershaft downwards against the spring-loading of the arm on which it is carried. In this way the tape rewind motor is automatically connected to the spool of a cassette through a friction drive as soon as a cassette is fully inserted in the loading slot.

In the standby condition the voltage applied to the tape rewind motor is reduced so that the torque applied to the cassette spool is just sufficient to tension the tape and the same light tension is retained while the tape is running forward. On the release of the RUN button, however, a greatly increased torque is applied to secure a sufficiently fast rewind.

11. Conclusion

The first machines of the type described in this monograph were put into trial service in the BBC in mid-1967. In these trials there was, of course, no 'library' of already recorded cassettes to draw upon; each machine had fifty cassettes which were loaded with programme on an *ad hoc* basis. With a substantial number of Programme Effects Generators in use it would become worth while to hold some of the more commonly used effects in stock in cassette form. The cassette is, of course, a comparatively

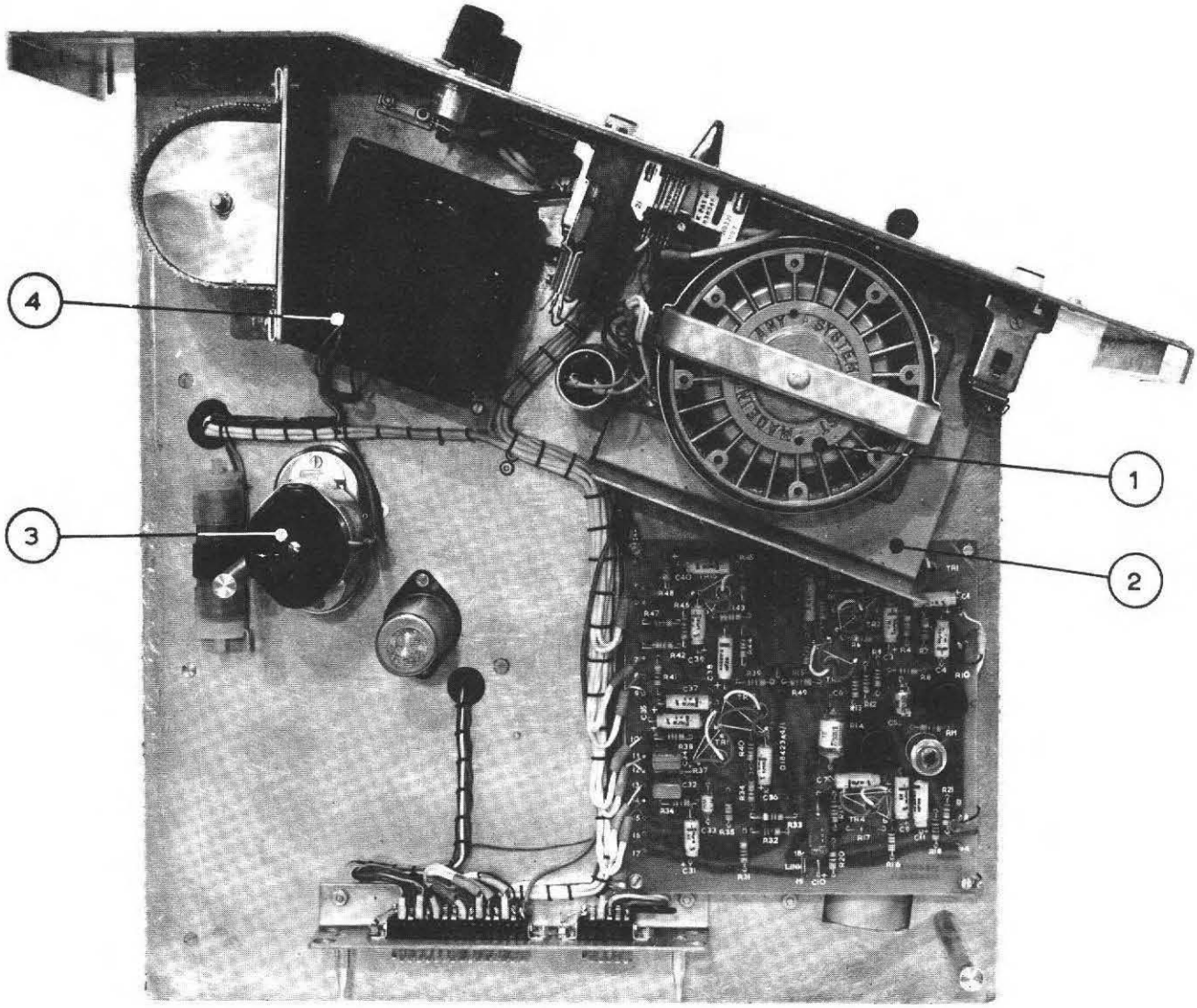

Fig. 6 — Reverse side of channel module

expensive and bulky way of storing 30 secs of recording but a simple two-channel effects generator installed in the library would provide a uniquely quick and simple way of obtaining copies. There would be no need to find the required starting point in a reel or to use two tape machines as is necessary when effects are stored on tape, and no need to hold multiple copies which is necessary when the material is stored and used on disk.

In this monograph the Programme Effects Generator has been considered only in the application for which it was originally designed, that is to say, for inserting recorded sound effects into sound and television programmes. There are, however, other applications to which equipment of this kind is suited or could be adapted. For example, it could be used in places like sound continuity suites for introducing short recorded announcements as required, with the advantage that any announcement can be replaced by another in a matter of seconds. It would be very easy, of course, to make a channel module 'cycle' so that, at the end of an announcement, after only a few seconds pause, the announcement would start again.

12. Acknowledgements

Grateful acknowledgement is made to the many members of the BBC Designs Department, past and present, who, in various ways, have contributed to the design and construction of this equipment.

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Last page. 9. References.
The source of Reference 3 should be Radio and Electronic Engineer, Vol. 30, No. 1, July 1965. (Not Vol. 43 as printed.)

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