Behind The Cameras: No. 2

THE EMITRON CAMERA

John Trenouth (Senior Curator of Television at the National Museum of Photography, Film & Television, Bradford) provides a definitive guide to the Emitron camera and its many variants

The Emitron cameras featured on page 61 of issue 22 of *405 Alive* and described in the caption as being 'modified' are in fact Super-Emitrons. During the 1930s and 40s several variants were made based on the original Emitron tube and there is often confusion when identifying early television cameras in photographs.

The Emitron tube

The Emitron tube is EMI's variation of the Iconoscope camera tube developed by Vladimir Zworykin at RCA. Both were developed during the early 1930s and the similarities between the two have led to suggestions that the EMI tube was a copy of the RCA one and that EMI was dependent on the American company for know-how during the development.

In fact this was not the case. The similarities exist because the technology of the 1930s did not allow the construction of a transparent photo-mosaic.

Later camera tubes such as the Image Orthicon (1946) and vidicon (1950) had transparent target plates allowing the electron gun to scan the target from behind and therefore normally (i.e. at right angles to the target – hence the word Orthicon.)

The lack of a transparent target meant the Emitron tube had to scan the target from the front and to prevent the electron gun getting in the way of the light coming through the lens, it had to be offset as shown in the diagram (fig. 1).

How the Emitron works

Light from the scene is focused on to the target by the camera lens through an optically flat 'porthole' window. The target comprises a thin insulating sheet of mica with a plain metallic backing called the signal plate. On the front surface is a very thin layer of photosensitive material (silver-caesium) which has been ruled in a grid to produce a 'mosaic' of thousands of individual photosensitive cells. These individual cells become electrically charged in proportion to the intensity of the light falling on them – hence the image of the scene is converted into an electronic image on the target.

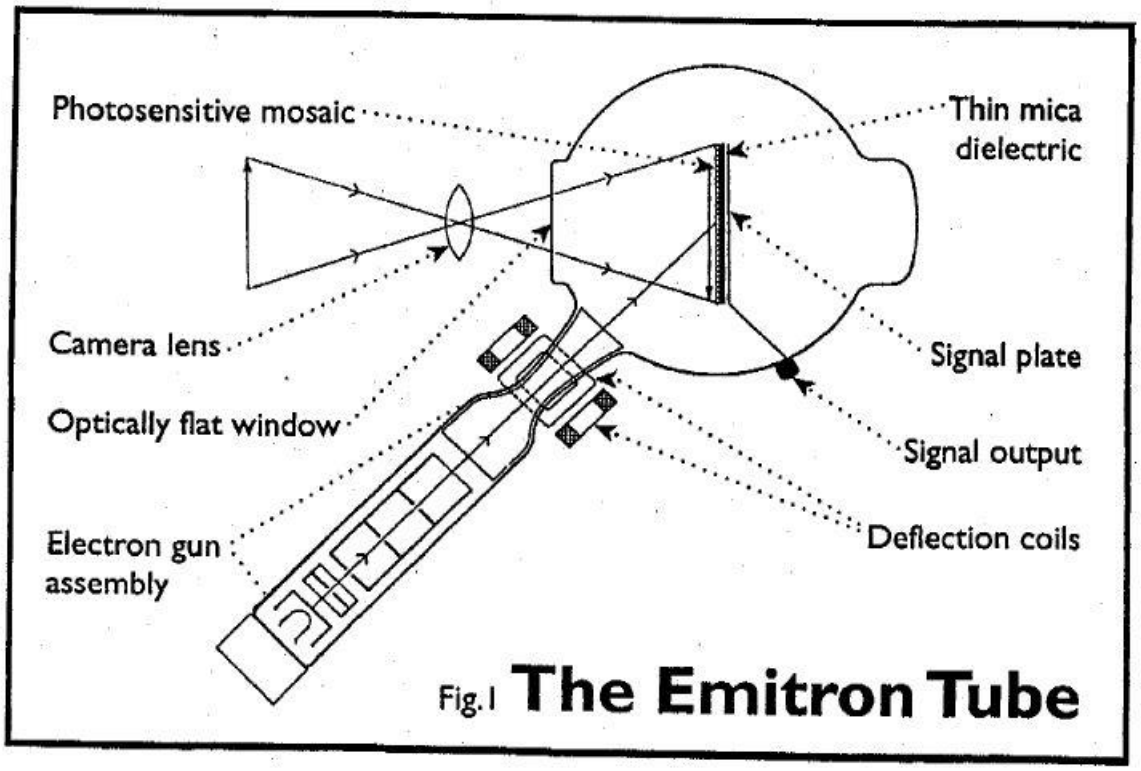

Fig.1 **The Emitron Tube**

A finely focused beam of electrons produced by the electron gun is then swept or scanned across the target forming the familiar 405-line raster and discharging each of the individual cells in turn. Each successive discharge of the cells on the front of the target produces a corresponding electrical impulse (because of capacitive action) on the signal plate behind the target. These impulses, after suitable amplification and combination with synchronising pulses, form the television signal.

Limitations

There are a number of inherent limitations in the operation of the Emitron tube, including the following:

i) Scanning geometry and focus – because the electron gun has to be off-set and does not scan the target at right angles, the scan at the top is naturally wider than at the bottom and so geometry correction had to be included in the scanning circuitry. Similarly the electron beam focus has to be varied from top to bottom of the scan to allow for the greater distance from the gun to the top of the target.

ii) Optical problems – the main part of the Emitron tube is not a tube at all, it's a sphere to help cope with the high vacuum inside, consequently there is a substantial distance between the back element of the camera lens and the target. This means that the image on the target is quite large (compared to later devices). Because of the inverse square law of light, a big image like this is very faint and so the Emitron is very insensitive, so much so that studio cameras were always run with the lens iris wide open – this in turn gave very shallow depth of field.

iii) Shading – unlike later camera tubes, the Emitron's electron beam has a high velocity and thus produces unwanted secondary electrons at the target. This secondary emission produces unwanted signals in the tube which cause amongst other things shading problems. Although an Emitron camera with the lens 'capped' should in theory, like all cameras, produce an even black on the monitor screen, in reality it produced an image which was black in the top left of the screen gradually changing to white in the bottom right of the screen. When pointed at a scene, the camera superimposed this shading on top of the image. Indeed if the lighting was poor and the tube beam current was increased to compensate, the shading problems swamped the picture. To overcome this, sawtooth and parabola shading correction waveforms were generated in the camera control unit and could be applied both horizontally (line shading) and vertically (field shading).

When a single television line was viewed on a waveform monitor, the sawtooth shading correction caused the waveform to 'tilt' and the parabola caused it to 'bend'. As the brightness of the scene changed, so did the degree of shading and so the 'racks engineer' was born – continually adjusting the 'tilt and bend' controls during the programme to maintain correct shading.

iv) Colour response – the colour response of the Emitron was determined mainly by the chemicals used in the mosaic. Unfortunately the early Emitrons had a peak in their response at the red end of the spectrum thus giving monochrome images of unnatural contrast and heavy makeup had to be worn by artistes to compensate. Red costumes had to be avoided as the clothing often seemed to disappear when viewed by an Emitron giving unexpected and striking results. The colour response also varied from tube to tube making camera matching difficult.

External variations:

1) The first batch of cameras supplied by EMI to Alexandra Palace, like the prototypes, did not have viewfinders. To check that the picture was in focus the cameraman had to peer through a tiny spyhole near the front of the camera which allowed him to see the very faint image on the front of the target plate inside the Emitron tube. Although this method was perfectly adequate for the laboratory bench, it was hopeless for studio use and a solution was urgently requested. These early Emitrons are instantly recognisable because the cameras only have a single lens (fig. 2).

2) All subsequent Emitron cameras were fitted with optical viewfinders screwed to the side of the camera. These comprise a ground glass screen displaying the image produced by a lens identical to the camera lens. The two lenses were mechanically linked ensuring that the viewfinder focusing accurately tracked the camera focusing and that the width between the two lenses was reduced during close-ups to reduce the parallax error. Cameramen soon got used to the fact that the image in the viewfinder was both upside down and back to front (and in colour!). The familiar twin lens version of the camera remained in use into the 1950s. (fig. 3).

3) The first experimental Emitron tubes capable of producing acceptable pictures were manufactured in early 1934 and within two years EMI were producing them in the quantities to sustain the fledgling TV service from Alexandra Palace. Tube design was however the subject of continued development and early in 1937 it was discovered that the picture definition could be enhanced by improving the focusing of the scanning electron beam: In turn this necessitated a longer electron gun assembly. Existing Emitron cameras were returned to EMI for modification, and all subsequent cameras were built to accept the long gun tubes. Soon all Emitron cameras had the extended casing below the lens assembly (fig. 4).

4) By the end of 1937 EMI had developed a new type of camera tube, the Super Emitron (known in the USA as the Image Iconoscope and in a version made by Pye as the Photicon). The new tube had an additional photocathode designed for maximum emission of photo-electrons which are then detected in the normal way. This tube had a sensitivity about five times greater than the standard Emitron as well as a much smaller optical image size thus allowing long focus lenses to be used.

The Super Emitron camera is instantly recognisable because of the odd bulge on the side of the case (fig. 5). The additional electronic image section on the front of the tube causes a slight image rotation within the tube itself. To compensate for this the entire tube assembly, complete with its scanning coils, is rotated slightly the other way. Thus the end of the electron gun, instead of sticking out below the lenses as in the standard Emitron, sticks out slightly to one side. The Super Emitron was in use from 1937 up to the early 1950s and a number of different case styles were evident during this period. The photograph in the last issue shows two styles, the centre Super Emitron has a different case style to the other two. The furthest camera has its rear cover removed and the cameraman is looking at the bulb of the Super Emitron tube. The nearest camera has long focus (12-inch) lenses fitted whereas the centre camera has the standard (6-inch) lenses fitted.

Note that the physical design of the Super Emitron prevents the use of a 'turret' of lenses so common in later cameras. Apart from the problems of the shape of the front of the casing, the turret would have had to carry matched pairs of lenses, one for the camera and the other for the viewfinder.

EMI also developed a 'midget Super Emitron' but I know of no surviving example, perhaps someone can enlighten me?

5) The Photicon tube, developed by Pye, employed the same principal of operation as the Super Emitron but in a more compact design. This permitted the camera to adopt a box shape allowing a lens turret to be fitted (fig. 6). The Photicon camera also had a motorised lens iris control – so for the first time variations in brightness were accommodated by iris adjustments rather than electronic gain adjustment which improved both signal to noise ratio and depth of field. This camera also had another feature never seen before, an electronic viewfinder (although the manufacturers were so worried about reliability that they also fitted emergency hinge-up 'aiming sights' to the top of the camera). Some cameramen found the new viewfinders difficult to get used to after the optical Emitron ones. A reprimand from management finally stopped the practice of "Modifying the viewfinder scan connections to give an inverted picture".

On the 9th February 1949 during an Outside Broadcast from the Albert Hall, a Pye photicon became the first television camera to be fitted with a zoom lens. The lens specially developed from work done by Siemens during the war was designed and built by W. Watson & Sons and had a 2:1 ratio.

6) On the 29th February 1948 the Olympic Games coverage from Wembley utilised a completely new camera from EMI. This used a camera tube called the CPS Emitron (standing for Cathode- Potential Stabilised Emitron). This should not be confused with the other Emitron types already described – this tube is a form of Orthicon, the forerunner of the well known Image

Orthicon tube which was to dominate all future monochrome broadcast camera design. But that's another story.

Where are they now?

Of about 30 Emitrons/Super Emitrons made, one complete standard Emitron camera chain has survived and is in the Nation's collection. There are a further 2 complete camera heads plus three partly complete heads. The six (or so) that were exported to France before the war disappeared without trace during the occupation. At least six tubes have also survived.

As for Super Emitrons, I know of no surviving complete examples although we have 1 tube in the National collection. Similarly with the Pye Photicon no camera has survived although we have one tube and I know of the existence of two more (one in its scanning yoke).

The CPS Emitron has fared rather better, we have complete examples of one full size camera chain plus a pair of miniature CPS Emitron cameras. If any readers know of other surviving examples of these early cameras I would be delighted to hear from them.

The following photos are courtesy of BBC Television, unless otherwise indicated.

Fig. 2. The first batch of Emitron cameras had no viewfinder.

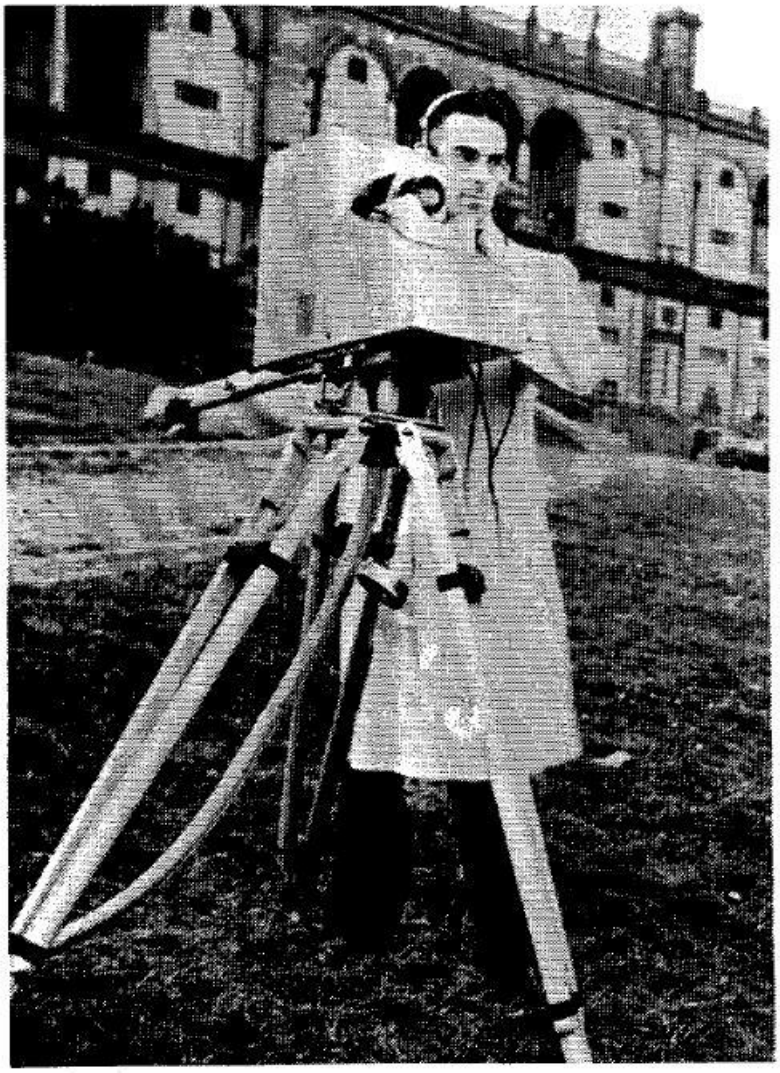

Fig. 2a. The first BBC camera with any form of viewfinder was this one, devised and built by Mark Savage in late 1936.
(photo: the late Mark Savage, courtesy Ray Herbert).

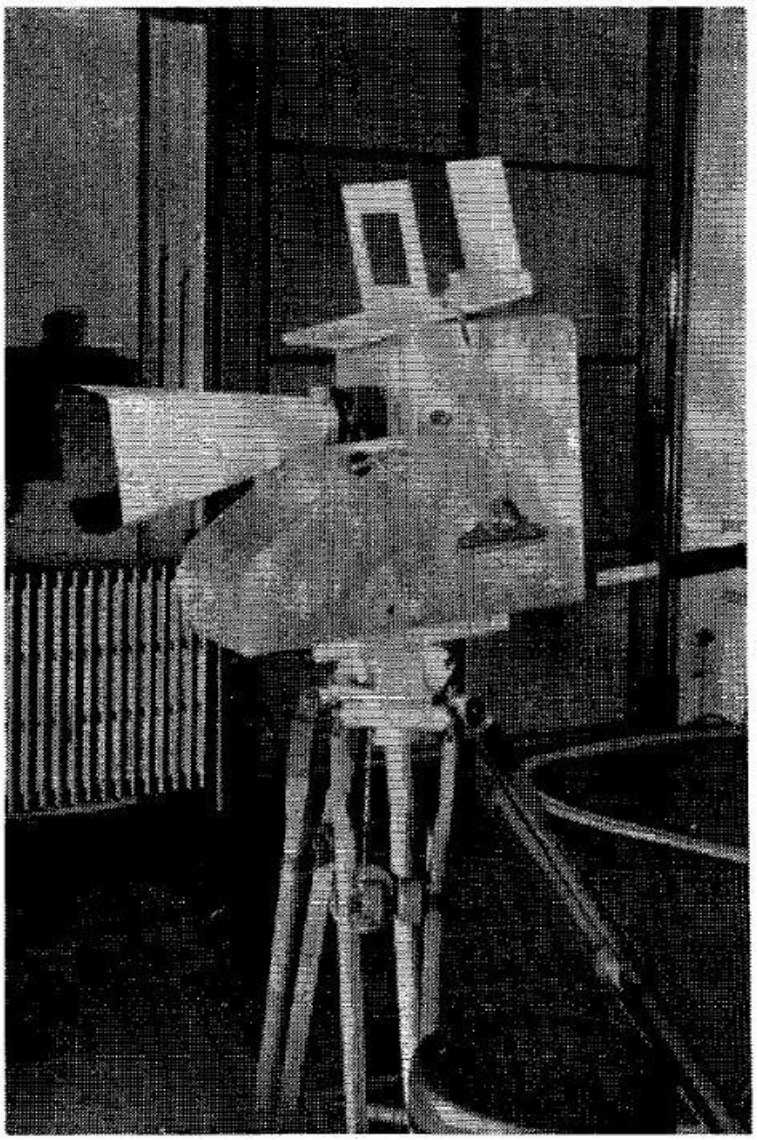

Fig. 2b. Mark Savage (on camera) with Elizabeth Cowell at Alexandra Palace in early 1937 (*photo: Ray Herbert*)

Fig. 3. All subsequent Emitron cameras had an optical viewfinder fitted.

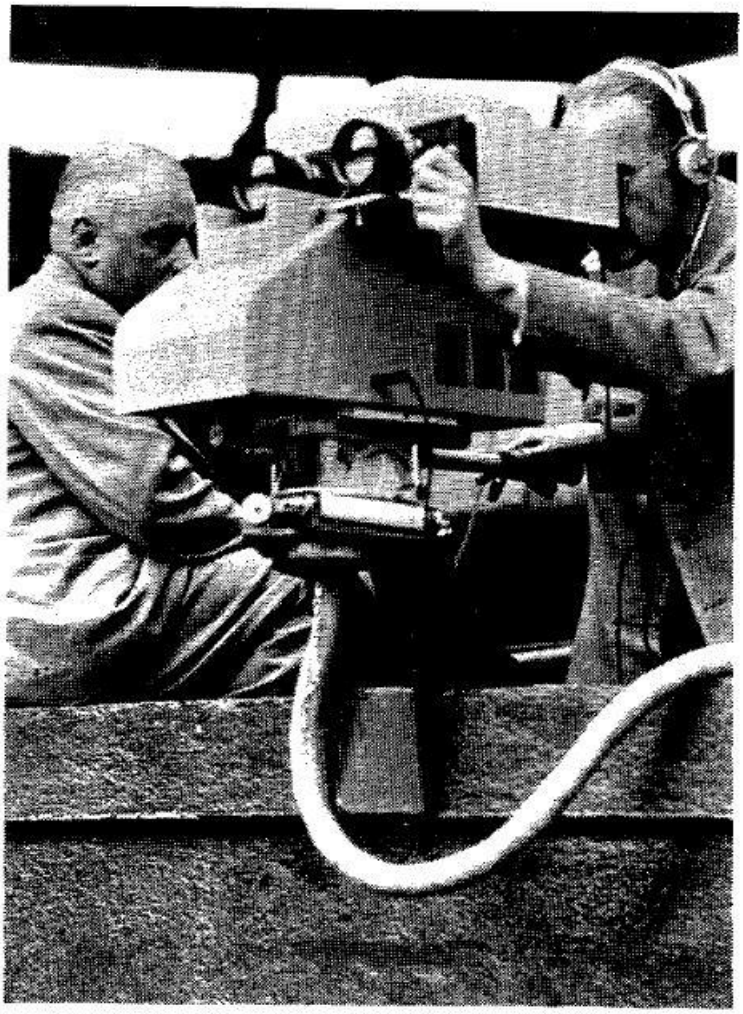

Fig. 3a. A striking view of the Emitron camera and viewfinder. Note wooden tripod. (*Fox Photos, courtesy Ray Herbert collection*).

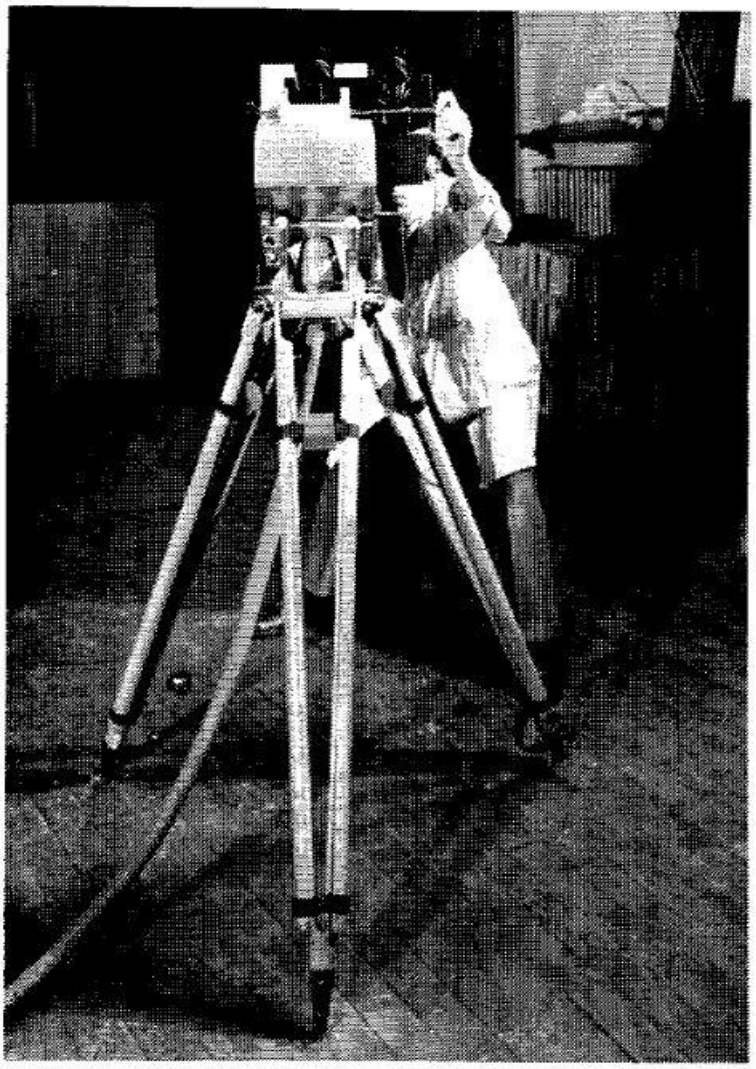

Fig 4. Soon all Emitron cameras had the extended casing below the lens assembly.

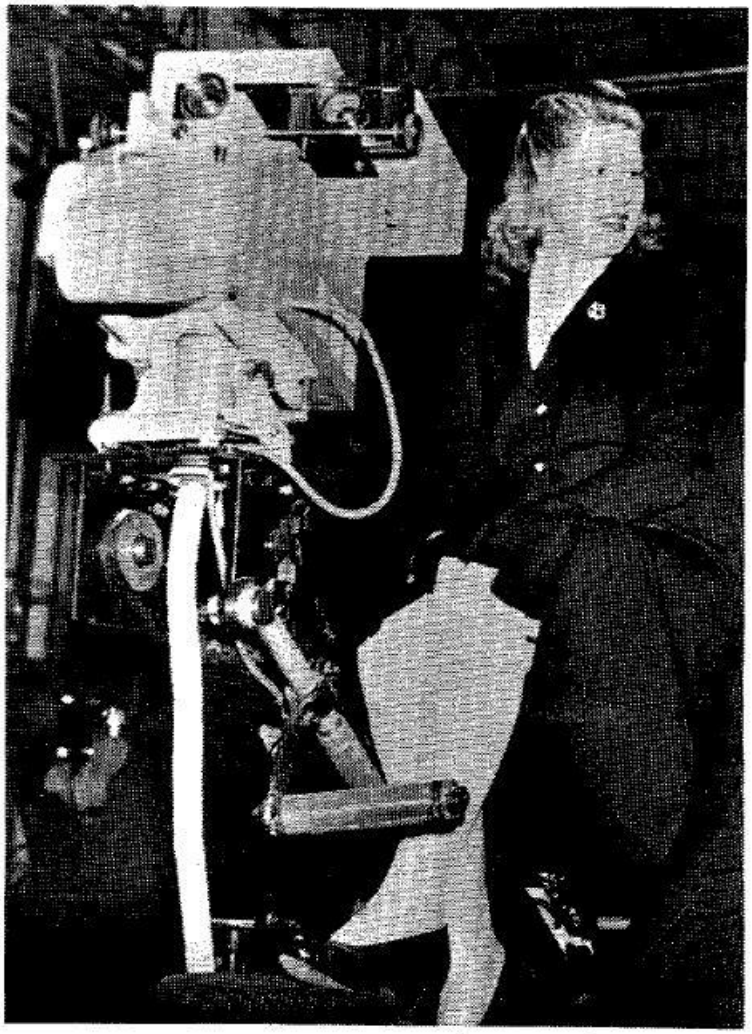

Fig 5. The Super Emitron camera is instantly recognisable because of the odd bulge on the side of the case.

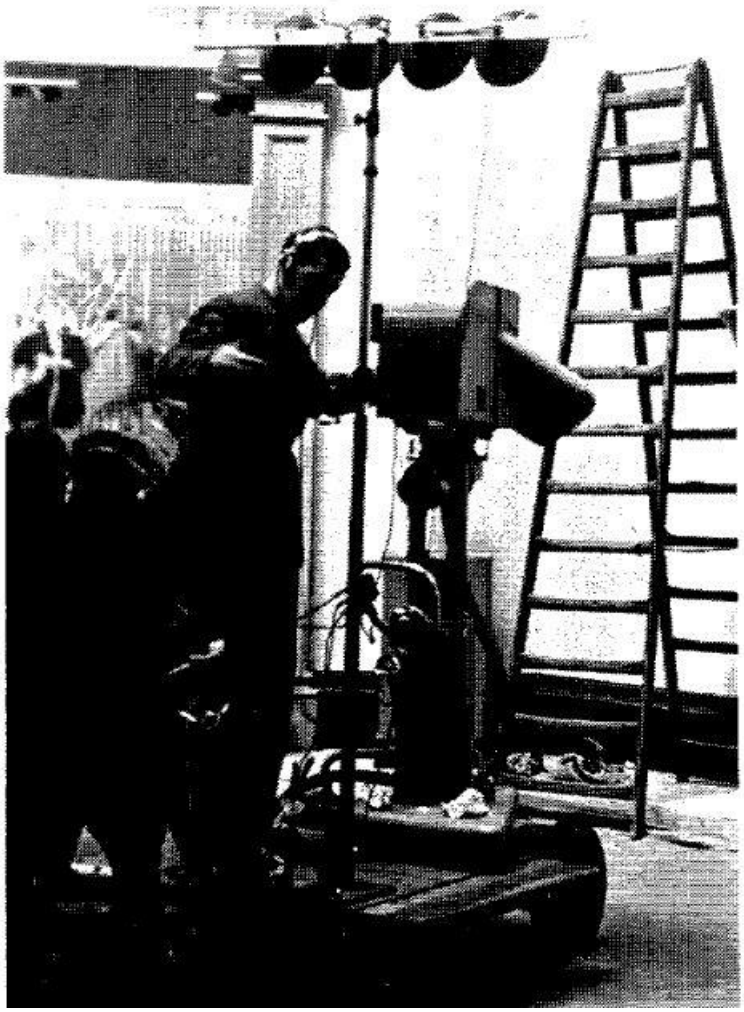

Fig. 5a. Another shot of the Super Emitron, taken in 1947 at rehearsals for the television presentation of *Better Late* at the Garrick Theatre, London.

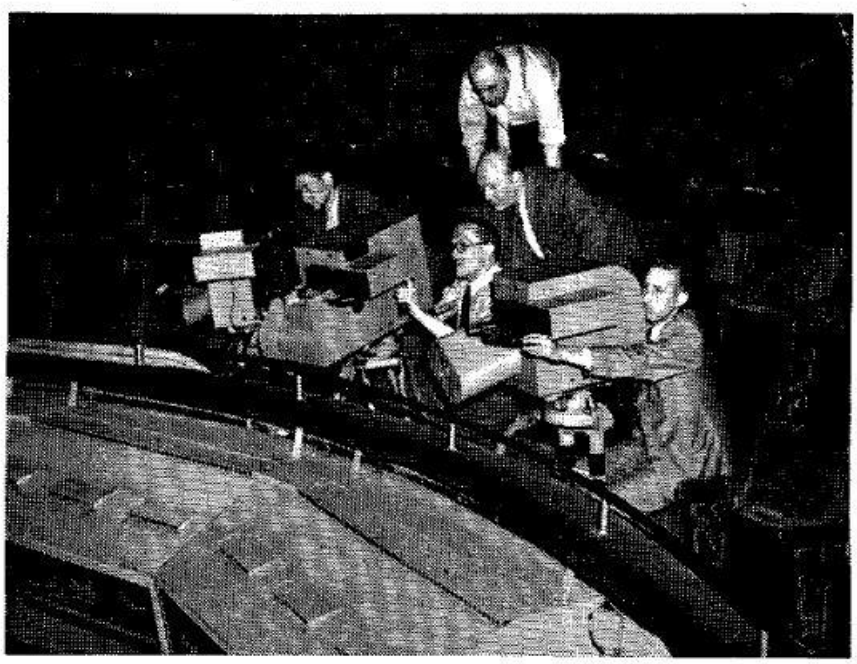

Fig. 6. The Photicon camera had a box-like shape, allowing a lens turret to be fitted. Note also the diagonal stroke between the T and the V of T/V. Later on this was considered a particularly vulgar way of abbreviating the word Television, typical of what happened if you left 'oily rag' engineers unsupervised!