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Automatic monitoring

by

F. A. PEACHEY, M.I.E.E.
(Designs Department, BBC Engineering Division)

BRITISH BROADCASTING CORPORATION

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FOREWORD

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

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AUTOMATIC MONITORING

SUMMARY

The monograph gives a general résumé of automatic monitoring practices in both sound and television. There is a discussion of the philosophy of automatic monitoring, and a description of the principles of new monitors which are being designed to assist in the extension of the broadcasting services without a corresponding increase in operational staff.

1. Introduction

About twenty years ago, the BBC Designs Department initiated the first automatic monitors ever to be used in broadcasting. There is some satisfaction in being first in any branch of scientific development but it was an inevitable consequence of the desire to extend broadcasting facilities without entailing the proportionate increase in staff that would otherwise be needed. The immediate needs at that particular time were partially satisfied by a series of monitors that enabled large economies in staff to be made at a critical period when the BBC-1 Television network was being extended. In some ways, a similar situation arises now. An enormous increase in network size is resulting from the progressive establishment of the BBC-2 service. The capital costs of the transmitters and the revenue charge for the links required to serve them will be very high, so that every effort must be made to reduce to a minimum the cost of any additional staff required to operate the new stations.

Concurrently, therefore, with the initiation of design work on the UHF translators that would enable small transmitters to run unattended, work was started on a series of automatic monitors to meet the requirements that would otherwise have to be fulfilled by extra staff. Actually the new impetus in automatic monitor work started about two years ago and is now resulting in the design of the initial batch of monitors to satisfy most applications. When the bulk of the present work draws towards completion, we shall, of course, be left with a residue of special cases, some of which are well worth dealing with but none of which provides the heavy profit obtainable from the first batch. A surge in design operation of this kind is initiated not only by particular demands in the field of application but also by advances in design technique which make it possible to do more with the devices concerned. Transistors have enabled computers to advance far beyond the scope that was practicable with valves. Automatic monitors may be regarded as a specialized form of computer and transistors have, in a like manner, permitted a considerable advance in their design.

2. The Purpose of Automatic Monitoring

In our early developments, in what was then a new field, the name 'Automatic Monitor' was given to a device which supplemented the normal transmission circuits and provided a watch or monitor on the quality of transmission, instead of employing an operator to do this. In some cases when the operator had to be available in any case to take action in the event of a fault, it has relieved him from the task of keeping a continuous watch so that he can be otherwise usefully employed. In other cases it has replaced the operator entirely and has been given the task, where it is relatively simple, of locating the block of apparatus in which the fault occurs, and replacing it automatically.

A further great complication occurs in the fact that this special computer has the task of relating its objective measurements to the subjective assessments of quality and in some cases the relationships between these two parameters are so complex that they are only partially understood.

The automatic monitor has therefore a long way to go before it can be programmed to behave with anything approaching the wit and knowledge of the human mind and before it can be said that it fully replaces a man doing the same job. Fortunately, however, it can deal with the great bulk of operations which are simple and do not require man's full capacity. Also as reliability in transmission networks increases—and this is taking place rapidly—the need for constant and critical watch diminishes and ultimately the automatic monitor may become an inbuilt and not immediately discernible part of the system to which it belongs.

3. The Translation from Objective to Subjective in Automatic Monitors

Because at present it is far too complicated to teach computers to distinguish (as man can!) between good language and bad language or between mist and bad focusing, the monitor can judge only by making objective measurements on the circuits concerned. These often involve long land lines or radio links and to test these it is fundamentally necessary for the exact relationship between the sent signal and the received signal to be known. This message can be passed on another circuit but this is expensive and cumbersome. We therefore become opportunists. In the case of the television signal, during the brief period not occupied by actual picture information, we transmit a special 'Test Signal'. Its precise value at the sending end is known, so all we have to do is to measure its distortion at the receiving end. This means that a continuous survey of quality can be kept whilst transmission of programme takes place. With the sound circuits, greater difficulties arise. Firstly there is no regular interval in transmission during which a comprehensive test signal can be sent. Also, the human ear is not appreciably conscious of small amounts of delay distortion, or small differences in time of arrival of the various components comprising a particular sound. This means that the expensive task of correcting for delay distortion, as is required in television transmission, is avoided in sound systems, but the resulting jumble in arrival time makes it difficult to compare the programme signal being sent with that being received, even when there is no noticeable distortion. So although sound transmission is in many ways less critical of distortion than its video partner, the moment-to-moment assessment of quality by a computer is more complex. It is for this reason that emphasis is given to the description of a new sound monitor which is intended, at first, to watch the sound component of the BBC-2 service (when this is relayed separately) and later will be applicable to BBC-1 and the three sound services. It is, of course, not the ultimate but it represents quite a step forward on earlier monitors. In some ways this monitor extracts the virtues of its predecessors, and the use of transistors and diodes has permitted a better translation from analogue to digital measurements than was possible with valves and relays. It will emerge that there is much in common between television and sound automatic monitors and indeed that a full understanding of those designed for sound will facilitate appreciation of the needs in the video field.

4. Methods of Measurement in Television and Sound Monitors

Both television and sound monitors look for 'noise', for changes in gain and so on, but whereas the sound monitor is designed to ignore group delay distortion as far as possible the video monitor should detect this as a transmission fault.

The principle adopted in measurement is first of all to convert the signal being monitored into a form that permits its evaluation in relation to subjective values. It will be seen that if this is not done—i.e. if an attempt is made to compare two programme signals in a direct way—the fault being looked for is more than obscured by the errors in timing or phasing between components in the signals being compared. Timing must not matter within the normal limits of the group delay distortion on the circuit in question. Hence, a simple move is to rectify the signal over periods of time so that brief 'looked for' differences in distortion are not smoothed out, but differences due to normal group delay distortion etc. are accepted. This value is obviously fairly critical and much study has been made to determine its optimum. It would seem that for most types of programme in sound the integration period should be about 5 ms whilst in television it must be much shorter, i.e. about 1 μs. The period could be varied to some extent, depending on the amount of group delay distortion in the circuit being monitored, but in practice it would be complicated to do this so an attempt is made to use much the same value in similar monitors. It will be seen that with a relatively brief period of integration of this kind and in relation to the average programme signal, the measurement of the rms value would have no great advantage. It is much simpler to integrate the peak voltage values, but this leads to difficulty in sorting out the 'looked for' distortion from the acceptable delay distortion.

Steps must also be taken to clear away this integrated signal as soon as possible so that the next part of the programme signal can be examined, and so on. This is of course accomplished by providing the rectifier circuit with a discharge time constant which is fairly fast but yet a good deal slower than the integration time. The slowing up obscures differences in actual transmission delay etc. It enables the assessment of any difference occasioned by a fault to be made more leisurely and simplifies the circuits required for this purpose.

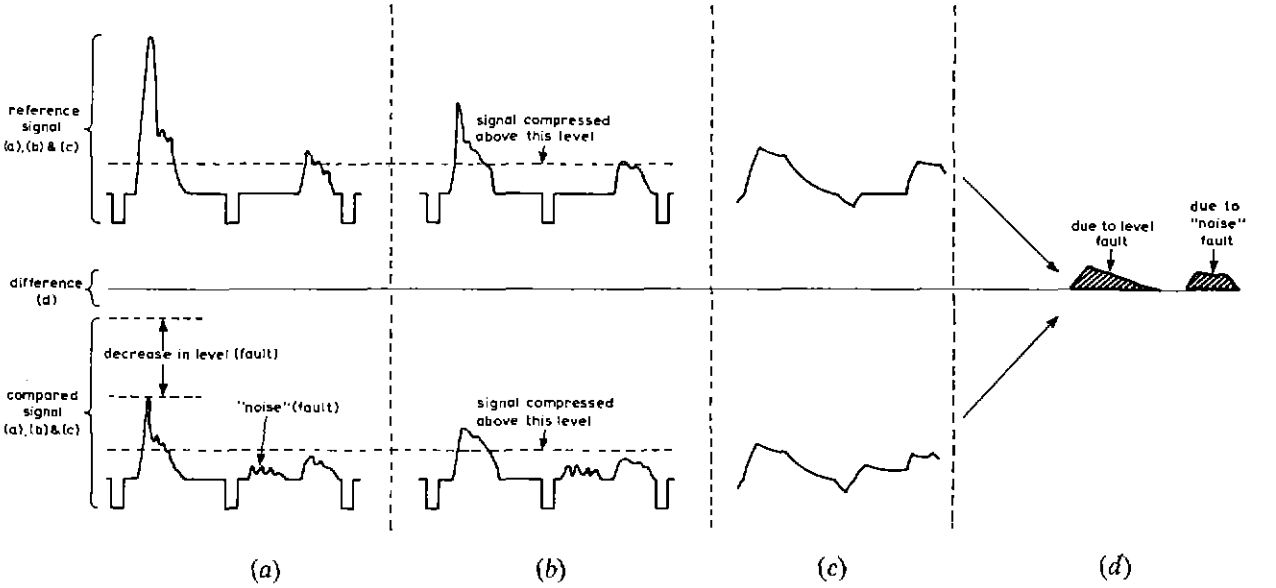
Integrated with this rectifying process there may be other gradings in either amplitude/amplitude or amplitude/frequency. The former permits one detector to be used to alarm on noise which is, say for sound, 40 dB below peak programme level, or to alarm on a change of, say, 3 dB at various levels up to peak values. The latter determines the amount of distortion acceptable in relation to frequency and thus helps to grade the objective measurements into their subjective relationships. This kind of processing has been described quite fully in some of the early publications.[1] It is shown in a general way for television in Figs. 1 and 2.

Despite the 'smoothing out' of delay distortion effects with the integrating circuits described, in sound transmission it is still quite possible for certain types of programme signals to introduce large and persistent unbalance in the comparison circuits. Again, the mode of its operation is described in an earlier paper[1] but in case this is not readily available, it is repeated here.

It should be emphasized that the effects described may occur infrequently and for relatively short periods but should be eradicated if they can cause false operation of the monitor. An example of an instance of this kind is given when two musical instruments, rich in harmonics, are played in 'unison' but vary slightly in relative pitch as can be expected under such circumstances.

In Fig. 3 the 'Reference' programme signal refers to the signal at the sending end of a line, whilst the 'compared' programme is the signal when it reaches the receiving end. The picture shows, indeed, the fundamental (f_1) of one instrument adding to the harmonic of the other (f_2) (where $f_2 = 3 f_1 + \Delta f$).

At one instant the resultant wave can be as shown in the top left hand half of the picture; a second or so later, due to the slight variation in pitch between the instruments, as in the top right hand half. And so, at the sending end of the line the 'integrated' voltage can vary slowly from $A - a$ to $A + a$. In a like manner, slow variations will take place at the receiving end but if, due to delay distortion, these are rephased as shown, then the difference in amplitude between the two ends of the circuit will vary by $2a$. This may operate the monitor falsely. A comparison of the phase of each component of the 'Reference' programme in Fig. 3 with the phase of the corresponding component in the 'Compared' programme will demonstrate, however, that



Signals before processing, showing differences in level on the first and second lines and a burst of 'noise' on the second line

The signals are compressed above a prescribed level to increase the sensitivity to noise relative to the picture signal

Shows (*b*) after rectification, with a fast charge and a slow discharge

The difference between the (*c*) signals—this operates the monitor

Fig. 1 — Amplitude/amplitude processing of a television signal in a 'comparison' type automatic monitor. (A similar principle is used in sound automatic monitors.)

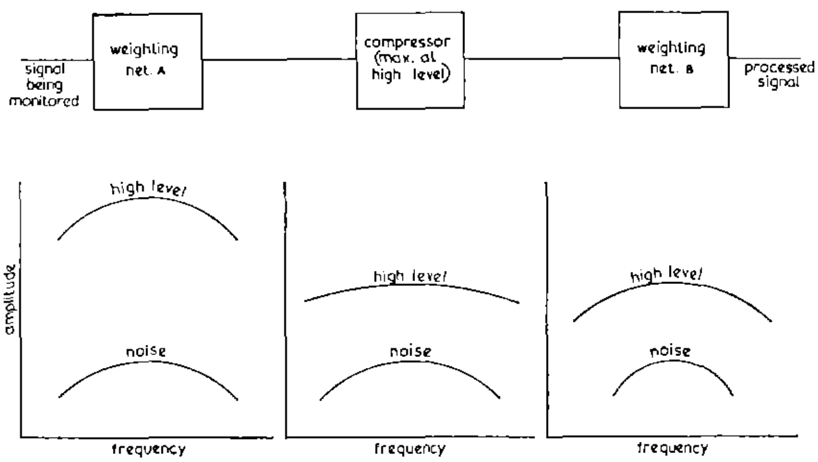


Fig. 2 — Frequency/amplitude processing. (The action of the amplitude/amplitude compressor is described in Fig. 1.)

The relative proportions of networks 'A' and 'B', in conjunction with the amount of compression, determine the required amounts of weighting at high level and noise level respectively

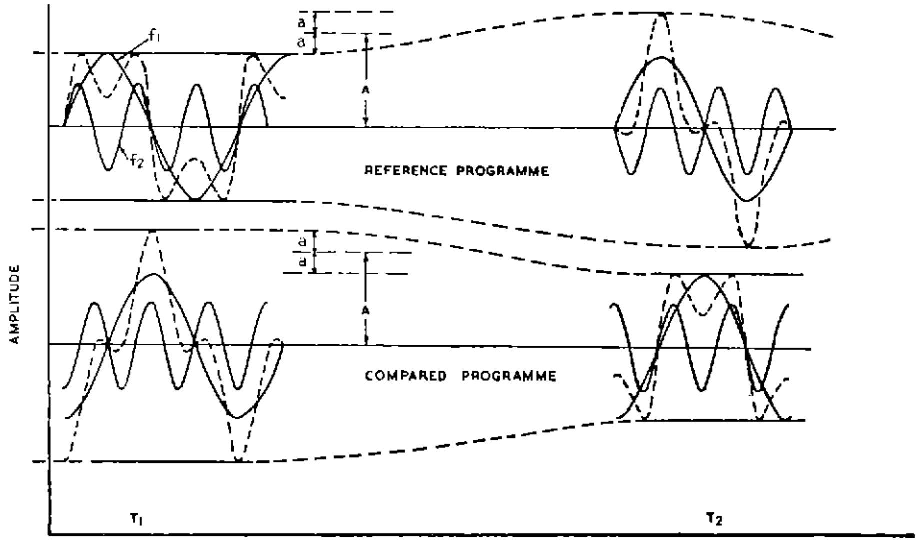


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Fig. 3 — Envelope phase-shift

the envelope variation is shifted by π if the phase of each of the components causing the beat is shifted by $\pi/2$.

This gives the clue to the method of combating this particular difficulty. If the low-frequency envelope variation is $A+a\ \text{Sin}\,\Delta\text{f}$ then when it is added to $A+a\ \text{Sin}\,(\Delta\text{f}+\pi)$, the sum is $2A$ which is constant. Thus the variation can be removed if the two processed signals are produced from signals in quadrature which are added together at both the receiving and sending ends. In practice the quadrature need not be exact and need not hold over the whole of the audio range. It should apply mainly to the frequency range over which, in programme, this kind of circumstance can arise with appreciable magnitude.

With short transmission circuits, or those with relatively little delay distortion, quadrature need not be applied. It is only for the longer circuits or those with enough delay distortion to produce these effects with sufficient magnitude that such steps may have to be taken.

5. Types of Automatic Monitor

Monitors that produce separately two processed signals from the two ends of the system (or part of system) that they are monitoring are normally classified as 'comparison' monitors.

Those that rely on making the assessment at one point only are regarded as 'absolute' monitors, although there is really little difference. In the 'absolute' monitor it must be assumed that a certain quality is attained at the sending end and so a departure from it can be assessed by measuring at the receiving end only. This is tantamount to making comparison but may save some complexity in arrangements. It is applied to television (vision) systems only, unless the 'programme failure'[2] type of monitor used in sound can be regarded as such. The latter is, however, an incomplete device. Because of severe limitation in the scope of its operation it can be made in a simple form.

6. Application of Automatic Monitors

The contribution in distortion that any one unit makes to the overall performance of a transmission link must be regulated to a value that makes the aggregate distortions for the link acceptable. In the same way, the distortion in any one link must be such that the overall distortion in the chain is acceptable. (Distortion is used in its general sense, and includes 'noise' and failure of transmission.) It is possibly fortunate that although most links that have to be monitored are terminated by a transmitter, the chain of links will not include many of these in cascade. Obviously the transmitter, being the high power and most expensive unit in the chain, has smaller margins on certain forms of distortion.

In the general application of automatic monitors, it is envisaged that the most useful results are obtained if a system is sectionalized from the monitoring point of view. For example, if a chain of links is to be watched, it is better that the only monitor to give an indication should be the one covering the faulty link, i.e. that subsequent monitors should give no indication although they are accepting a signal of sub-standard quality.

Unfortunately, this procedure is possible at present only with the 'comparison' type of monitor. This compares the transmission at one particular point in the system with another particular point and gives alarm only on the section affected by the fault. With the 'absolute' monitor as mainly applied to television this is not possible with a simple system but if the 'alarm' system were made more complex it would be feasible to counter this disadvantage.

In mitigation of the 'absolute' monitor's performance it might be argued that before automatic monitors were generally available it was customary for operators beyond the source of the fault to report back on the system so that the fault could be located. Indeed, recent and moderately successful aural monitoring has been secured by posting an observer at the extreme end of a long chain.

Doubtless there may be scope for improvement in this respect and if this is found to be so, steps could be taken to deal with it. It might be practicable, for example, to re-insert the test-line signal at each section. Security is most easily attained by taking action on the spot rather than relying on remote control facilities, so that it is advantageous to monitor each section separately.

7. Subjective Margins of Operation

The primary purpose of an automatic monitor is to draw attention to, or remedy automatically, any fault which increases the distortion as observed at the output of a transmitter to such an extent that entertainment value of the programme is appreciably impaired. Such impairment may be due to a fault in the transmitter itself or the links which supply it—indeed, any part of the system embraced by the monitor. The main point to be appreciated is that the automatic monitor normally acts at a 'rejection' level rather than at the 'acceptance' level. This rejection level must be set at an ample margin from the acceptance conditions otherwise slight degradations in performance of the link being monitored will cause unnecessary—and undesirable—monitor action.

At first sight it might seem that such margins, being rather indeterminate, would be difficult to set, but the very fact that no particularly critical values have to be observed leaves a fair latitude in design. For example, it may be agreed that a sound transmitter and the line feeding it should not be 'accepted' unless the weighted noise level is 50 dB at least below the peak programme signal value. It would seem reasonable to set the monitor to operate at −40 dB. This provides a margin of 10 dB above the acceptance level and yet operates before the noise becomes appreciably obtrusive to the listener.

A change in general level of 3 dB is just about noticeable to the listener, particularly if he lives in a fringe area where the noise level is already rather high, but a drop of 3 dB in the amplitude/frequency response between, say, 1,000 and 10,000 c/s would not be noticeable under domestic listening conditions. Hence the processing circuits in the monitor are biased to relate the monitor's operation roughly to these subjective factors.

In the television monitor, far less sensitivity to noise is needed. A value which has been chosen arbitrarily as the 'rejection' point is about −30 dB (i.e. the rms value of 'white' noise relative to the peak-to-peak value of the picture signal). Obviously, it is convenient to use the same circuitry for the assessment of any kind of 'noise' and so time-constants are introduced which enable the accepted subjective relationship between different types of noise to be broadly observed in the monitor. In the more sophisticated television monitor the vertical interval test line signal is used to assess other forms of distortion. It is well known that the 'K' rating gives a distortion assessment which bears some rough relationship to subjective values and this is largely used in the monitor. It would, however, be unduly complicated to provide monitor circuits which gave an accurate measurement of the 'K' rating. Such accuracy may be desirable in 'acceptance' tests but is not essential in 'rejection' tests. The monitor has therefore been designed to operate mainly on a difference in pulse-to-bar height. It is not provided with circuitry for the direct measurement of overshoot, as it is assumed that for fairly large values of distortion the fault will be detected adequately by the simpler measurement. This, at first, may appear to be an inherent weakness but it should be remembered that a monitor is applied to a circuit which has been set up to good working standards and so there are some types of faults which are not likely to arise unless they are accompanied by the faults which the monitor measures. To a reasonable degree, the monitor circuits are kept to a minimum in size and complexity but some allowance has been made for possible additions if experience in the field shows this to be necessary.

8. Cost, Complexity, and Reliability

The size and simplicity of automatic monitors are important, particularly as these normally determine cost and reliability. Within reasonable limits it may be argued that if an automatic monitor can replace the services of operators and thus save a revenue charge of several thousand pounds per annum, its cost is relatively insignificant. This might be true if the sole aim of such automation were to replace the services of an operator. However, that initial stage is soon passed and the automatic monitor becomes just another device which enables the broadcasting system to extend in size at a lower cost than would otherwise be the case. Obviously, the cheaper the apparatus becomes the more we can have, and so an attempt is made to produce, for a reasonable standard of reliability, apparatus of relatively low cost.

From this point of view alone it would be uneconomic at the present stage to produce just one monitor for 'Sound' and another for 'Television'. It is important to pare the apparatus to its minimum size and so a range of models, stepped in performance and usage, is produced. An attempt is made to generate one step from another so that design effort is less costly, the apparatus is cheaper to manufacture, and its operation is made easier.

Simplification of the apparatus from this point of view also assists reliability. Reliability must be an important feature in a monitor. It should seldom, if ever, fail to alarm on a gross fault. Alarms which indicate faults in the monitor itself should be rare, but it is better that an alarm should turn out to be due to a fault in the monitor, than that the monitor should fail altogether to alarm. Failure to alarm, due to a monitor fault, is well guarded against in the greater part of most 'comparison' monitors. These monitors operate as a balanced bridge and failure in either arm causes alarm. Even so, the detector on the bridge may be vulnerable.

Reasonable steps have been taken in the design to make these monitors as reliable as is practical under the circumstances in which they are intended to be used.

The large sophisticated television monitor does not 'fail safe' in all its circuits (i.e. some faults in the monitor itself may not initiate the alarm). This would add undue complexity to apparatus which is complicated enough. A modicum of security is added by a timed tester so that every half hour or so the broad performance is checked. However, this monitor is not designed to operate at an unattended station. It is intended for use at large centres or transmitters where it is envisaged that for some time to come there will have to be staff to hand for other reasons. It relieves the operator from having to watch a picture monitor continuously and thus frees him largely for other occupations.

The smaller monitors are in some cases designed to take executive action at an unstaffed station or call an engineer from a distance to service the station. Here it is rather more important for the monitor to have greater reliability, but on the other hand its task is usually simpler and the standards on which it is required to operate are rougher. These conditions fit together and enable simple, cheap, and really reliable monitors to be designed.

There may be a point at which the service to be monitored becomes so reliable that no automatic monitoring is necessary. To some extent this condition is approaching in the case of small unattended transmitters using solid state circuitry. Not only may such transmitters be very reliable, but if the area they serve is small, reliability can be considered of less importance.

9. Sound Automatic Monitor Major (with and without Quadrature)

Fig. 4 shows the block schematic for the most comprehensive form of the Sound Automatic Monitor Major. From this at least one other and possibly two simpler monitors will be evolved.

It is essentially a 'comparison' monitor. The programme signal is processed by rectifying with an integration time of approximately 5 ms and a discharge time of about 200 ms. Frequency response networks are included in this process so that the correct subjective relationships are observed with regard to amplitude frequency response, noise, etc.

In some ways, the monitor adopts a principle used on a sound monitor of an earlier type.[3] The programme signal is processed and then used to switch a pair of tone generators. These tone generators are switched at the transitions between three ranges of programme level corresponding to -35 dB and below, between -35 and -9 dB, and above -9 dB (where 100 per cent modulation is regarded as having the normal line-up value of $+8$ dB). At each one of these levels, one or the other, or both tones are sent to the distant end of the system being monitored, thus describing the momentary state of the programme level at the sending end.

At the far end of the system a similar processing arrangement is employed except that the switching levels chosen correspond to the levels at the sending end ± 3 dB. If therefore the level of programme at the receiving end differs by 3 dB or more from that at the sending end and is in a different range, the fault will be detected. It should be noted that noise is recognized by the condition in which the sending

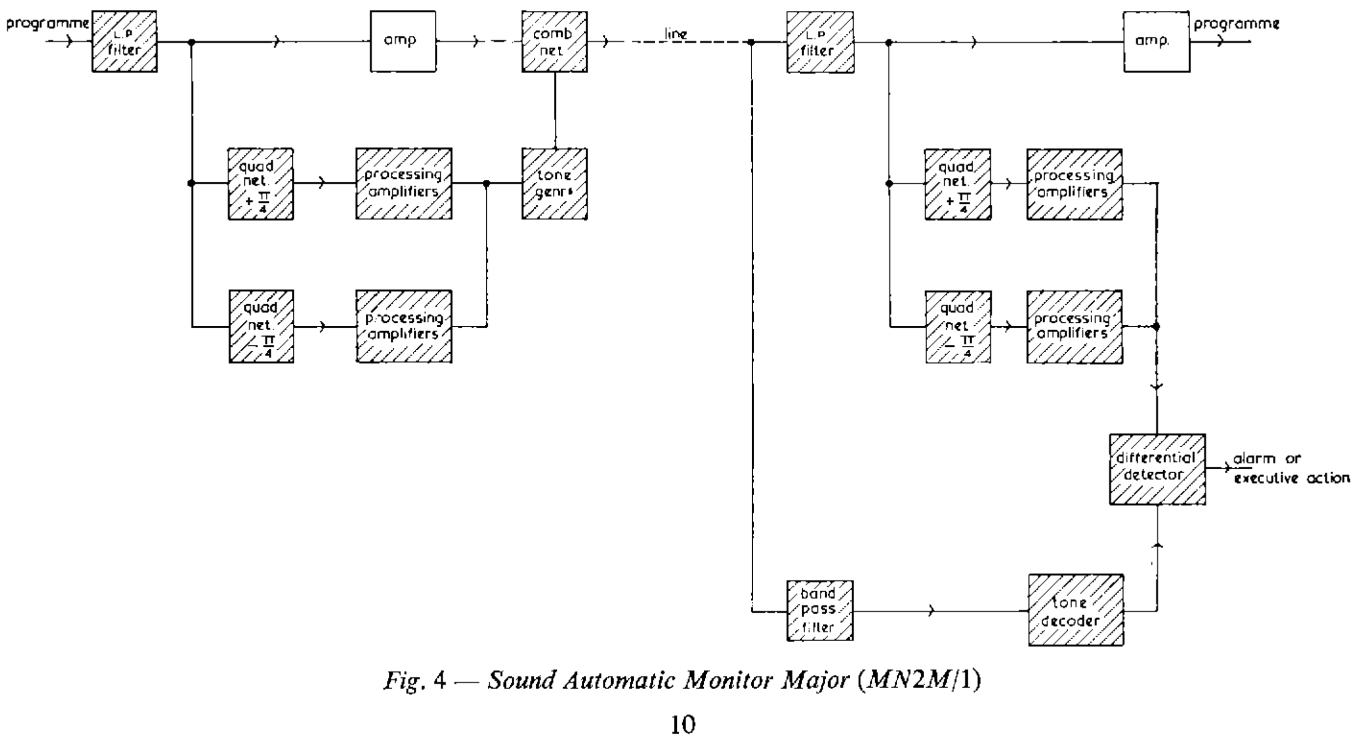

Fig. 4 — Sound Automatic Monitor Major (MN2M/1)

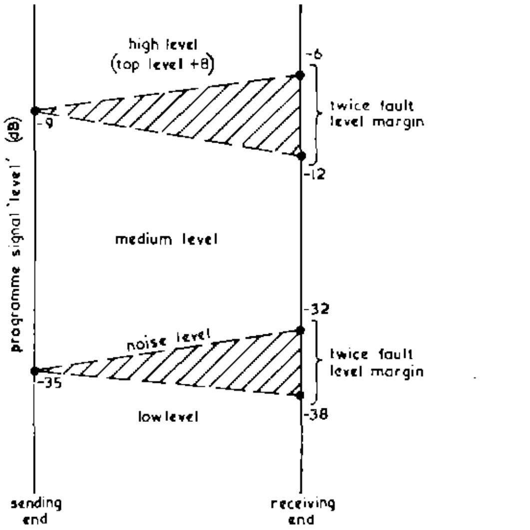

Fig. 5 — Comparison level arrangement in Sound Automatic Monitor Major

The monitor is muted if the received level falls in a shaded section or in the same plain area at each end. It alarms if the signal level is not in the same plain area at each end

end indicates lower than —35 dB whilst the receiving end indicates — 32 dB or above. In this way it will be seen that four levels must be distinguished at the receiving end. (Fig. 5 shows the general arrangement of levels in the system.)

Referring again to Fig. 4, it will be seen that the response range of the sound circuit being monitored must be reduced slightly by a low-pass filter in order to clear a narrow band channel over which the relevant contribution of tones may be sent. As, after processing, the rate of change from one to the other tone etc. is relatively slow, the channel width required is only a few hundred cycles. With allowance made for practical filter design, this will reduce the width of the audio programme channel by about 500 c/s.

Normally such a reduction would not be appreciable from the subjective point of view on wide band transmission. However, if circumstance should arise when it is considered preferable to avoid using a part of the programme circuit being monitored, a separate narrow channel could be provided. It is practicable to contemplate transmitting this processed signal during the vertical interval of the television signal. The plan to use the same circuit as that being monitored has, of course, much to recommend it and will doubtless normally be chosen.

The sensitivity of this monitor is:

Level: ±3 dB with suitable grading to give roughly subjective values to frequency/amplitude response faults.

Noise: 40 dB below peak programme level with rough aural sensitivity weighting.

Including its power supplies it will occupy about 12 in. (30 cm.) of rack space at each end of the system.

Quadrature networks have been shown in Fig. 4 as this arrangement will probably be necessary for long circuits. For shorter circuits it is hoped that quadrature arrangements will not be necessary and a simpler assembly will therefore result.

10. Sound Automatic Monitor Minor

A third type of monitor may be derived from the 'major' types described above by omitting the tone generators and detectors. It might be applicable, for example, at a site where a monitoring receiver enables the output of a distant transmitter to be compared with the programme signal being sent to its line, or for checking local apparatus (Fig. 6). This is virtually a transistorized version of the valved Automatic Monitor Minor. However, it may be found more economic to design a monitor specifically for such tasks.

11. Television Automatic Monitor Major

Fig. 7 gives the broad block schematic of the Television Automatic Monitor Major, which is an 'absolute' monitor and operates by assessing the test signal normally provided in the vertical interval period. Noise is assessed by examining the level of noise on an unused line in the same period. The monitor is intended for use at main centres or transmitters where, for one reason or another, it is necessary to employ operational staff. It provides an automatic watch on the transmitted picture quality and therefore permits the attention of the operating staff to be used for other purposes.

This monitor is not being designed for unattended station working or for taking executive action. It is intended that it should call attention (by alarm indication) to a suspected fault and leave the operator to judge the action, if any, that should be taken. Unavoidably, it is a complicated device and as this increases the possibility of a fault

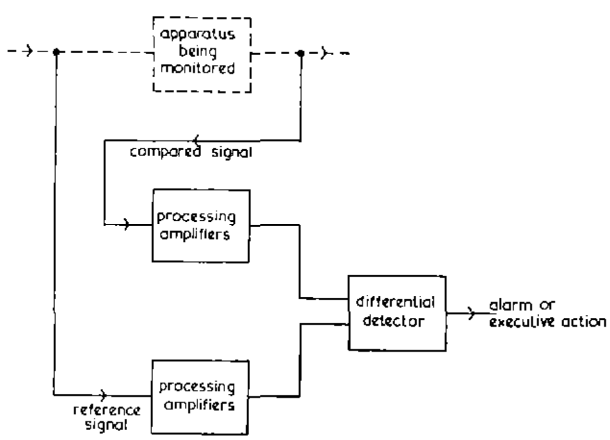

Fig. 6 — Sound Automatic Monitor Minor

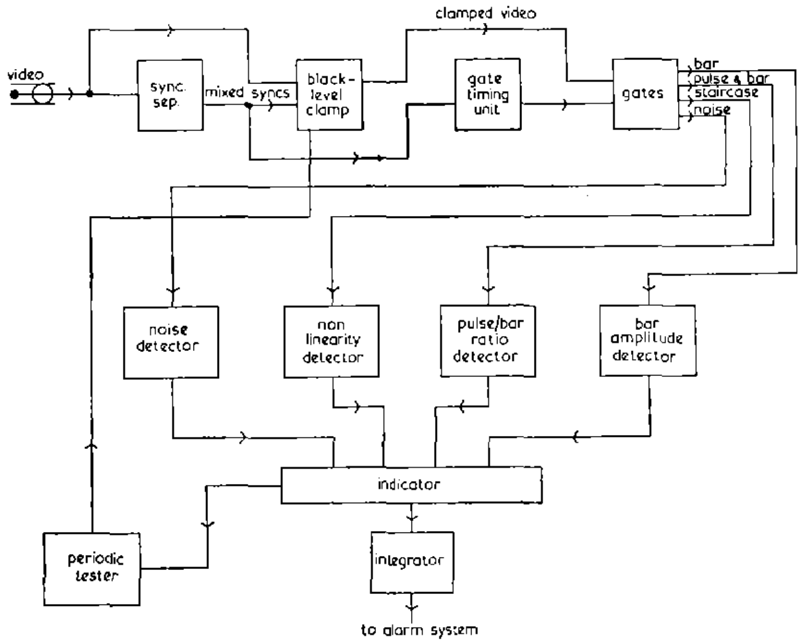

Fig. 7 — Television Automatic Monitor Major (MN2M/506)

occurring within the monitor itself, it requires to be checked occasionally. For this purpose two facilities will be provided; the one automatic and the other manual. They both perform the same function. When the test is made either automatically or manually a 'lift' is applied to the test signal and the resulting gross distortion causes alarm operation. The monitor indicates broadly the nature of the fault, i.e. whether it is level variation, amplitude/frequency response, non-linear distortion, or noise. When the automatic test is applied, clearance is given only if these four fault indications are received.

On a transmission fault external to the monitor, the operation is briefly as follows (the figures given refer to maximum sensitivity):

Level variation. This is assessed by height of bar measurement. Alarm is given if the level varies by about $\pm 1\frac{1}{2}$ dB.

Amplitude/frequency response. This is assessed by measuring the difference in height of the pulse and bar. It operates very roughly on a 'K' rating of 5 per cent.

Non-linear distortion. An assessment is made of the ratio in height of the minimum and maximum staircase 'risers'. The alarm is given when this falls to about 80 per cent.

Noise. A direct amplitude measurement is made during the particular vertical interval line which is to be kept clear for this purpose. Circuits with appropriate time constants and frequency responses are provided so that, very roughly, the subjective relationship between the various types of noise is followed. As the measurement for noise is made during a very brief period at field interval, the monitor tends to be insensitive to impulsive noise. In an earlier monitor an attempt was made to measure noise by detecting its effect below black level in the picture period. Unfortunately, at times, the programme signal made momentary excursions below black level and this confused with the noise assessment. The detection of noise during the vertical interval may be satisfactory only in a system that is not mains synchronized. It follows therefore that further devices may have to be employed to make this monitor suitable for noise measurement in both our present 625- and 405-line systems.

The normal sensitivity to noise is about -30 dB.

At present the monitor with its power suppliers occupies about 12 in. (30 cm.) of rack space, and has been designed with the various units in 'book' form. This will facilitate design changes should field operation show these to be necessary.

12. Television Automatic Monitor Minor (Fig. 8)

This is an 'absolute' type monitor for stations where the use of the larger Television Automatic Monitor Major is not necessary. As it is of a much simpler form than the elaborate monitor, it could, under certain guarded conditions, be used to take executive action at an unattended station. Indeed, some attention has been paid to circuits 'failing safe' so that it is suitable for this purpose.

A rectified peak value of the picture signal is sustained by the test line signal. A variation in this value corresponding to a programme level change of about ± 2 dB operates the monitor.

Noise is measured by the rectification of any spurious signal during the line synchronizing pulse, and it is hoped

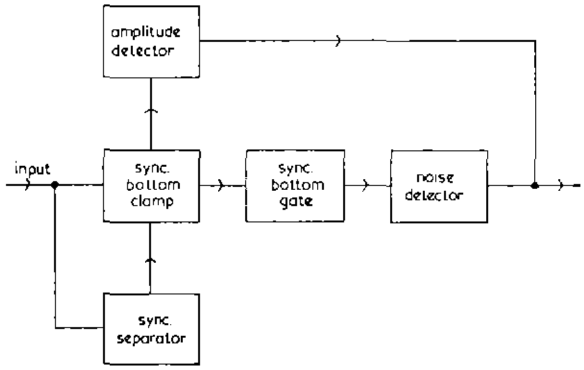

Fig. 8 — Television Automatic Monitor Minor (MN2N/507)

that a degree of subjective grading can be introduced without undue complication. The level of noise on which the monitor operates is −30 dB.

With power supplies etc., it will occupy about 6 in. of rack space.

13. Television Transmitter Monitor (Fig. 9)

This is being designed for use at transmitter stations and may be used to compare the video signal derived from the output of the transmitter with the video signal at the input. If a suitable receiver is available this monitor may be used to keep watch on a 'remote' transmitter, providing also that the transmission loop is relatively short. It is a 'comparison' monitor and makes use of the normal picture signal as the testing signal.

The 'processing' of the video signals before comparison takes place is as follows (see also Fig. 1):

The video signal is clamped and compressed at high levels so that a change of about 2 dB in signal level can produce the same voltage change in the processed signal as the voltage produced by (say) −25 dB noise, when no programme signal is present. The compressed signal is then rectified using an integration time of about 1 μs and a discharge time of about 50 μs. The signals at both the input and output of the transmitter are processed in this way. The processed signals are then compared via a detector with time constants chosen so that, roughly, the correct subjective relationship is preserved in the operation on various types of noise.

A rough grading of response with frequency is provided.

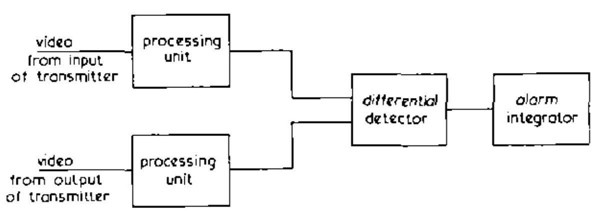

Fig. 9 — Television Transmitter Automatic Monitor (MN2M/505)

The resulting detector output provides a relatively immediate alarm indication, but as isolated incidents are normally to be ignored at unattended stations, the signal from the detector will usually be passed into an integrator unit which will decide on the final executive (or alarm) action.

The need for a receiver to provide video from the transmitter output is avoided by providing a simple detector in the monitor, followed by an equalizer network to correct the vestigial-sideband distortion, as this would be unacceptable to the comparison circuit.

14. Continuity Automatic Monitors for Television and Sound

A report of this kind on the present state of automatic monitoring, particularly in relation to the expansion required by the BBC-2 network, would not be complete unless some mention were made of those monitors which do not actually appraise the subjective value of distortion, but merely keep watch on the continuity of the service. Some of these are used for giving alarm if failure occurs but they are most profitably applied for switching purposes.

The Band II VHF sound services make extensive use of a 'pilot' tone of 20 kc at very low level superimposed at the transmitter and checked at its output. At the output of rebroadcasting receivers used at the distant relay stations, monitors are provided which detect the presence of this signal. Absence of the signal indicates that either the source transmitter has failed or the receiver. The former is checked by local means and is dealt with appropriately if it is the cause of failure. The detector on the output of the distant receiver initiates switching action to bring a spare receiver into operation if this is necessary.

In a radio link of this kind the likelihood of failure, as it depends on the behaviour of the receiver alone, is small. It is therefore logical to provide a simple means of checking. This emphasizes the advantages of such radio links, both in terms of overall reliability and ease of automatic monitoring for television and sound stations and applies, of course, to the television and sound translator stations. The small translator stations, particularly, have to be made extremely reliable and to work with negligible attention. As at such stations no circuits operate at video or audio, the likelihood of distortion normally associated with such signals is small and all that is really required is a watch on continuity.

In the television translators this may be effected in one of two ways. Either a simple monitor is provided to watch the value of the AGC voltage and (if this is abnormal) change over to spare equipment or, the beat frequency between the video and audio carriers is detected and used for a similar purpose.

The latter type of monitor is shown in Fig. 10 and is also employed at such stations to suppress transmission when the parent station closes down at the end of the programme period.

In the sound translators it is usual to mute the translator output by measuring the signal received from the main

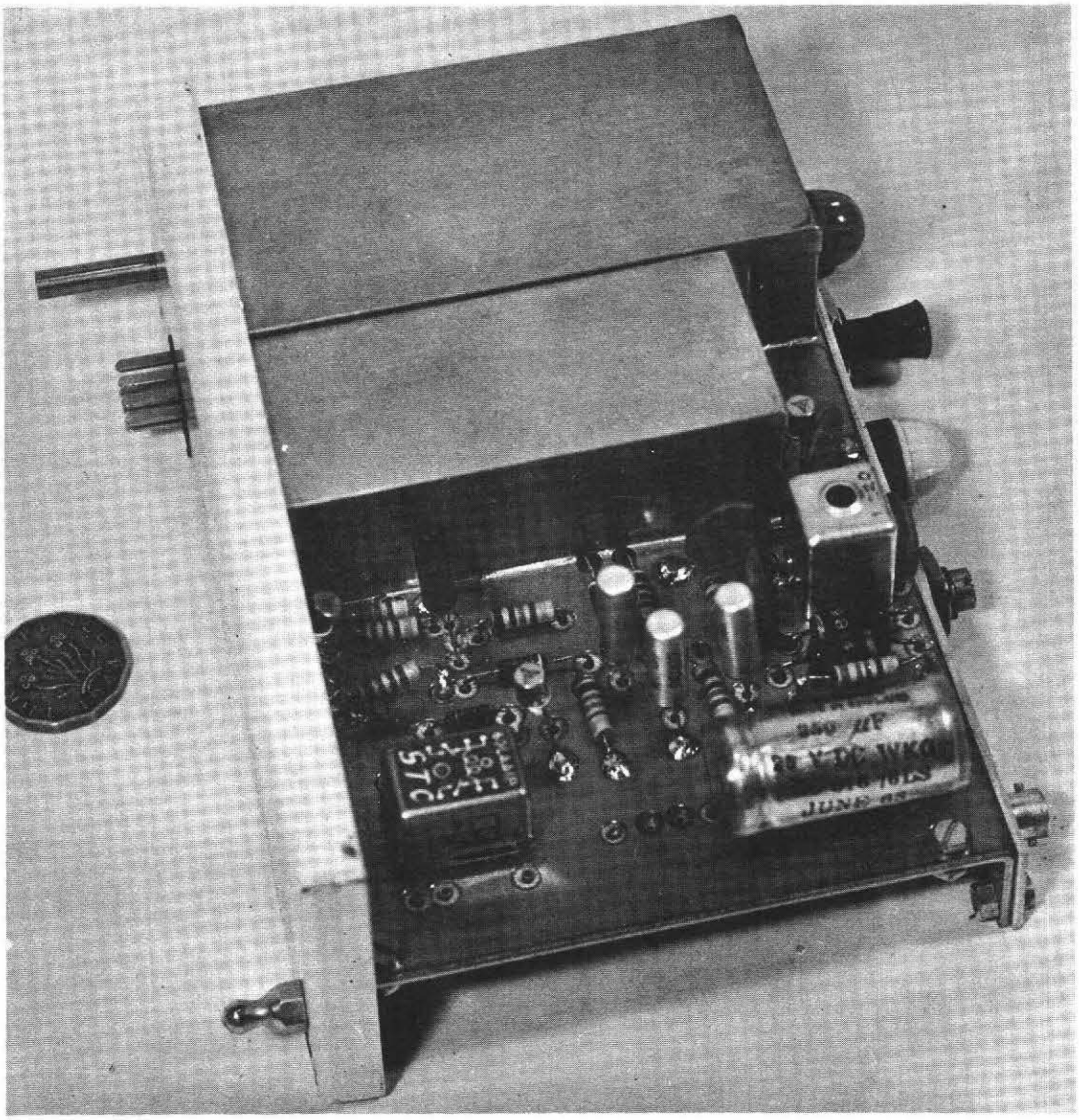

Fig. 10 — *Television Intercarrier Automatic Monitor* (*MN*2/503)

station and taking the appropriate action when this falls below a prescribed value.

At some transmitters, where an audio line feed is used, a 'programme failure monitor', Fig. 11, is sometimes employed to initiate changeover to a rebroadcasting receiver if the line link fails. The device is also used on some television transmitters in conjunction with a 'Field Pulse' automatic monitor to switch on power to the transmitter when both signals are present.

Some of these smaller monitors are relatively crude in operation but are extremely useful if they are applied to the part of the system where their scope is adequate.

15. Conclusions

In development of any kind it is useful to speculate on the future by an examination of history up to the present.

At first, broadcasting plant had to be watched and cared for by skilled operators. Later the number of skilled operators was reduced and in some cases an operator was given facilities at a central position to control remotely some of the functions he had earlier performed on the site. This enabled him to cover a wider field but it reduced to a state of almost stark simplicity the number of observations he could make and the number of remedial steps he could take. He had to initiate by telemetry a regular investigation of the remote conditions. It was evident that in many ways the benefits of his great skill and versatility were being lost by these restrictions and that if transmission apparatus was becoming reliable enough for remote control to be satisfactory, the operator could be replaced by simple automatic apparatus on the stations concerned.

In some cases this automatic apparatus, designed to find faults, gives an alarm when a fault occurs, or alternatively,

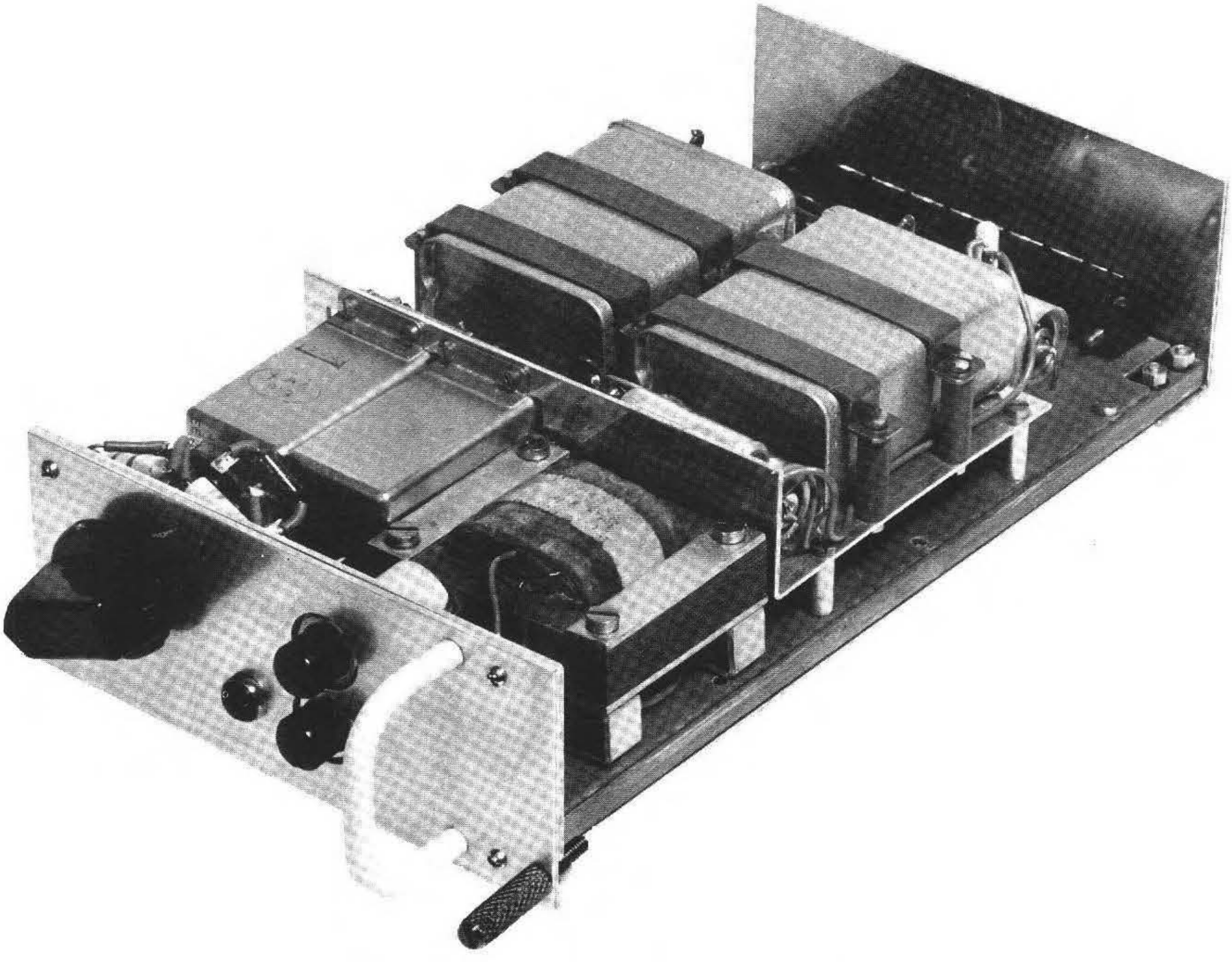

Fig. 11 — Sound Failure Automatic Monitor (MN1/1)

in some cases, takes simple remedial action. Which of these duties it performs is still a matter of expediency and is largely influenced by the overall degree of reliability attainable.

The advent of solid state elements in the form of special diodes and transistors has opened up new possibilities. Automatic monitors and associated control apparatus can now have a combined inbuilt complexity and reliability which was not available in the days of valves.

The tendency in the future to produce the present complex circuits as a single component, by the use of thin film and related processes, will, without doubt, enable a great intricacy of automatic observation and control action to be built into the equivalent of the present automatic monitor. Such apparatus will thus reach more and more towards the versatility of action available from a man.

At the same time, the transmission circuits being watched will become more and more reliable in performance and the need for watching them less. This suggests that ultimately the automatic monitor will no longer be a separate box but will be a part of each individual transmission unit.

16. References

1. Rantzen, H. B., Peachey, F. A., Gunn-Russell, C., **The Automatic Monitoring of Broadcast Programmes,** Proc. I.E.E., Vol. 98, Part III, No. 5, September 1951.
2. See Appendix.
3. Wynn, R. T. B., Peachey, F. A., **The Remote and Automatic Control of Semi-Attended Broadcast Transmitters,** Proc. I.E.E., Vol. 104, Part B, April 1957.

APPENDIX

The following is a list of the principal monitors already in use on the BBC network, with a brief indication of the way in which they are used.

Transmission Quality Automatic Monitors

Sound Automatic Monitor Minor (AMM)

This is a valved, comparison type monitor suitable for closed-circuit quality monitoring or link monitoring including lines up to about 30 miles (48 km) in length. (To be replaced by a derivative of the solid state 'Sound Automatic Monitor Major' described in this report.)

Sound Line Automatic Monitor (LAM 1)

This is a version of the above monitor but is provided with 'quadrature' processing so that longer lines may be monitored. It was designed to complete the monitoring loop over a phantom circuit. (To be replaced by the 'Sound Automatic Monitor Major' (or its derivative) described in Section 9.)

Sound Transmitter Automatic Monitor (AMT/2 and 2A)

This is a valved comparison monitor used for comparing the programme quality at a transmitter output with that at its input.

Continuity Automatic Monitors

Sound, Pilot Tone Monitor (OSC2/5 and AM3/1)

This apparatus watches the continuity of rebroadcasting links. 20 kc pilot tone is superimposed on the modulation at the transmitter and detected at the output of the rebroadcast receiver (mainly valved).

Sound Failure Monitor (MN1/1)

This monitor comprises a detector which indicates continuity if the audio does not fall below a prescribed level for longer than an arbitrary period. (Solid state.)

Television Line Sync. Pulse Monitor (MN1/502A and B)

This monitor indicates the continuity of the synchronizing line signal for the appropriate standard of transmission (405 or 625 lines). (Solid state.)

Television Field Sync. Pulse Monitor (MN1/505 and 505A)

This is a guard monitor to be used in conjunction with the above when discrimination is required against line sync. signals transmitted for test purposes outside normal programme periods. (Solid state.)

Television Intercarrier Monitor (MN1/503 and MN2/503)

This monitor detects the presence of the sound and vision carriers. It is primarily used for starting up and closing down relay transmitters which receive their input signal by radio link from a parent station. It may also be used to give alarm if either carrier fails.

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