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A Mobile Laboratory for UHF and VHF Television Surveys

by

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and

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BRITISH BROADCASTING CORPORATION

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It is regretted that Mr L. C. Munn died between the preparation and the publication of this monograph

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BRITISH BROADCASTING CORPORATION

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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A MOBILE LABORATORY FOR UHF AND VHF TELEVISION SURVEYS

SUMMARY

This report describes the mobile laboratory used by the BBC Research Department for assessing the reception conditions during the Band I/Band V comparison tests carried out in 1957–8. The mobile laboratory was equipped for the measurement of vision field strength and test waveforms, and the subjective assessment of the picture quality resulting from the transmissions from Crystal Palace.

1. Introduction

From November 1957 until August 1958 a survey[1] was carried out under the auspices of the Technical Sub-Committee of the Television Advisory Committee and the BBC to assess the potentialities of the ultra-high-frequency Band V (610–960 Mc/s) for television broadcasting. A transmitter and aerial system were installed at the BBC transmitting station at Crystal Palace and measurements were made in eight sectors around the transmitter. As its contribution to the survey,* the BBC undertook to make measurements in four of the eight sectors; sector 1, due east of Crystal Palace; sector 3, due south; sector 7, due north; and sector 8, approximately north-east. It was hoped that measurements would be made at not less than 100 sites in each of these sectors at ranges up to about 50 miles (80 km) from the transmitter. Because the tests were to be carried out twice, first (Series A), with the Band V transmissions conforming to the 405-line standard and then repeated (Series B), using a 625-line standard, the effective number of sites visited would exceed 800: in view of this it was decided to install the receiving and ancillary apparatus in a robust vehicle and in such a manner as to permit reliable measurements to be made in all but the most extreme weather conditions.

2. Measurements Made at Each Site

At each site, measurements were made of both the Band I (Channel 1) and Band V signals with the receiving aerials at 30 ft (9 m) above ground level. The main test carried out was a subjective appraisal of the received pictures. This was made by two independent observers viewing high-grade 21-in. (53-cm) monitors. The same observers also assessed the quality of the sound transmissions, although acoustical conditions were far from ideal for making this assessment.

The following objective measurements were also made:

(*a*) The e.m.f. of the incoming vision signal was measured by replacing it with a square-wave-modulated carrier from a signal generator. The signal generator output voltage was adjusted until the peak-to-peak amplitude of its demodulated waveform was the same as that of the received signal (bottom of synchronizing pulses to peak white): before the measurement, the frequency of the known carrier was checked by 'beating' it against the appropriate incoming vision carrier. This method eliminated any errors due to receiver defects, and measured the effective e.m.f. of the received signal, which could then be converted to field strength by means of a calibration factor obtained in co-operation with the Field Strength Section of Research Department.

(*b*) 'Pulse-and-bar'[2,3] test-waveform measurements were made. In the Series A transmissions the test waveform was superimposed on the eleventh line of each field, i.e. in the field blanking interval: the Series B Band V transmissions were interrupted at prearranged intervals by the transmission of the test waveform on every line for a short period.

(*c*) The noise level in the blanking periods was measured as a deflection on a waveform monitor.

A six-figure grid reference was recorded for each site and a note was kept of topographical characteristics and such information as was necessary to facilitate revisiting the site at a later date. The aerial bearing corresponding to the best reception at each site was determined using a prismatic compass.

3. The Mobile Laboratory

The mobile laboratory had a working space of 11 ft 6 in. × 6 ft 9 in. × 7 ft 0 in. high (3·35 m × 2·06 m × 2·13 m) and was built on a 3-ton commercial vehicle chassis. A bench occupied most of one side and provided useful cupboard and drawer space. The installation included a voltage-stabilized a.c. distribution system supplied from an alternator carried in a trailer. The vehicle was fitted with two masts, each capable of reaching more than 30 ft (9 m) above ground level. One was a pneumatically operated extending mast capable of being rotated and adjusted in height from within the laboratory, while the other was a sectional tubular mast which needed to be assembled and raised manually. The second mast was not used in the Series B tests. Fig. 1 shows the vehicle with the pneumatic mast in the receiving position.

The crew of the mobile laboratory comprised two observers, two engineers, and a driver, who also attended to the alternator.

4. Description of Equipment

4.1 *General Considerations*

Figs. 2 and 3 show in schematic form the arrangement of the apparatus for the Series A and Series B tests, respectively. In both series the Band I and Band V receiving chains were completely independent. While having the disadvantage of increased bulk and power consumption, this arrangement had, in the Series A tests, the following advantages:

(*a*) Both video signals were available all the time, enabling subjective and objective observers to work independently (see Section 4.5).

(*b*) In regions of low field strength, the less noisy synchronizing pulses could be selected to trigger the waveform-monitor display (see Section 4.6).

(*c*) All inter-channel switching was at video frequency,

* A list of the other participating organizations is given in Reference 1.

Fig. 1 — The mobile laboratory equipped for the Series B tests

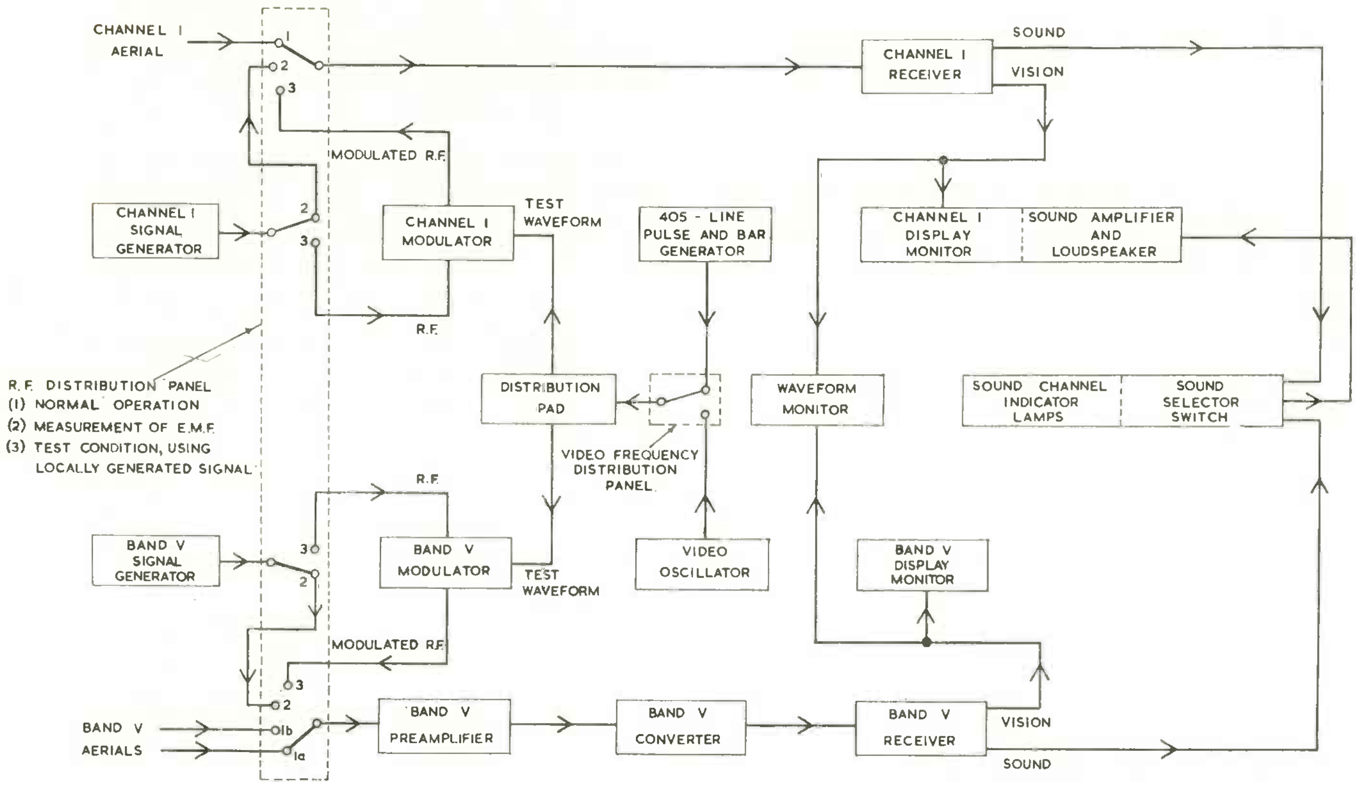


Fig. 2 — Block schematic of equipment used for the Series A tests

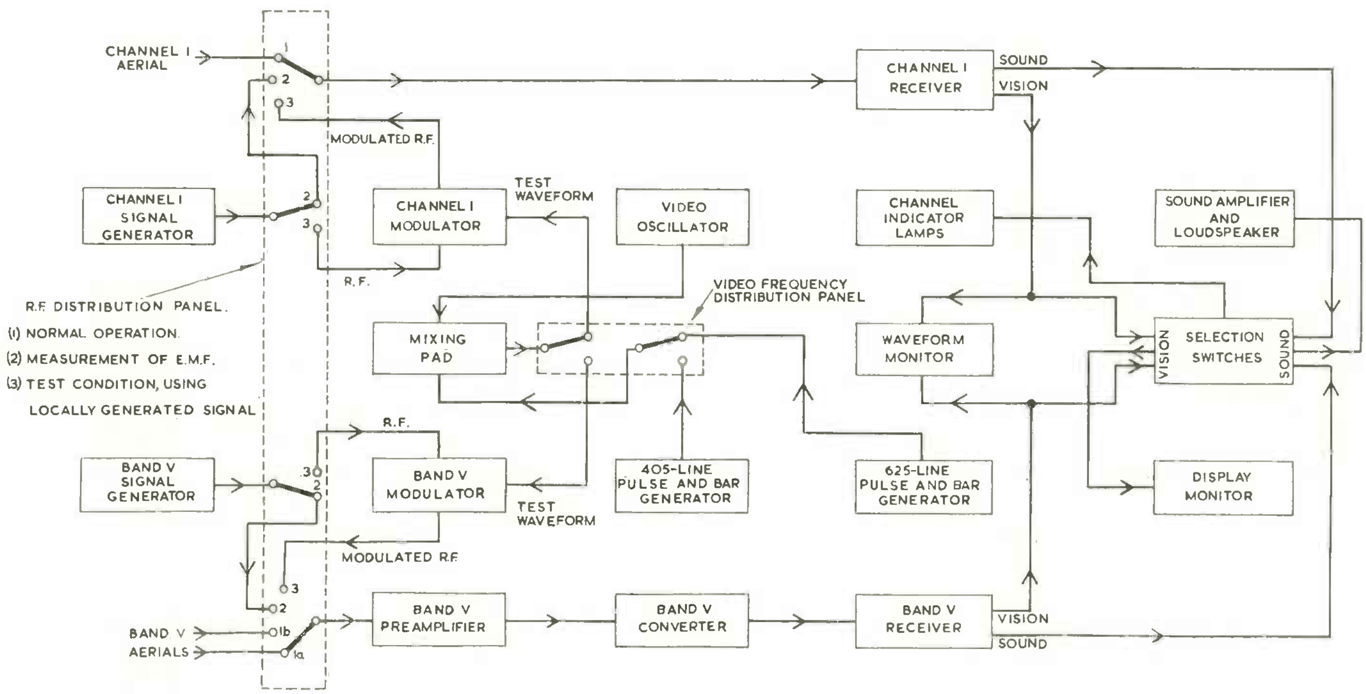


Fig. 3 — Block schematic of equipment used for the Series B tests

In both the above diagrams the interconnections normally used on the distribution panels are represented as switches; other connections were available if required avoiding any danger of breakthrough due to the use of a common intermediate-frequency amplifier.

4.2 *Band V Aerials*

During the survey a very large range of field strengths was encountered and three aerials of different gains were therefore carried. The aerials were all based on a Yagi array consisting of four directors, a folded dipole, and a wire-mesh reflector. Assemblies comprising one array (Fig. 4(a)), two arrays (Fig. 4(b)), and four arrays (Fig. 4(c)) provided aerials with low, medium, and high gains respectively. The aerial chosen for use at a particular site (during the Series A tests) was the least complicated array that would produce a satisfactory picture. Usually the choice was influenced by the necessity of having sufficient aerial gain to provide an adequate input to the receiving chain and so ensure a good signal-to-noise ratio, but sometimes an aerial of higher gain than was necessitated by this consideration had to be used to reduce unwanted echoes. For the Series B tests the aerial used at each site was the same as had been previously used for the Series A tests, in order to make the two series of tests more directly comparable.

Throughout the main series of tests the aerials used unbalanced feeders directly connected to the folded dipole. Some tests were carried out to compare these aerials with others which were identical in all respects except that a balance-to-unbalance transformer was interposed between the dipole and the feeders: it was found that, provided the aerial impedance approximately matched the feeder, no advantage resulted from the use of the transformer. Other tests were made to compare the performances of aerials of differing gain, and, in addition, a dipole was constructed and used to help in estimating the advantage of the greater directivity of the Yagi array.

4.3 *Band V Receiving Chain*

Two stages of frequency conversion were used before detection of the vision signal, a converter being used to produce the first intermediate frequency of 64·75 Mc/s (vision carrier) which, in the Series A tests, was fed to a standard rebroadcast receiver (BBC type TV/Rec/3A)[4] tuned to this frequency. Tuning was accomplished by varying the frequency of the local oscillator in the converter until minimum breakthrough of the sound carrier on the video waveform occurred; the tuned circuits comprising the sound traps in the receiver were thus used as the frequency standard, and periodic checks were made to ensure that the video response was correct when this tuning procedure had been carried out.

The converter was a commercial model of American manufacture which had been modified to make the local oscillator frequency lower than that of the incoming signal, in order to preserve the relative positions of the sound and vision carriers and make the signal suitable for feeding into a standard receiver. This modification resulted in a pronounced frequency drift during the warming-up period, and stable conditions were not achieved until about half an hour after switching on. With the converter fed directly from the aerial, the noise factor was 19 dB. This was later improved to 13 dB by inserting a low-noise u.h.f. pre-amplifier between the aerial and the converter.

For the Series B tests the 405-line rebroadcast receiver was replaced by one designed, by the Receiver Section of Research Department, to accept the 625-line signal, and the pre-amplifier was adjusted to accommodate the new frequency spectrum; apart from this, the basic construction of the chain was unaltered and the noise factor was maintained at 13 dB. A tuning meter was incorporated in the discriminator of the sound channel and this proved to be a useful supplement to the method of tuning already described.

The output of each of the receiving chains was a composite video signal: Figs. 5 and 6 show the overall modulation/frequency characteristics of the two chains.

In regions of high field strength the output from the converter was sufficiently great to overload the receiver, causing interference patterns and 'sound-on-vision' effects, and attenuators were therefore used between converter and receiver in order to reduce the signal to a reasonable level. During the Series A tests it was thought that overloading was taking place in the u.h.f. pre-amplifier as well as in the receiver, and an attenuator was sometimes inserted between it and the aerial to prevent this; however, further tests made while re-equipping the vehicle for the Series B trials proved that the pre-amplifier could tolerate a high input signal before overloading took place, and, for this second series, therefore, an attenuator was rarely used in this position.

Although both receivers were provided with the facility for automatic gain control, this was not used when making the subjective assessment of picture quality, because it would have masked the presence of fading and flutter. It was sometimes used when making the objective measurements, which could be made more accurately with a stable waveform.

4.4 *Channel 1 Equipment*

Owing to the very much larger size of the Channel 1 aerials, it was not possible to carry an elaborate array for use in areas of low field strength and all measurements were made with a commercial 'H' aerial having a quarter-wave spacing between the elements. The 'driven' element was connected by a length of vertical balanced cable to a balance-to-unbalance transformer mounted at the point of entry of the feeder into the vehicle, and a length of unbalanced cable led from this to another standard 405-line rebroadcast receiver. Tuning was carried out by the method already described, the local oscillator frequency of the receiver being varied in this case. The noise factor of the receiver was 9 dB.

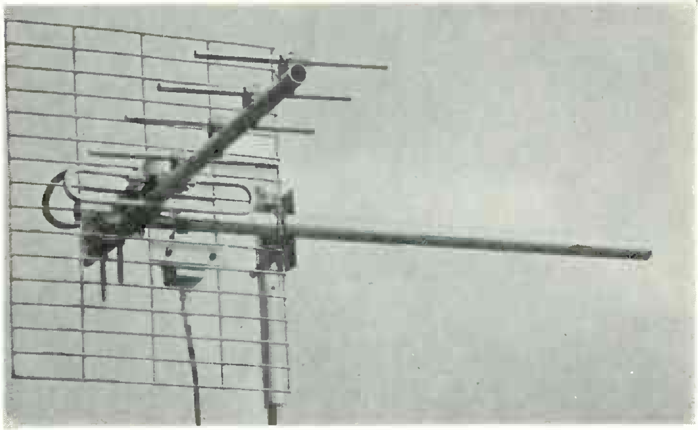
In regions of high field strength, overloading of the receiver occurred and this was prevented, as in the Band V chain, by inserting attenuators between the aerial and the receiver input. The automatic gain control facility was used, as mentioned before, only when making objective measurements of a signal of fluctuating amplitude.

Figs. 7 and 8 show the overall modulation/frequency characteristics of the 405-line receivers used for the Series A and Series B tests respectively.

4.5 *Picture Monitors and Sound Channel*

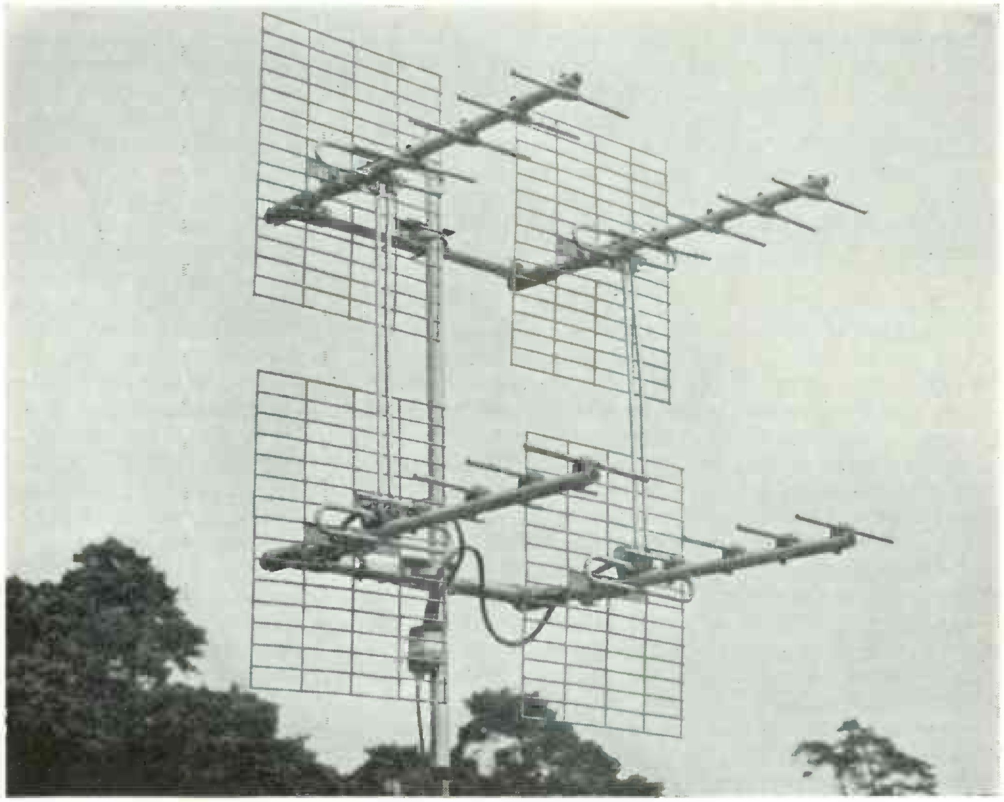
In the Series A tests the video outputs from the two receiving chains were fed to two picture monitors, so that the pictures could be compared easily. These monitors were 21-in. (53-cm) domestic receivers adapted to accept a video input signal. The sound output from either receiving chain could be switched into the a.f. amplifier of one of them, the chain in use being shown by indicating lamps.

In the Series B trials one 21-in. (53-cm) 'variable standards' monitor was used, which automatically displayed the



(*a*) *Low gain*

(*b*) *Medium gain*



(*c*) *high gain*

Fig. 4 — *Band V aerials*

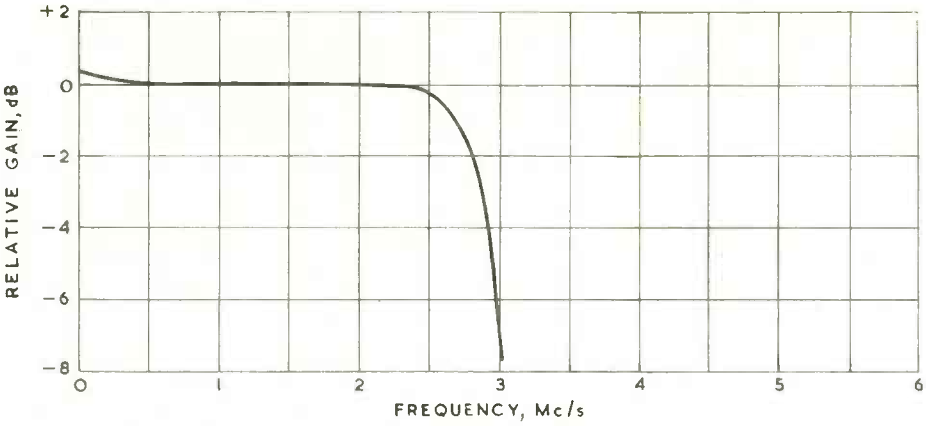


Fig. 5 — Overall modulation/frequency characteristic of Band V receiving chain—Series A tests

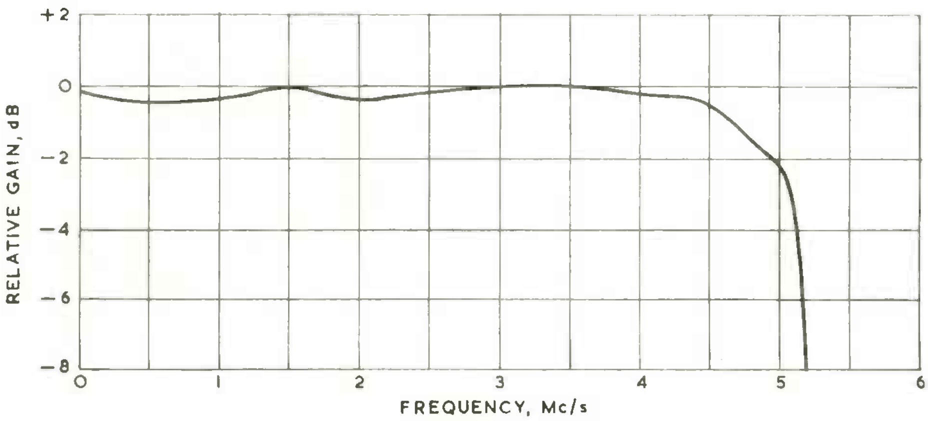


Fig. 6 — Overall modulation/frequency characteristic of Band V receiving chain—Series B tests

picture of the appropriate standard when fed with a video signal of that standard, and in this case both video and audio outputs from the receiving chains were switched. Care was taken in the switching circuit to keep the cross-talk between the wanted and unwanted video signals as low as possible (the ratio of wanted to unwanted signal was 60 dB at 5 Mc/s) and the circuit was tested with a 625-line '2T pulse-and-bar' waveform and found to introduce no degradation of this signal.

4.6 *Waveform Monitor*

The video waveform was observed on a wideband waveform monitor, the two inputs of which were connected to the video feeds from the receiving chains. At first, distribution amplifiers (which gave four identical outputs from one input signal) were placed after the receivers, one feed being supplied to the display monitors and one to the waveform monitor, but these were found to be unreliable for mobile use and were removed, and for the rest of the Series A tests the waveform monitor was supplied through a short length of unterminated cable. Although this gave no visible distortion of the 405-line 'pulse-and bar' waveform it was eliminated in the Series B tests by 'bridging' the waveform monitor across the video feeds to the display monitor, using coaxial T-junctions at the input sockets of the waveform monitor.

It was found that at sites where the field strengths were relatively low, the Band I signal was usually less noisy than the Band V signal, and in the Series A tests the waveform monitor was triggered at all times from the Band I signal; this could be done because the two transmitted signals were always derived from the same picture source. In the Series B tests this was no longer possible because of the different line scan frequencies.

4.7 *Test Facilities*

The inclusion of test facilities as part of the permanent equipment of the vehicle provided a method of immediately determining whether any abnormality in the observed signal was due to reception conditions or an equipment fault. For the Series A tests video-frequency signals could be derived from either a video oscillator or a 'pulse-and-bar' generator, and these could be fed into modulators (one for each channel) which were supplied with carriers from signal generators; the double-sideband modulated carriers from the modulators could then be used for checking the receiving-chain performance. In making this test a 'sound carrier', which facilitated the tuning of the receiver, was generated by modulating the carrier obtained from the signal generator with a sine wave having a frequency equal to the difference between the sound and vision carrier frequencies; the 'pulse-and-bar' test signal was then substituted and the demodulated output observed on the waveform monitor.

For the Series B tests both 405-line and 625-line 'pulse-and-bar' generators were carried; arrangements were also made for mixing the 'pulse-and-bar' signal with the output from the video oscillator, so that the 'sound carrier' could

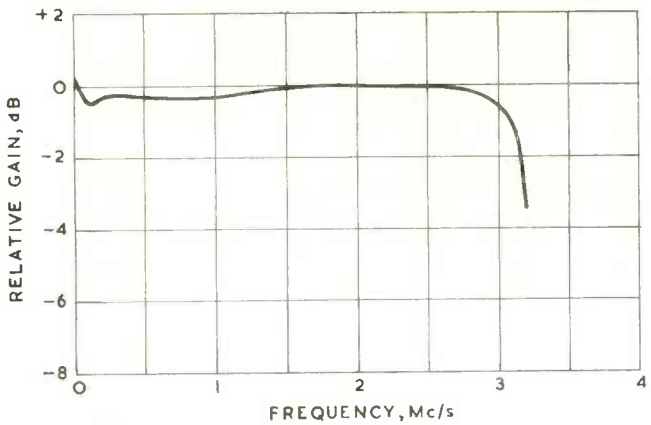


Fig. 7 — Overall modulation/frequency characteristic of Channel 1 receiver—Series A tests

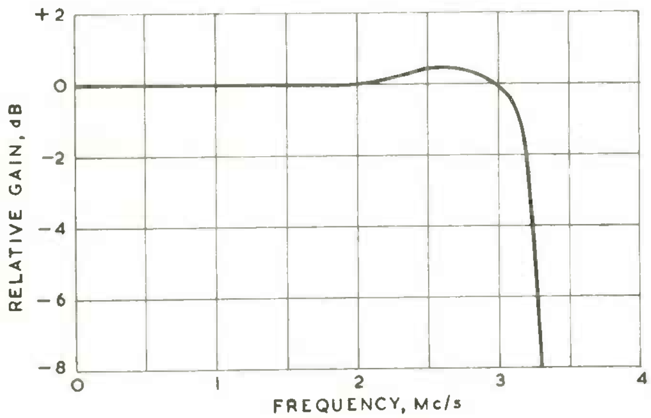


Fig. 8 — Overall modulation/frequency characteristic of Channel 1 receiver—Series B tests

be generated and used for checking the receiver tuning while measurements were in progress.

The signal generators were also used to provide a reference voltage when measuring the e.m.f. of the incoming signal.

4.8 *A.C. Power Supply*

All the equipment required a 240-V a.c. supply, which was obtained from the motor-driven alternator towed by the vehicle. This source of power gave rise to some effects which were not present when the equipment was operated from the normal mains supply; the principal defects were as follows:

(*a*) The waveform from the alternator contained a pronounced 12½ c/s component which was not completely removed by the smoothing circuits in some of the h.t. power units. The effect of this was particularly noticeable on the display monitors because it caused modulation of the line and field scan amplitudes, and steps had to be taken to remove this component from the supplies to these circuits.

(*b*) The frequency of the alternator was not locked to the field synchronizing pulses of the received signal, and any 'hum-bar' effect or scan displacement due to stray magnetic fields was made much more visible by its movement up or down the picture. Steps were taken to reduce these effects as far as possible, and it was found that they did not degrade the picture quality, provided that the alternator frequency did not depart too greatly from that of the field synchronizing pulses.

(*c*) At the beginning of the tests a petrol-driven alternator giving 3½ kVA output was used: this output was only just sufficient to operate the normal survey equipment and any additional load (e.g. the test equipment) caused a large drop in voltage and frequency. The voltage change could normally be compensated by the stabilizer, but the large frequency drop caused the effects noted in the previous paragraph to become obvious. A 6-kVA diesel-driven alternator with better voltage- and frequency-stability was therefore substituted.

(*d*) The ignition system of the petrol-driven alternator was well screened, but interference from this source was experienced in areas of low field strength, and it had to be moved some distance from the vehicle; this precaution was, of course, not necessary when the diesel alternator was in use.

5. The Mobile Laboratory as an Operational Unit

5.1 *General*

It has already been stated that the number of sites visited during the Series A tests was required to be at least 400 in order to give statistical validity to the results. During the Series B tests, it was necessary to revisit all the sites previously assessed during the Series A tests, although the duration of the Series B tests was less than half that of the first series. To meet this requirement, the arrangement of the equipment and the method of operating it were considered in some detail in order to secure the maximum operational efficiency.

The basic operations involved when testing a site were as follows:

(*a*) Raising and lowering the aerials and orienting them correctly.

(*b*) Carrying out the tests described in Section 2.

The operational methods of the Series B tests will be described and the improvements over the Series A methods discussed.

5.2 *Masts and Aerials*

During the Series A tests the sectional mast which carried the Channel 1 aerial was raised and lowered at each site, and considerable time was taken up in assembling the mast and aerial before the test and subsequently dismantling it. The use of two masts was adopted initially to prevent coupling between the Channel 1 and Band V aerials, but later tests showed that mounting the two aerials on the same mast had a negligible effect on their performance. During the Series B tests, both aerials were mounted on the pneumatically controlled mast. The Channel 1 aerial was so mounted that its element could rotate from a horizontal to a vertical position about an axis formed by the cross-member of the aerial assembly. When the mast was lowered a system of springs retained the aerial elements in a horizontal position. The weight of the feeder to the aerial was arranged to exert a couple in opposition to this spring system: as the mast was raised, the free length of

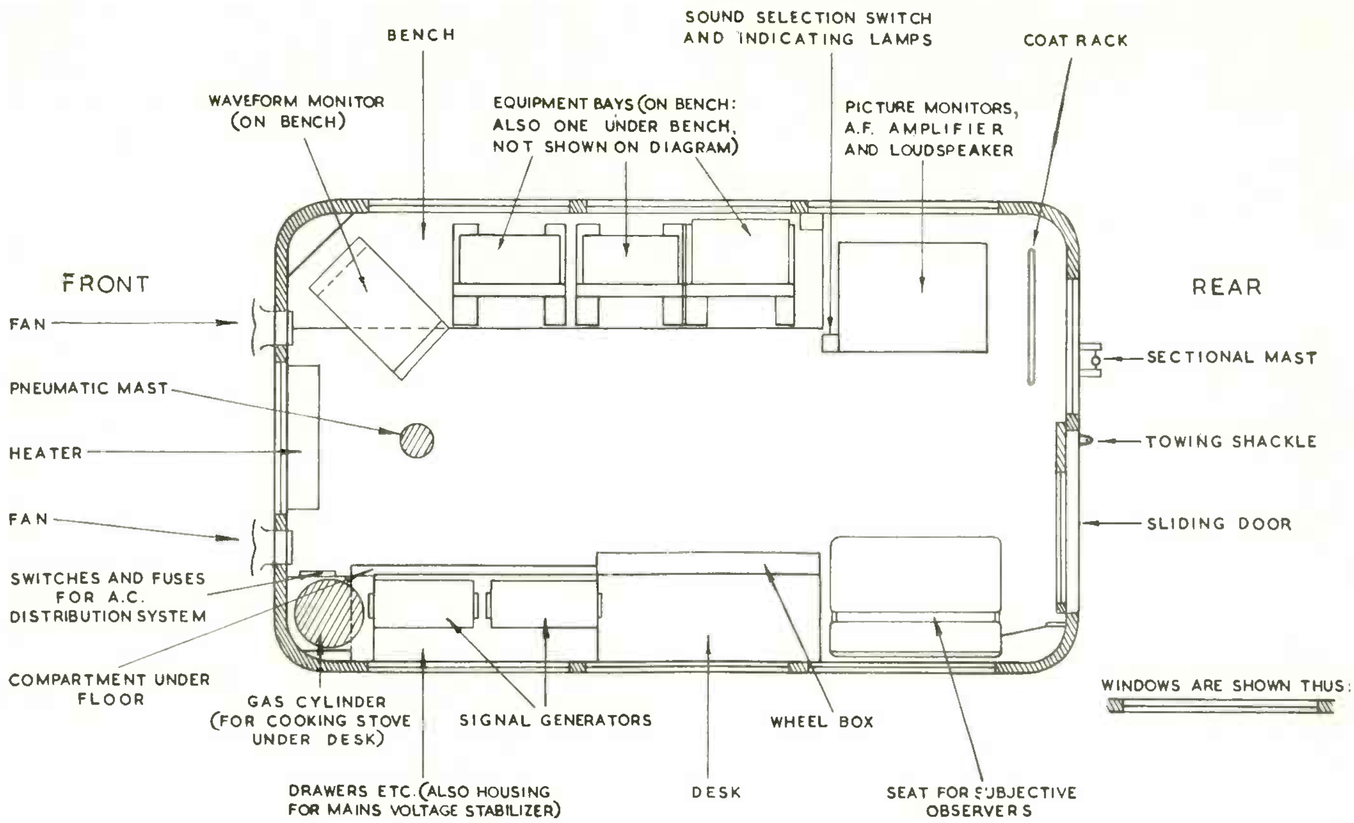


Fig. 9 — Plan of the mobile laboratory equipped for the Series A tests

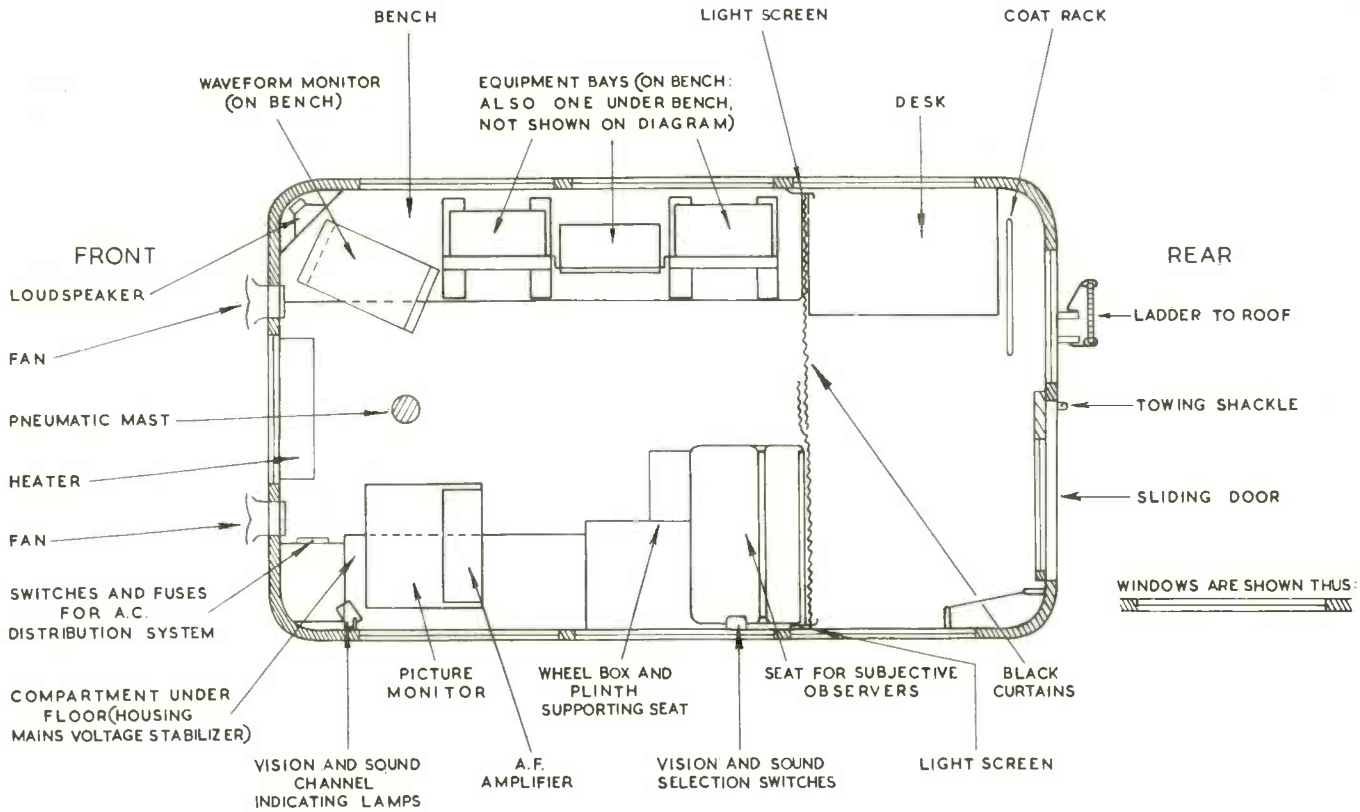


Fig. 10 — Plan of the mobile laboratory equipped for the Series B tests

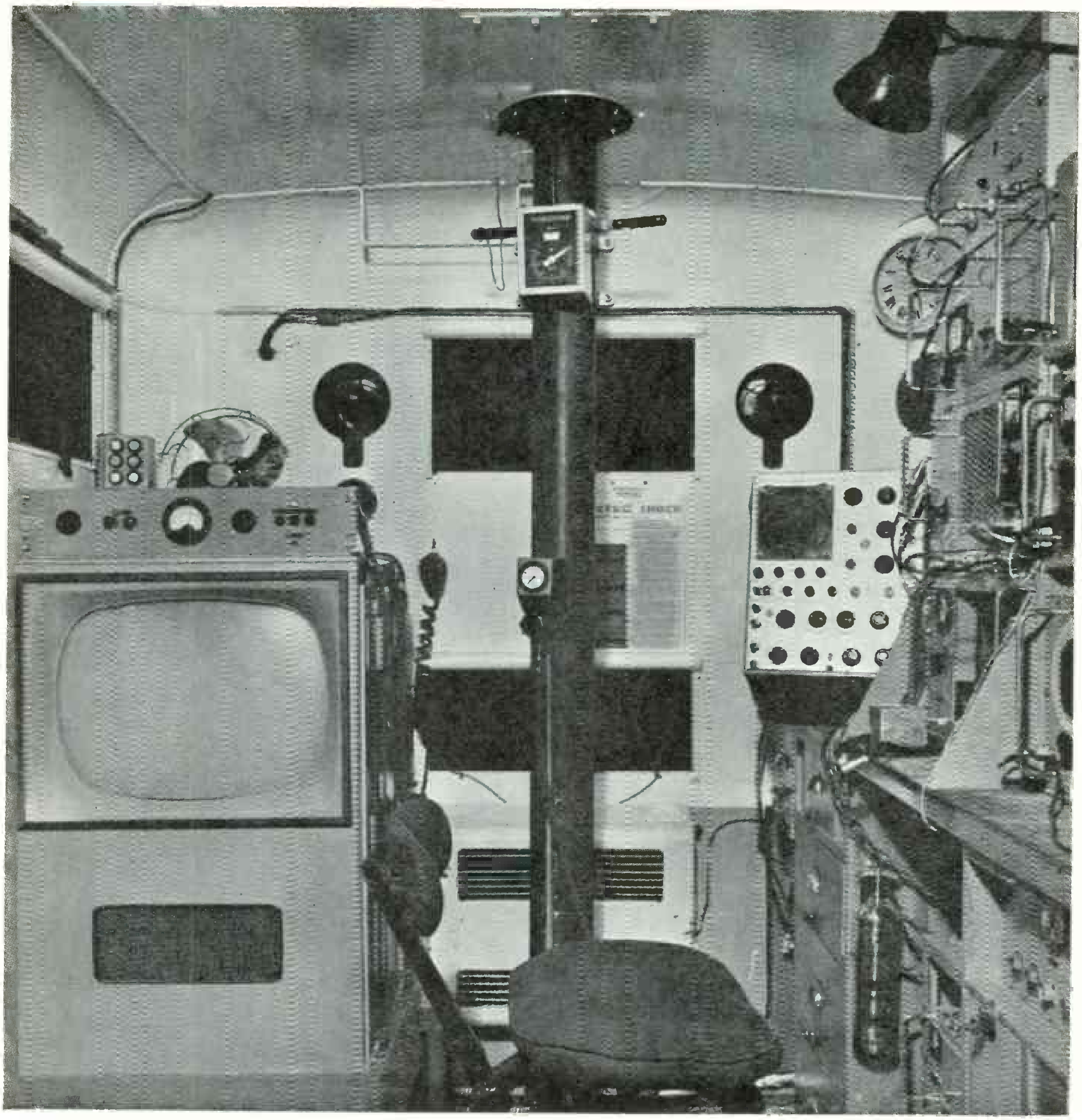


Fig. 1[illegible] — Mobile laboratory—view looking forward, showing picture monitor (left), pneumatic mast (centre), and waveform monitor (right) as arranged for Series B tests

cable increased and the couple became greater until it overcame the spring system and rotated the aerial into its vertical operating position. This was arranged to occur as the full operating height was reached.

Because the elements of the Channel 1 aerial overhung the roof of the vehicle when in the travelling position, they were clipped to wooden supports to prevent damage, and were further protected from branches of trees by angles members; these can be seen projecting over the driver's cab in Fig. 1.

The Band V aerial, which was mounted rigidly on the pneumatic mast, could safely be left on its mounting while travelling and, because the aerial cables could be secured from ground level, access to the roof was required only when the array required attention: the number of times that this was required was reduced by testing groups of

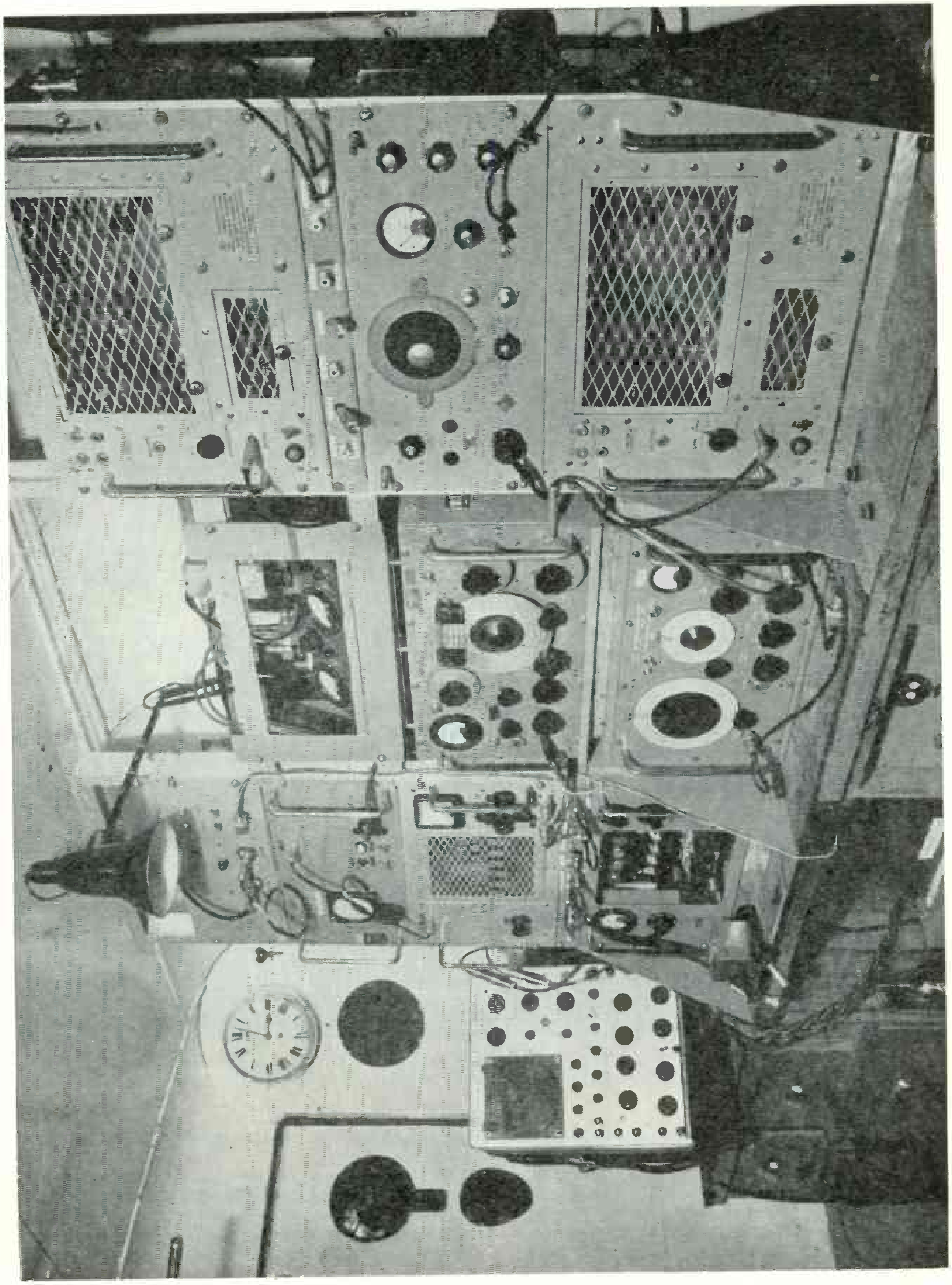


Fig. 12 — *Mobile laboratory—view of receiving and test equipment as arranged for Series B tests*

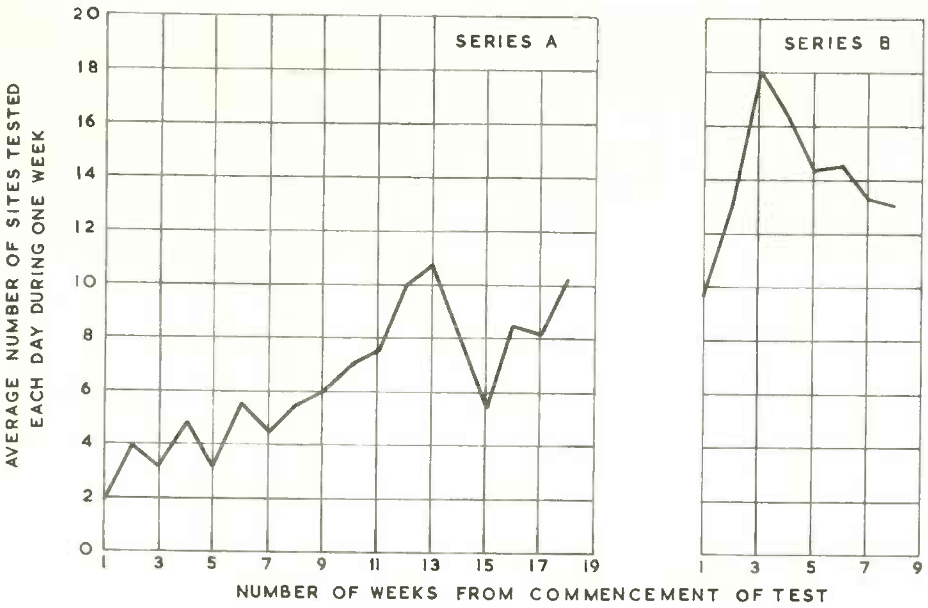


Fig. 13 — Average number of sites tested per day during each week

	Series A	*Series B*
Average number of sites tested per day during the last six weeks of each test	8·6	15·0

sites all requiring the same array. When not in use the one-array and four-array aerials were carried on the roof of the driver's cab (these can be seen in Fig. 1), and the two-array aerial was carried inside the vehicle.

5.3 *Arrangement and Operation of the Equipment*

The arrangement of the equipment for the Series A tests was designed to fit in with the existing permanent fittings installed in the vehicle. It became apparent during these tests that an improved arrangement leading to more efficient working could be obtained if the permanent structures were modified. Because the time allotted for the Series B tests was relatively short, these alterations were considered to be justified by the greater rapidity with which it was expected to be able to carry out a test.

The equipment layouts for the two series of tests are shown in Figs. 9 and 10. During the Series A tests the seat for the subjective viewers was near to the door of the working space of the mobile laboratory, and their work was interrupted when the door was opened: in the Series B tests their assessments could be carried out without disturbance. Figs. 11 and 12 show photographs of the interior arrangements for the Series B tests.

None of the equipment was designed for mobile use and it therefore had to be protected against vibration to minimize faults due to mechanical failure of components. Much of this equipment was mounted in 19-in. racks suitably installed to afford this protection, and was arranged to be accessible from one operating position: interconnection of units was facilitated by extending their input and output terminals to distribution panels. When possible, the equipment was allowed a generous warming-up period, in order to eliminate errors due to thermal drift, and for the same reason the equipment was run continuously while tests were in progress, even when travelling between sites, the generator being maintained in operation for this purpose.

Because of the lack of space in the vehicle, it was not possible to provide easy access to the rear of all units for maintenance, but they could be readily removed from their operating positions and the interconnecting leads were long enough for them to be operated in this condition. As far as possible all maintenance was carried out at base, where there were adequate test facilities, maintenance while away from base being confined to simple fault-clearing operations.

6. The Effect of the Equipment Arrangement on the Operational Efficiency

Fig. 13 shows the average number of sites tested per day during each week of the survey. The steady increase during the Series A tests as operational experience was gained can be clearly seen: the increase during the Series B tests is also apparent and the steps taken to increase the speed therefore appear to have been justified. Comments from the subjective observers confirmed that their work was on the whole made much easier by the arrangements adopted for the Series B tests, but that the provision of two display monitors (as in the Series A tests) would have made the comparison of the two pictures easier, particularly in the presence of intermittent interference. As only one monitor of the type used in the Series B tests was available, this arrangement was, unfortunately, not possible because it was considered more important to avoid differences which might be introduced into the display pictures by the use of two monitors having different characteristics.

Although the mobile laboratory travelled some 5,400 miles (8,600 km) during the survey, no major faults due to mechanical failure of components were encountered, and the measures taken to protect the equipment from vibration appeared to be adequate.

7. References

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