A FRENCH PORTABLE TV CAMERA

By J. POLONSKY*

A paper read to the Society on Thursday January 9th, 1958

Introduction

The more or less immediate future of television will no doubt be largely influenced by the technique of sound broadcasting development. For the present, sound broadcasting possesses two great advantages over television:

First: wire or radio links for transmission over long distances. To-day, it is quite natural for listeners to be in touch successively with New York, Paris, London or Tokio whereas TV long distance connections are only at the development stage, pending the advent of intercontinental liaisons with the aid of ionospheric and tropospheric propagation.

Second: the small weight and bulk of sound pick-up and transmission equipment enables the operator to be on the spot with the speed required by modern life.

To match this facility, it has been found necessary to develop a light portable TV camera associated with a self-contained transmitter. We know that this camera has not solved all the complex problem of mobile television but has made a modest step in that direction.

The pictures of one or several portable cameras can be passed by radio to a light reception-van. The latter can be considered either as a satellite of the normal OB van located in its neighbourhood or as an independent van directly linked to the studio by microwaves. The mobile operator walks or sits in a car, in a helicopter or in a plane

This paper is divided in three parts: the first describes the technical requirements for a portable and autonomous TV camera, the second is a discussion on the figure of merit of the principal parameters, and the third is a description of the French equipment, type CP 103, of the Compagnie Générale de T.S.F.

TECHNICAL REQUIREMENTS

The technical requirements which we laid down for such an equipment were:

1. The picture received by radio must be a fair reproduction of the original in spite of field fluctuations caused by the movements of the cameraman at the viewing point.
2. The synchronising signals in the mobile equipment must be capable of synchronising commercial receivers, either directly or with the insertion, of appropriate converters.
3. The range will be in excess of several hundred yards for a ground-to-ground or some ten miles in the case of an air-to-ground link.
4. The mobile equipment must meet ruggedness requirements compatible with its condition of use.
5. The portable part of equipment must be as light as possible and have an endurance of two or preferably four hours.

Many of these requirements are in some way contradictory. Miniaturisation being insufficient answer, it was necessary to consider a thorough and systematic simplification of the circuits.

Fig. 1 is a block diagram of a portable TV equipment without its sound accessories, which will be dealt with later. This equipment may include:

The hand-held camera, which will not exceed 2 or 3 pounds in weight.

All the camera and transmitter accessories weighing at most 30 lbs and portable, on the back of the cameraman.

The fixed receiver equipment, which can be the heaviest part and located in a van.

This leads to the following arrangement of the equipment:

The hand-held camera will include:

1. the analyser tube with its focusing and deflection coils,
2. a video pre-amplifier with a gain just sufficient to clear thermal noise and interference, in the camera cable,
3. an optical system, combined with the analyser tube,
4. a view finder of the simplest possible design.

The portable camera control-unit and RF transmitter

This, in any adopted solution, must contain the following parts:

* Compagnie Générale de T.S.F., Paris

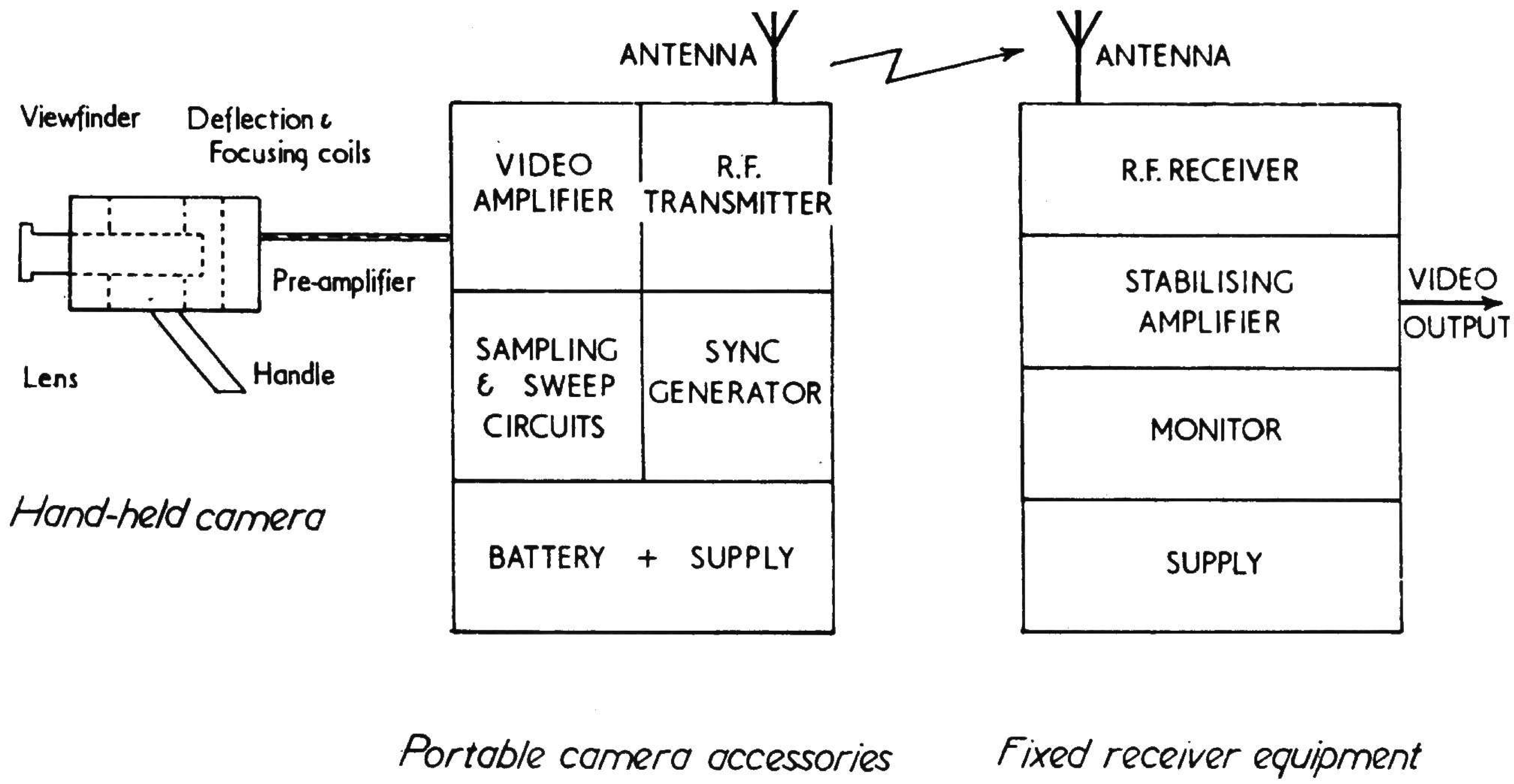


Fig. 1. Schematic diagram of the portable video chain

1. the video amplifier, with corrections,
2. the sweep circuits, for the analyser tube,
3. an interlaced synchronising generator,
4. the mixer for video and for synchronising and blanking pulses,
5. the video transmitter and aerial,
6. the power supply and battery.

The fixed receiver

Fundamentally, anything necessary for the proper performance of the system, and not located at the transmitter must be at the receiver end. This includes:

1. The R.F. picture receiver and aerial,
2. the stabilising amplifier with corrections for the luminance and of the synchronising signal,
3. the video monitor and scope,
4. the power supply.

The whole may be located in a van or in a trailer and occasionally with a microwave relay transmitter for connection to the studio for autonomous operation.

Sound accessories (Fig. 2)

These are basically:

1. the equipment for transmission of the sound commentary (the commentator being alongside the TV cameraman)
2. intercommunication by radio between the cameraman and the receiving van.

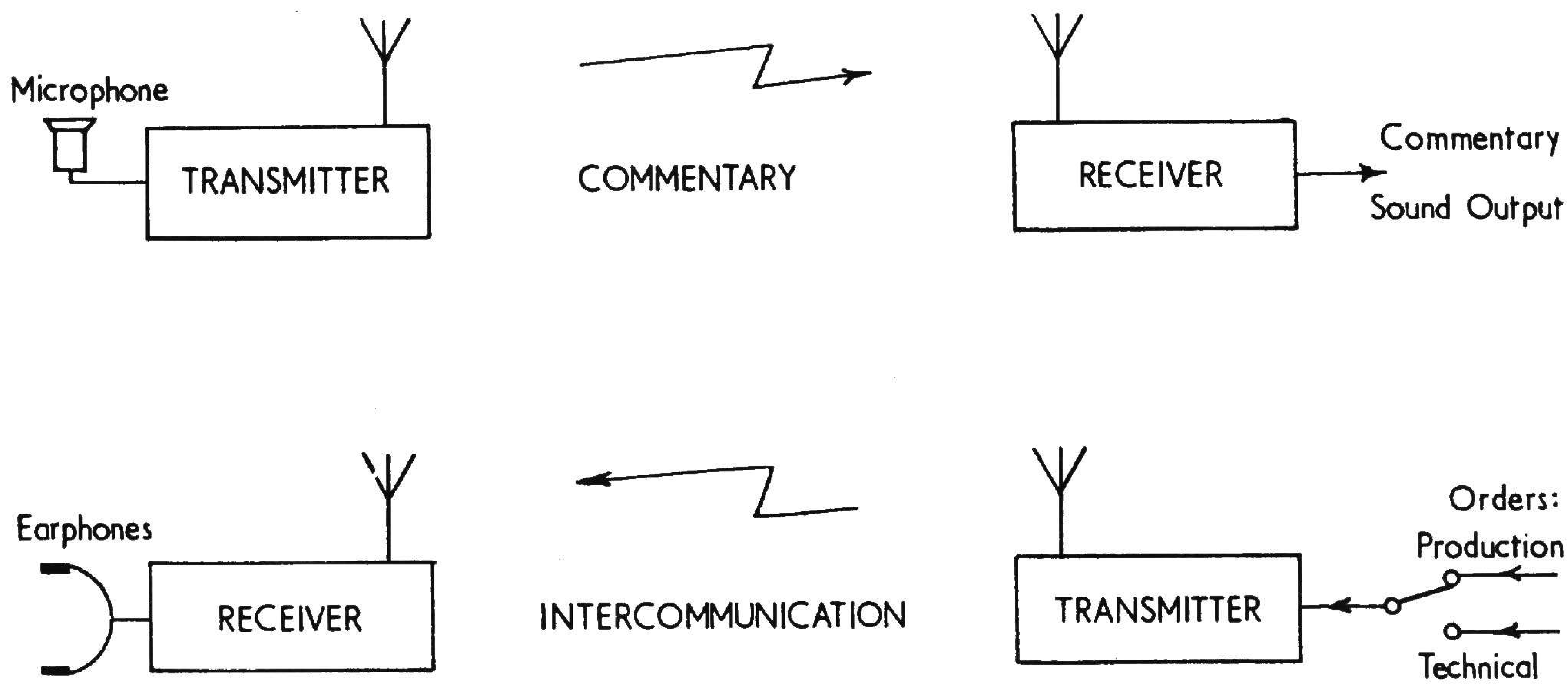


Fig. 2. Schematic diagram of the sound channel and accessories

The commentator carries a microphone, amplifier and transmitter as in normal sound OB, the receiver being located in the stationary van. For intercommunication the transmitter is located in the van and a light-weight receiver and earphones are carried by the cameraman.

The intercommunication unit can be unidirectional and used to transmit to the cameraman two types of information:

(*a*) orders from the producer for choice of pictures,

(*b*) orders from the technical control to improve the adjustments of focusing and aperture.

Occasionally, the commentary transmitter can be used by the cameraman as a service channel, in particular in the preparatory stage.

DISCUSSION OF REQUIREMENTS

Before describing the CP 103 equipment of CSF, I should like to explain why we have adopted certain solutions and rejected others.

First, it was necessary to make a choice on the following:

1. camera tube,
2. extent of the transistorisation,
3. type of picture transmitter (frequency, power, type of modulation and aerial)
4. power supply.

Camera tube

As regards the camera tube, we would have liked a tube combining the small size, simplicity and ruggedness of the Vidicon with the sensitivity of the Image Orthicon. Unfortunately there is no such tube at this moment, and so we could only consider the Vidicon. For obvious reasons, we were tempted to take the half-inch tube, but this would have meant a substantial sacrifice of horizontal resolution (350 instead of 650).

We did not wish to miniaturise whatever the cost and, so long as weight and size were not prohibitive, we went for quality. The matter would need reconsideration if the performance of the half-inch Vidicon in this respect should be improved in the future, as we hope it will be.

Transistorisation

It is highly desirable to transistorise to the utmost, but experience has shown that great circumspection is necessary in this field for the following reasons:

1. There must be absolutely no sacrifice of reliability. The transistors used in such an equipment must meet the most severe requirements, both from the technical and from the climatic point of view.
   In the video section of the equipment, the transistors used are of the low-noise, wide-band type and are sometimes required to handle quite a fair amount of power. In the transmitter R.F. stages, the problem is even more difficult to solve at present.
   As regards temperature, the equipment may be required to operate at temperatures ranging from -20 or $-30°$ C to $+40°$ and even $+50°$ C.
2. Also, there should be no misconception as to the advantages to be gained by only partial transistorisation.

The ratio of the power consumption between the conventional valve and the transistor is so great that it is impossible, so long as a few valves remain in the circuits, to replace accumulators by dry batteries. The Vidicon alone already uses a far from negligible amount of power; the same applies to the R.F. transmitter.

Hence we have transistorised the power pack and the synchronising generator. A more thorough transistorisation is under development, but so long as all the elements of quality, reliability and appreciable saving in weight and size are not catered for, we consider it premature to adopt a fuller transistorisation.

Transmitter

Turning now to the transmitter, the following features had to be examined; wavelength, power, type of modulation and aerial.

The wavelength

We had the choice of metric, decimetric and centimetric waves; these have their specific advantages and disadvantages.

Metric waves are more favourable as regards propagation in the presence of obstacles. Limited directivity being imposed, it is relatively easier to obtain a good figure of merit for the radio link on metric waves than on shorter waves.

Centimetric waves present the following features:

reduced occupation of the ether (more easily obtained allocation)

less danger of interference and absence of static, allowing of the use of a smaller figure of merit for the radio link,

possibility of using frequency modulation, particularly advantageous for a mobile TV link, by the use of klystrons and by virtue of the larger waveband allocated in that band.

Decimetric waves present similar advantages or disadvantages when the lower or upper band is considered respectively.

On the whole, the wavelength does not appear to affect weight and size to any appreciate extent.

Thus each of these bands offers major advantages and disadvantages, and the choice will depend on the operating conditions.

In the present version, the mobile equipment operates in the band of about 200 Mc/s, but a 7000 Mc/s equipment has been developed and used experimentally.

The power problem

For a ground-to-ground range of 300 to 400 yards, a power of 100 to 200 milliwatts appears sufficient for the metric band. On centimetric waves, a power of 10 to 20 milliwatts gives equivalent results.

In the case of ground ranges of several miles, or of some tens of miles from an aircraft, about 5 watts are necessary on metric waves and some hundreds of milliwatts on centimetric waves, when there are no obstacles in propagation.

As regards the type of modulation, the advantages of frequency modulation as against amplitude modulation are self-evident in the case of a mobile TV link, unavoidably subject to large field fluctuations at the receiver. For the centimetric waves, we have adopted frequency modulation, whereas in the CP 103 equipment, operating on metric waves, amplitude modulation has been adopted and in that case it is essential to provide the receiver with a very effective and quick-acting anti-fading system.

The transmitter aerial

The horizontal radiation diagram of the mobile transmitting aerial must be omnidirectional, with moderate directivity in the vertical plan.

For the metric waves, we have adopted the quarter-wave vertically polarised aerial fixed to the transmitter unit. In the case of the centimetric waves, satisfactory results were obtained with an " helical " aerial. The aerial has to be suitably matched to the transmitting feeder in order to be able to connect it to the transmitter by a relatively long cable, in the case of operation in an aircraft.

A serious question then arose: what would be the effect of room reflection on the radio signal?; would multiple path reception make the picture unusable?

Experience has frequently shown that with a careful study of the receiving aerial, of its radiation diagram, and sometimes by using a number of receiving aerials located at different points, it has been possible to secure good reception without troublesome echoes.

For instance, in the case of the TV broadcasts of the August 1956, national conventions in USA of the Democratic Party at Chicago and of the Republican Party at San Francisco, most of the pictures were taken inside the hall whose dimensions were about 300 by 600 feet. The pictures supplied by the portable camera were incorporated in an overall programme and broadcast over the whole of the C.B.S. TV network.

A large number of transmissions have since been made with this type of equipment, in France and elsewhere, by an operator walking round, or in a car, a boat or an aircraft (Fig. 3).

Power supply

The power requirements for this complete mobile equipment are about 50 watts. The silver-zinc battery offers at present maximum ampere-hours per pound of weight. For a 4 hours endurance, a

Fig. 3. The complete portable equipment CP 103 in action. See also the picture on the front cover

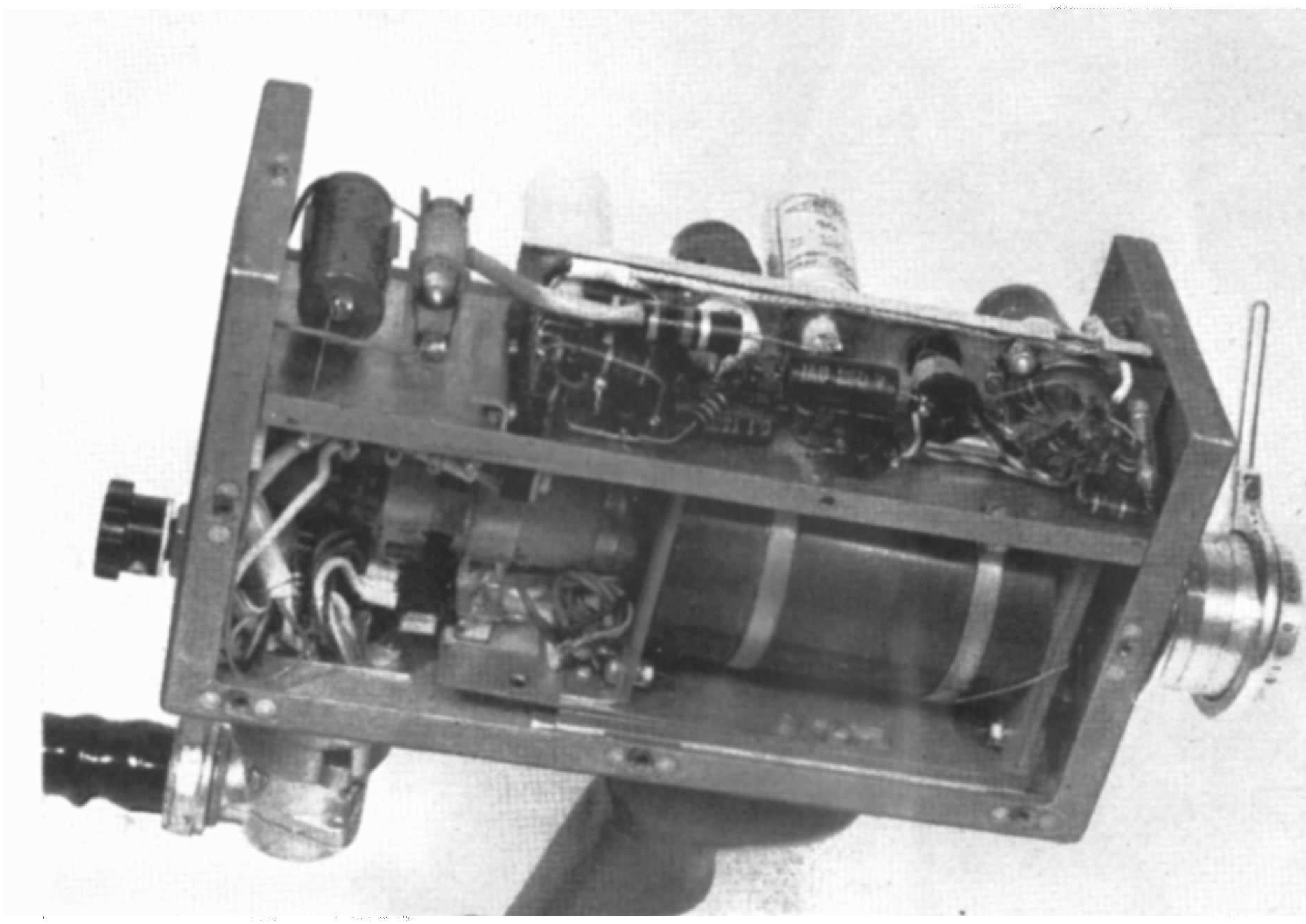


Fig. 4. Interior view of camera, showing the Vidicon

20 ampere-hours 12 volt battery has been adopted.

Power for the filaments and for the focusing coil is taken directly from the battery, while that for the high voltage and grid bias is obtained through power transistors and germanium rectifiers.

DESCRIPTION OF THE CP 103 EQUIPMENT

The camera, the camera control unit and the transmitter use 12 valves altogether, the power supply and the synchronising generator being transistorised.

The camera, whose dimensions are 85 by 110 by 190 mm weighs some two-and-a-half pounds, and is connected to the control unit by a multicore cable. Its accessories are arranged in two small units fixed to a frame and provided with a strap.

The whole equipment weighs about 29 pounds and can be carried by a cameraman.

The camera (Fig. 4) consists of:

(*a*) a Vidicon tube, type RCA 6198, or similar, with its carriage, deflection and focusing coils,

(*b*) a low-noise cascode, an amplifier and a cathode follower output stage,

(*c*) a standard 16-mm cinema lens of 25 to 160 mm focal length or, when required, a zoom lens variable from 25 to 100 mm,

(*d*) an optical 16-mm cinema viewfinder.

The aperture and focus adjustments have been designed to facilitate their operation, and in addition the cameraman can improve the adjustments from indications received over the service channel.

The camera is provided with a single electrical control from electrostatic focusing: it is set when the equipment is put in operation. An automatic device for stabilising the Vidicon focus with respect to battery voltage makes adjustment unnecessary when the camera is in use.

The camera control unit and accessories

This unit comprises:

1. *The transistorised synchronising generator* which consists of a crystal oscillator on frequency $2f$ (f is the line frequency) and of several re-injection binary counters whose combinations depend on the particular standard used. Thus, for the 405-line standard, the counter combination is $15 \times 3 \times 3 \times 3$ for the 625-line standard it is 125×5, and 63×13 for the 819-line standard. The synchronising generator provides three types of pulses required for synchronising the blocking oscillators which deliver the basic signals; line and frame synchronising blankings.

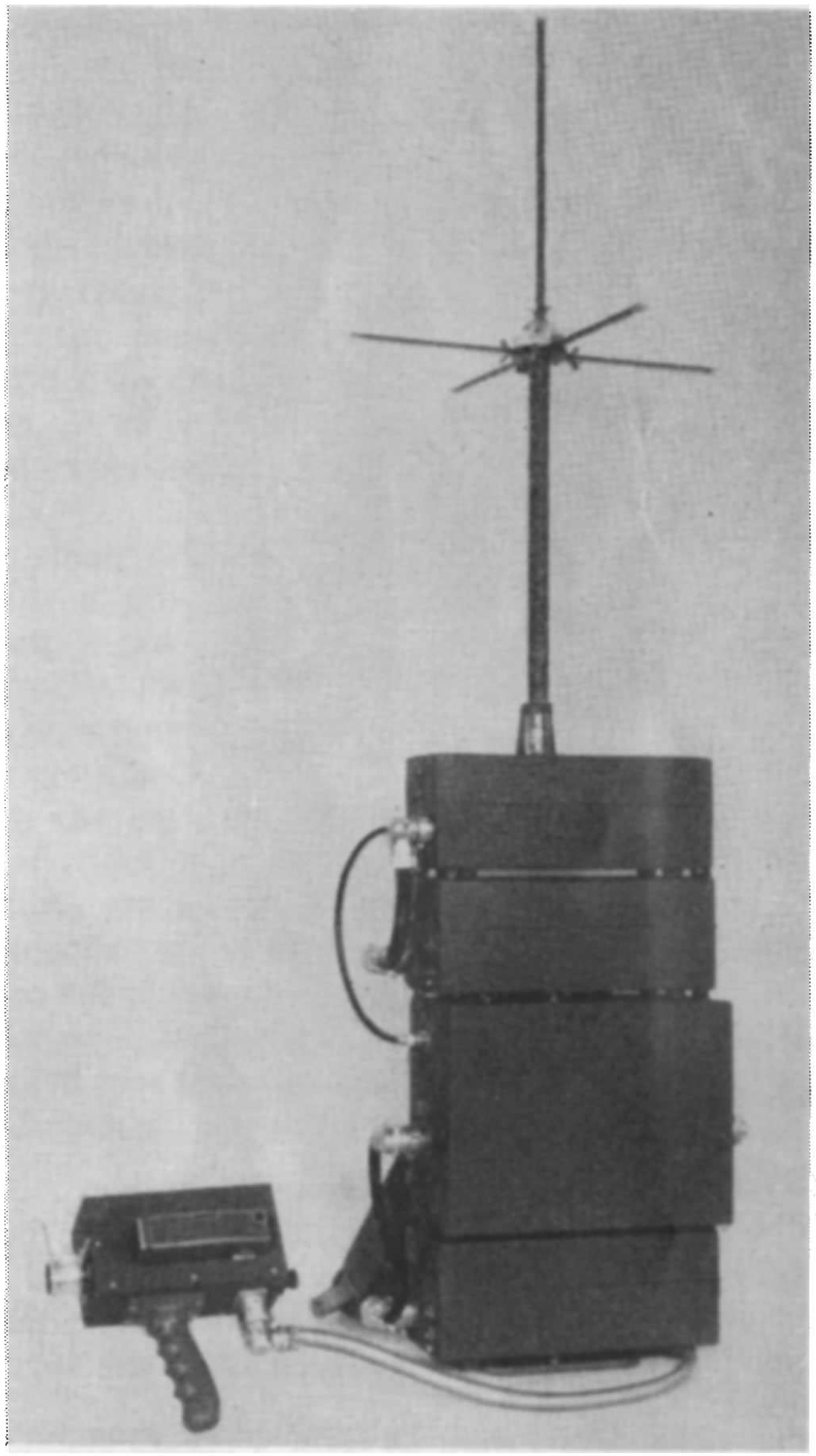


Fig. 5. View of portable equipment with 5 kW transmitter

2. *Shaping and sweep circuits*
   A blocking oscillator and an amplifier provide the horizontal sync and blanking pulses and the sweep signal for the Vidicon.

   The front porch of the horizontal blankings is obtained by clipping the positive pulse and selecting the negative one obtained from a transformer ringing on its natural frequency. The latter is triggered by the horizontal blanking pulses.

   The sync blankings and sweep on the frame frequency are obtained in a similar way.

The video amplifier consists of two stages with corrections. Blankings are mixed with the video signal in a next stage. A cathode follower delivers the complete video signal of 1 volt peak to peak, the sync signals being introduced in this stage.

This output can be used for monitoring or for close-up circuit.

In order to simplify the optical adjustments by the cameraman, an automatic control of the target voltage by the video level was introduced.

The VHF *transmitter* consists of two valves, one of which is an oscillator of about 200 Mc/s.

The synchronising pulses are applied negatively to the oscillator grid which is therefore blocked for the duration of the pulses. A R.F. amplifier stage is grid-modulated by the video signal.

The output R.F. circuit feeds a quarter wave antenna through a matching unit, and an artificial earth at the lower part of the radiator stabilises the aerial impedance.

The radiating element and the artificial earth consist of flexible bands designed to facilitate transport.

In the microwave transmitter, the two R.F. valves and the V.H.F. aerial are replaced by a 100-milliwatt reflex klystron and by a microwave "helical" antenna. The klystron is frequency-modulated by the complete video signal.

5-watt transmitter (Fig. 5)

The 5-watt V.H.F. transmitter is a small unit developed for a larger ground range and for an aircraft connexion. It consists of an oscillator stage, a buffer and a grid modulated amplifier. The video amplifier driven by the complete video signal from the camera control unit consists of 3 valves.

The 5-watt unit includes a power pack similar to that used in the portable camera. The whole unit weighs about 18 pounds and can be fixed to the same frame as the camera control equipment. It can be separated from the camera control by a relatively long cable, for airborne or car operation.

THE RECEIVER

Let us now consider the receiving equipment. This is mounted in a light stationary van and consists mainly of:
(*a*) the radio receiver with its aerial and feeder,
(*b*) the stabilising amplifier,
(*c*) the picture monitor.

The V.H.F. *receiver*

The R.F. circuits use a low-noise cascode arrangement, a crystal oscillator and an I.F. cathode-follower output stage.

The I.F. amplifier uses valves of variable slope and has the normal selectivity of a high fidelity TV receiver.

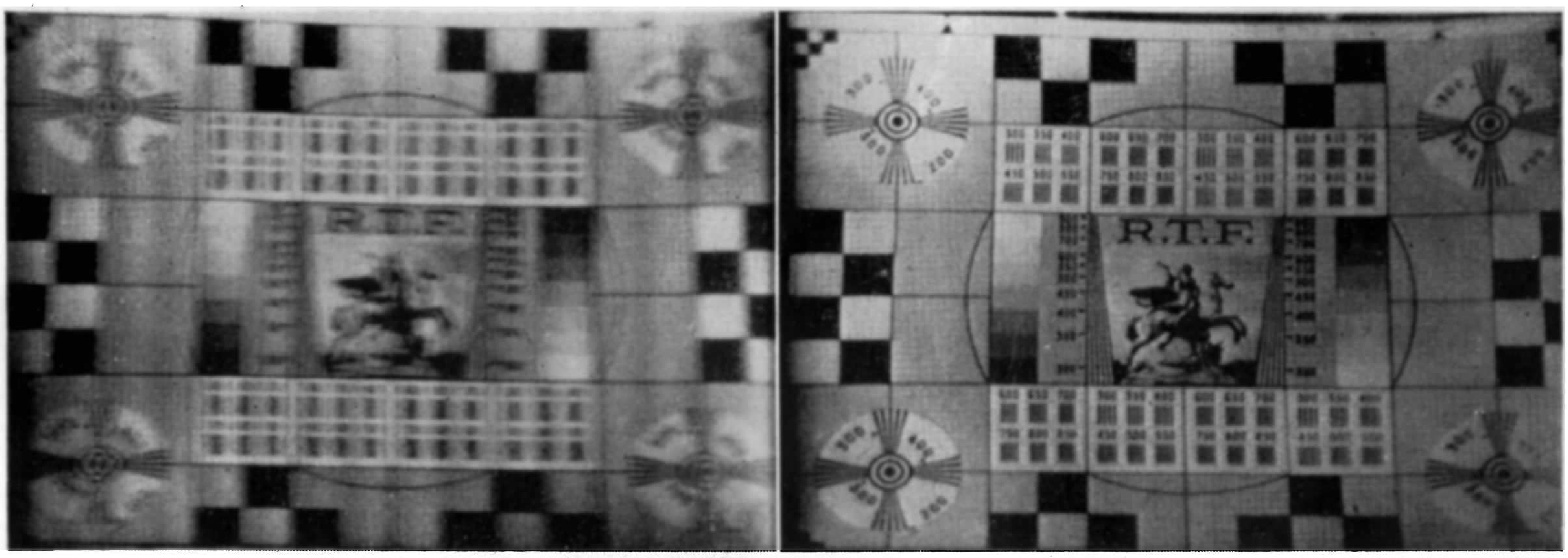


Fig. 8. Left: Test card on receiver with heavy interference, before stabilising; Right: The same pattern after stabilising.

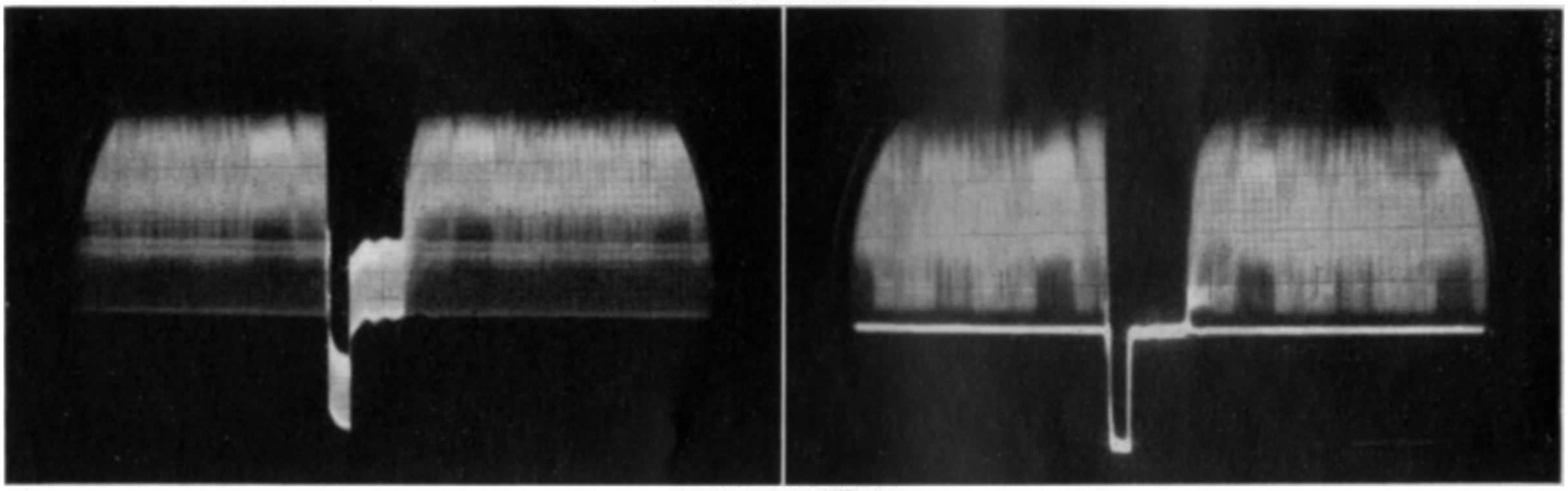
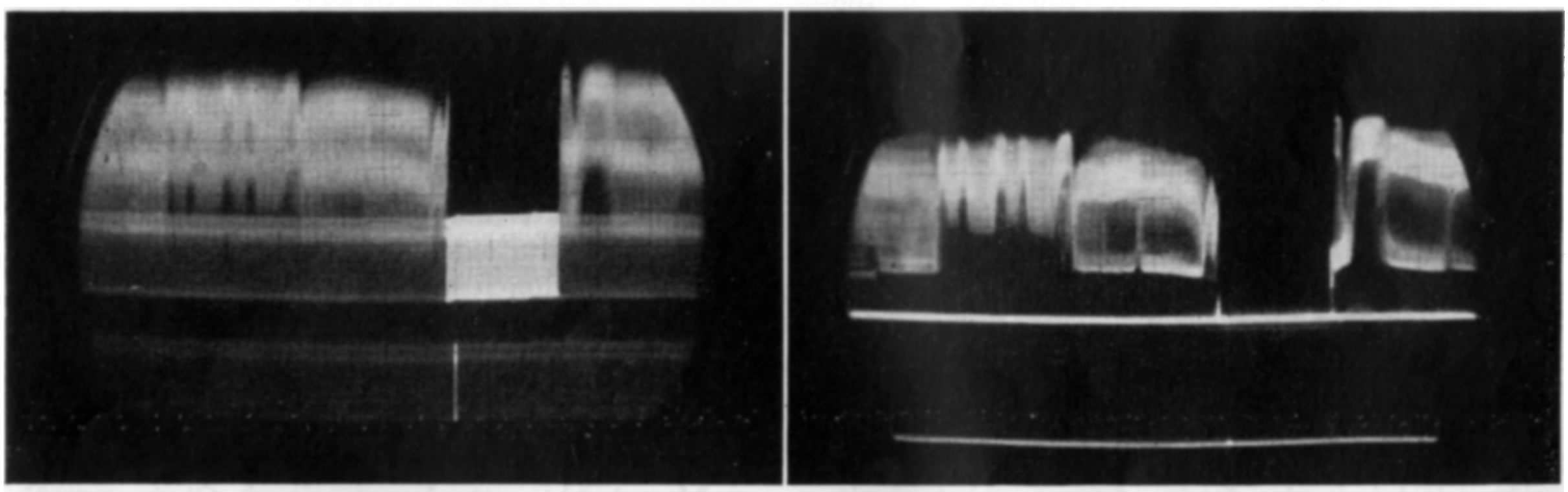


Fig. 9. Video signal corresponding to the two pictures shown above: line waveform.



Frame waveform corresponding to the two top pictures shown in Fig. 8.

The video signals feed three channels:
(*a*) a video amplifier including a black level clamp
(*b*) a generator of keying pulses for clamping,
(*c*) the clamped automatic volume control channel.

The error signal of the A.V.C. is proportional to the amplitude of the sync pulses and not to the mean value of the video signal.

Field strength fluctuations of 30 dB are reduced to 3 dB by the A.V.C.

Microwave receiver

This is the receiving part of the standard mobile link TM 110 of CSF, regularly used in TV OB work (Fig. 6).

This equipment consists of:
- a klystron local oscillator,
- a crystal mixer,
- an IF amplifier with 90 dB gain and a $\pm$ 14 Mc/s bandwidth with AVC,
- two limiter stages,
- a wide-band video discriminator followed by a video amplifier.

Field strength fluctuations of 20 or 30 dB have practically no effect on the quality of the video signal by use of frequency modulation and automatic volume control.

The stabilising amplifier (Fig. 7)

The improvements by the stabilising amplifier are:
(*a*) Gamma-correction in order to enable a good mixing with Image Orthicon cameras.
(*b*) Aperture correction of the Vidicon. It is normally introduced in the camera control unit but omitted in the portable camera for reasons of size and weight.
(*c*) Readjustment and stabilisation of the black level in order to secure the best of the luminance characteristic.
(*d*) Regeneration of the sync and blanking pulses in order to obtain noiseless signals and by better calibration to approach standard equipment signals.

In conclusion, the stabilising amplifier consists of two channels:
- the video chain with the corrections of gamma, aperture and black level,
- the second one provides sync and blanking regeneration.

Figs. 8 and 9 show the efficiency of the stabilising amplifier in presence of heavy interference.

A genlock is in development as an accessory, in order to enable the signals from the mobile cameras to be mixed with those from the studio or van without causing any disturbances in the home receivers, during switch operation. This genlock is associated with the stabilising amplifier. It generates sync pulses for locking the central sync generator to the portable camera.

Fig. 6. The microwave receiver and aerial used in the mobile link.

In this case, the regeneration of sync signals and blankings of the stabilising amplifier are not useful.

The picture monitor is a standard equipment. It controls by switching the input or the output signal of the stabilising amplifier.

CONCLUSION

I think that in the next few years this type of equipment will be further developed to take advantage of improved analyser tubes and transistors. The interest that the CP 103 camera has awakened in various countries in a relatively short time shows that it meets a real need. The introduction of a portable and self-contained television camera may deeply modify the technical facilities available to the producer and enable him to apply his artistic talent in organising a novel programme technique.

My thanks are due to your Chairman for organising this lecture, and in particular to Mr.

Farmborough and his colleagues of the BBC for their assistance in preparing the practical demonstration.

I am also pleased to mention the C.S.F. engineers who have participated in the development of the equipment, particularly MM. Roger Fontenit, Raymond Cahen, and Jean Le Cam who were concerned with the video side and MM. Claude Babillon, Gérard Melchior, and Guy Plottin, who were responsible for the R.F. part of the equipment.