Photographing Television Pictures

by Ray E. Knight and David J. Bryan†*

Special precautions need to be taken when photographing a television picture to avoid a 'strobing' interference between the relative movements of the camera shutter and the television scan. An electronic timing unit is described that switches the television picture on for one, two or four fields, when the camera shutter is fully open, after receiving a trigger pulse from the flash contact. It should be possible to apply the principle to a domestic television receiver having an input from a camera flash contact and a switch marked 'tv' and 'photo'. By setting highlight brightness to 85cd/m^2 at f4 for one television frame, and increasing black level to ensure recording of good shadow detail, a normal colour monitor grey-scale balance produced first-class results on Agfa CT18 film.

While at Thames Television we were asked to photograph the television coverage of the Apollo 11 moon landing. To do this we developed a piece of equipment that eliminated shutter bars, usually present when using a camera shutter speed of approximately 1/25 second. The usual solution to this problem — a longer exposure time — was not acceptable in this case because we wanted to freeze movement at least as well as the moon camera had done.

A television picture is a series of fields, each taking 1/50 of a second to write its 312½ lines from top to bottom of the picture. The lines of each alternate field are traced out between the lines of the previous field. This is called interlace. One complete television frame uses two fields, it lasts 1/25 second and because the persistence or memory in our vision is just longer than 1/25 second, we effectively see a picture of 625 lines. However, because there is no persistence in a photographic emulsion it is possible, by using a fast shutter speed, to catch and record part of the television scan as an incomplete picture. Of course, a longer film exposure time stores up successive fields as the eye would, and a normal looking reproduction is obtained.

Fig. 1 illustrates the action of both a focal plane and a blade camera shutter. The diagram is marked off in television fields. The blade shutter opens quickly and remains fully open for the majority of its exposure time, and then closes quickly (a). On the other hand, a focal plane shutter opens steadily and relatively slowly, and closes in the same way (b). It is only briefly fully open when set to about 1/30 second. If a blade shutter opens in the middle of a field and its open time is longer or shorter than 1/25 second there will be a bright or dark shutter bar across the photograph where either more or fewer than 625 lines have been exposed and recorded.

This effect can be minimized by accurately adjusting the shutter's open time to be 1/25 second. If the photographer happened to press the shutter release in between one field and the next, when no picture information is being transmitted, a good photograph would be obtained. Sometimes the shutter bar falls on an area of picture information of little interest, in which case a part of the negative may be satisfactorily used.

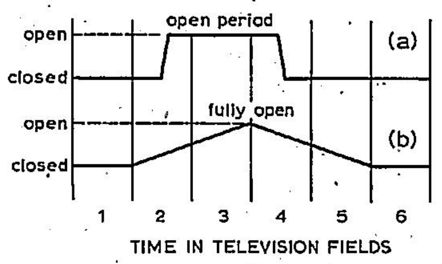

Fig. 1. Both blade-type (a) and focal plane shutters (b) have disadvantages for controlling exposures — overcome by switching two fields as in Fig. 3.

The focal plane shutter is unique in that the speed of the shutter blinds across the film is similar to the speed of a television scan down its picture. This can result in two diagonal lines of exposure demarcation, one for the opening blind and another for the closing blind. The normal photographic solution to this is a longer exposure time, but unfortunately this will not capture any movement.

It is clear that both shutters have inherent drawbacks that prevent them being used to photograph a television display with a shutter speed that both stops movement and guarantees a perfect record each time.

Electronic shutter

A solution to this problem is to pulse two fields on to a picture monitor, but only when the camera shutter is fully open. This may be arranged to occur at precisely the right moment by triggering the electronic shutter from the camera flash contact. Fig. 2 is a block diagram illustrating this arrangement.

Most cameras with focal plane shutters have two sets of flash contacts operating

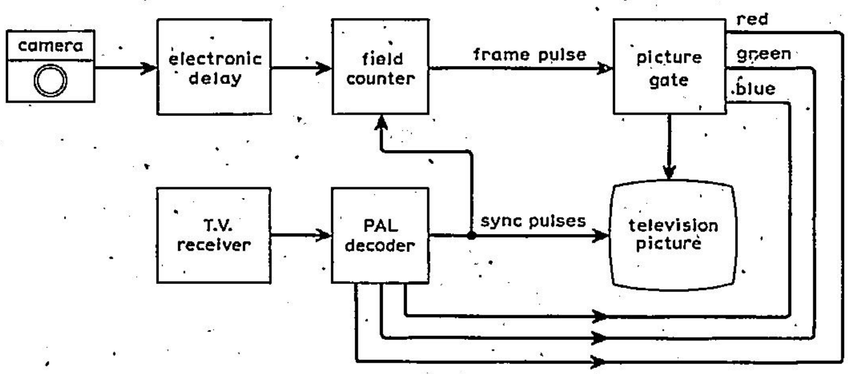

Fig. 2. Closing the camera's flash contact initiates an electronic delay, which in turn starts a field counter to determine the exposure time, i.e. 1, 2 or 4 fields duration. A frame pulse is formed to gate the colour signals to the television monitor. These colour signals are derived from a PAL decoder, which also supplies the synchronizing pulses to operate the field counter and to synchronize the monitor.

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at slightly different times. The M or FP contact, used with flash bulbs, closes as the first shutter blind starts to move, thus giving the flash bulb approximately 25ms to reach its peak brightness coincident with the full opening of the camera shutter blinds. The X contact closes as the shutter reaches its fully open position and is used with electronic flash equipment which reaches its brightness peak instantaneously when triggered.

Operation of the electronic shutter is best described by considering it in use with a focal plane camera shutter timed to open in 1/25 second and using M or FP flash sync on the camera. Fig. 3(a) shows the camera shutter release pressed at the start of field 2.

An electronic delay, adjusted to end when the shutter is fully open, is started by the camera flash contact. After the delay the next two television fields are selected and switched to the monitor. After the exposure is completed the shutter may close. To operate the electronic shutter with the X-synchronization contact, the delay in the electronics must be reduced to negligible proportions.

If the camera shutter was released after the start of field 2, Fig. 3 (b), then the first complete field cannot be seen by the open camera until the start of field 5. In this case the open time of the shutter must be longer to capture the full picture composed of fields 5 and 6. The total

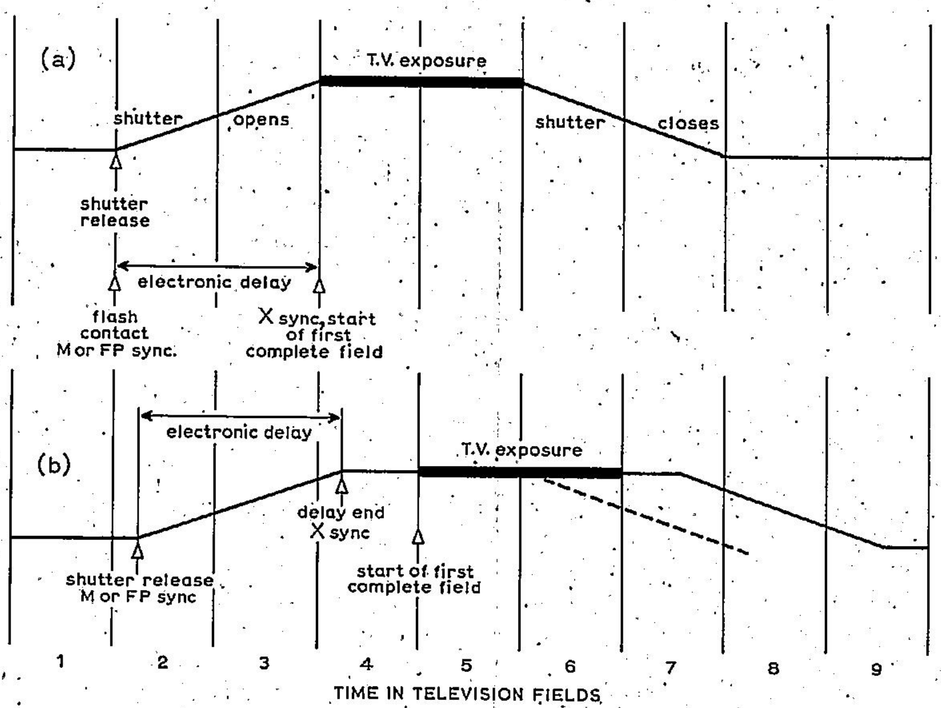

Fig. 3. Operating the camera shutter at the start of a frame starts a monostable delay which switches when the shutter is fully open (a). To allow for a shutter operating during a field scan, camera exposure time chosen must be at least 80ms — ⅛ second in practice (b).

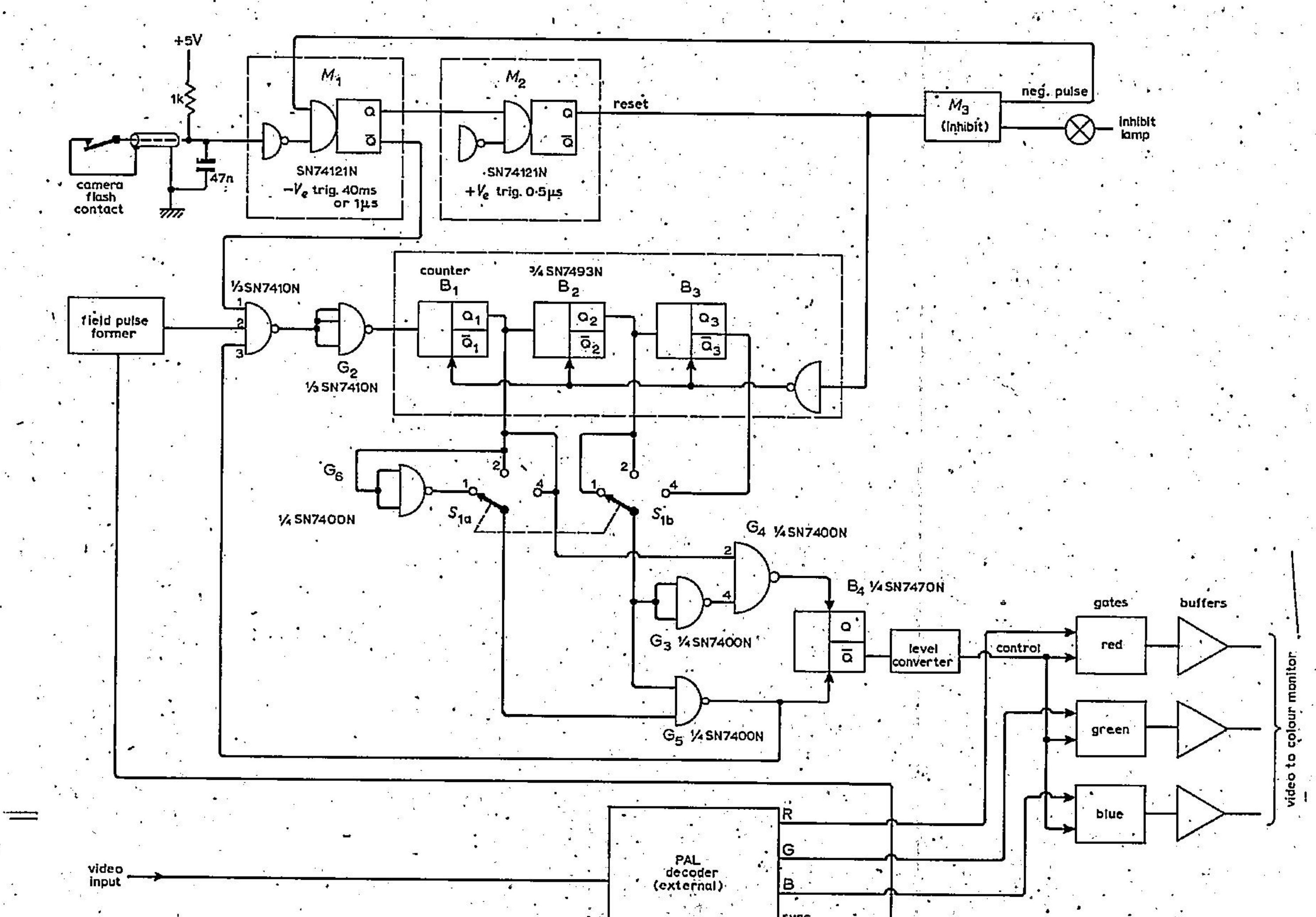

Fig. 4. Block diagram of complete system.

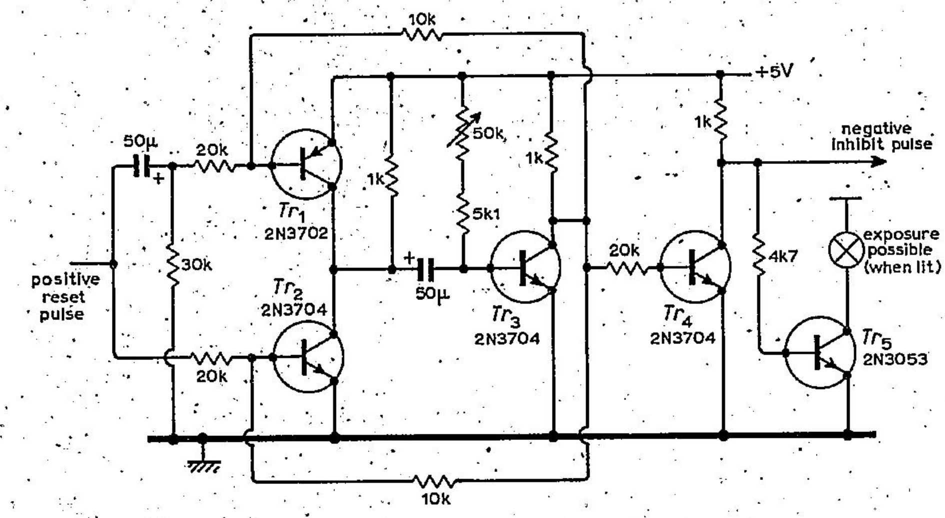

Fig. 5. This inhibit monostable circuit (M_3) is provided to prevent M_1 from being triggered by camera contacts making a second time.

camera shutter time required to fully cover the electronic exposure is made up of 40ms of electronic delay during fields 2 and 3, followed by 20ms wait for the start of field 5 and then 40ms exposure for fields 5 and 6. In practice this sequence is covered by choosing the next longest camera shutter speed which is 125ms — or 1/8 second.

The electronic shutter built for the moon landing photography had two additional features. The flash contact on the camera could bounce and produce a second pulse. To overcome this an inhibit circuit was incorporated that prevented the circuit responding to any pulses other than the first one for about 0.5 to 1.0s. A further refinement was a switch enabling the selection of one field (half a television picture), two fields (one picture) or four fields (two pictures) for photography.

Circuit description

Electronic delay and reset. Closing the camera flash contact triggers the integrated monostable circuit M_1 — Fig. 4. The 40-ms negative-going output of M_1 is used to inhibit the field pulse counter until the camera shutter has opened fully. The 47-nF capacitor at the input prevents spurious signals which may be picked up in a long flash cable from triggering the circuit. The leading edge of the positive output of M_1 triggers M_2. The 0.5-μs positive-going output of M_2 resets the field pulse counter B_1, B_2 and B_3 to the 000 state. When the counter is in this state gate G_5 will have a high output whatever the condition of S_1, and hence input 3 to gate G_1 will be high.

In the X mode of synchronization the timing capacitor of M_1 is removed from the circuit thus reducing the 40ms delay to 1μs which in this context is negligible.

Field counter. At the end of the 40ms or 1μs period of M_1 input 1 to gate G_1 becomes high. Positive-going field pulses from the field pulse former can now pass through G_1 and after inversion by G_2 clock the binary counter. As the counter is clocked into the 001 state by the first field pulse, gate G_4 is enabled as Q_1 is high and Q_2 or Q_3 (as selected by S_{1b}) is low but, after inversion by G_3, appears high at input 1 to G_4. The low output of G_4 sets B_4 thus producing a low on the Q output.

Gate G_5 is enabled on a count of either 010(2), 011(3) or 101(5) as selected by S_1 and when enabled resets B_4, causing the Q output to revert to high. An output pulse has thus been produced starting on the first television field pulse after the delay of M_1 and lasting for a further 1, 2 or 4 fields as selected.

Inhibit circuitry. Transistors Tr_1 to Tr_3, Fig 5, form a monostable circuit (M_3) which inhibits M_1 from triggering a second time if for any reason the flash contacts make a second contact while the shutter is still open. This second contact, sometimes produced as the shutter is in the act of closing, is not a problem with normal flash photography, as a bulb can flash only once in its life and electronic flash equipment has a recharge time of several seconds. As unwanted television 'flashes' disturb the photographer even when the shutter is fully closed, the period of M_3 is adjusted to be less than the minimum wind on time of the camera. Transistor Tr_4 is an inverting transistor, and Tr_5 and LP_1 indicate to the photographer the state of the inhibit circuitry. The monostable is designed with a complementary input to give a fast re-set time, necessary for correct inhibiting when photographing at maximum speed (that is as fast as the photographer can wind on the film).

Field pulse former. Mixed sync pulses derived from the video signal by the PAL decoder are passed *via* the emitter follower Tr_6, Fig. 6, to an integrating circuit (C_A, R_A). The output of the integrator switches Tr_7 at field rate, remaining line-rate information being removed by a shunt capacitor at the collector. In practice the monostable circuit Tr_8 and Tr_9 was needed as remaining broad-pulse serrations in the output of the integrator could produce a double pulse at the output of Tr_7, thus causing the field pulse counter to miscount.

Level converter and signal gates. The negative-going pulse output of B_4 is used to switch Tr_{10}, Fig. 7, to produce a positive-going pulse switching between −12 and +12V with respect to earth. This is used to switch three signal gates, one each for the red, green and blue video outputs of the PAL decoder. Switch S_2 turns off Tr_{10} thus allowing the video signals to be routed continuously to the picture monitor while setting up.

Video switches are of the series-shunt type and were chosen for their good isolation and lack of d.c. offset. The junction f.e.t. gates are driven *via* series diodes to prevent forward biasing of the gate junctions. The gates are decoupled to the control line to improve switching speed and to prevent pick-up at the high impedances produced when the series diodes are reverse biased. A standard Thames Television video buffer amplifier

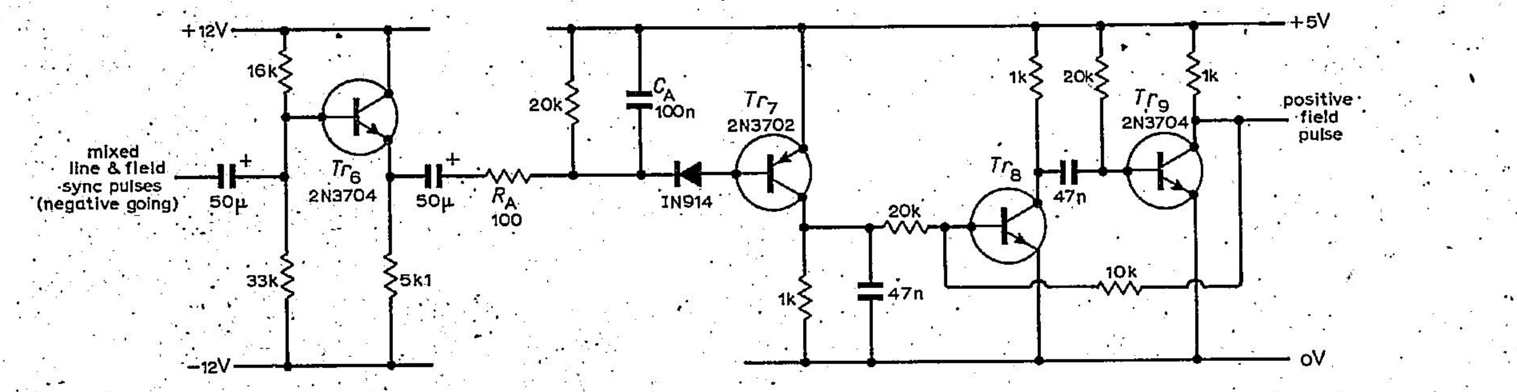

Fig. 6: Circuit for providing positive field sync pulses.

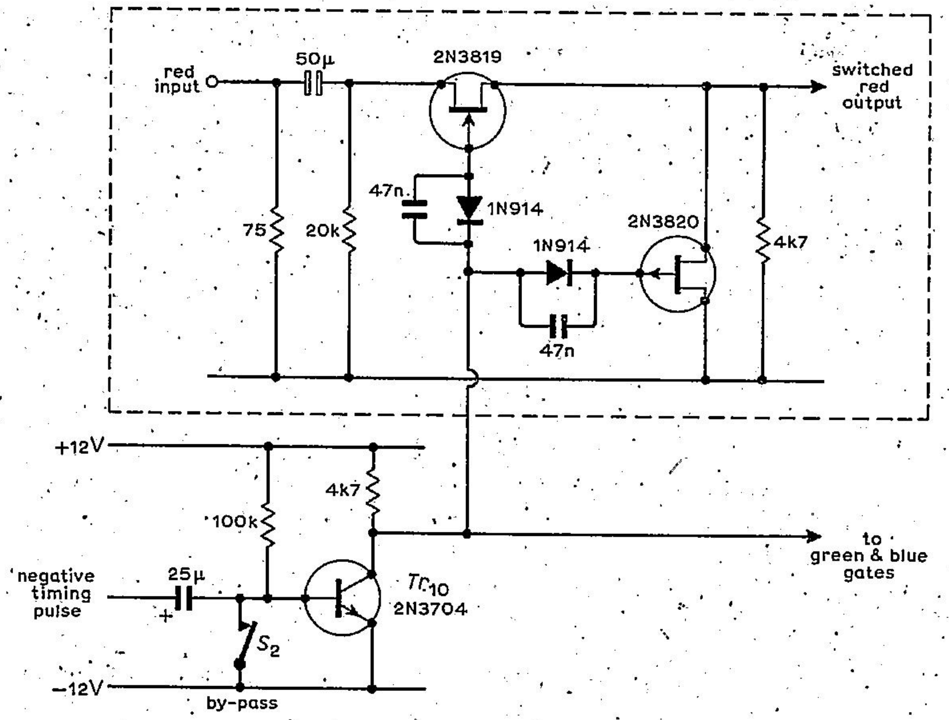

Fig. 7. This level changer converts the timing pulse output of B_4 into a form suitable for driving the three signal gates.

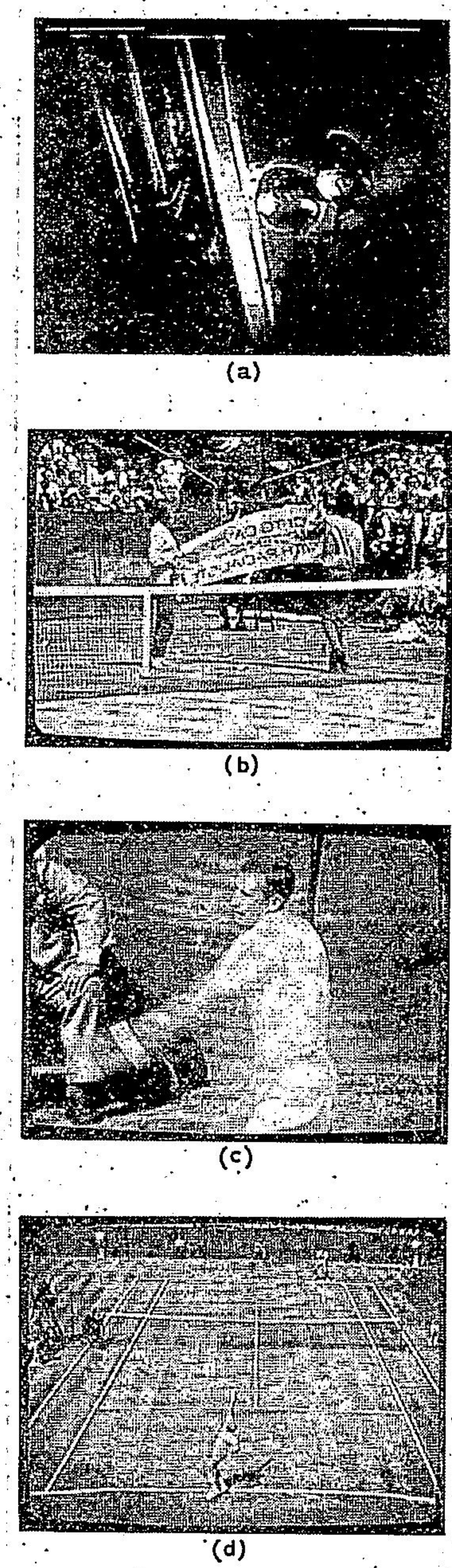

Fig. 8. Examples of electronic shutter in use. While (a) and (b) are satisfactory (c) shows movement too fast for the frame rate to capture, but almost frozen on each field: With both (c) and (d) poor e.h.t. regulation results in loss of interlace.

(type VA200) is used in conjunction with each signal gate to make up the small loss of the gate and to provide an output with a source impedance of 75 ohms.

At first sight it might appear more economical to install a single gate at the input to the PAL decoder. This is not possible because the colour decoding circuits must be fed continuously with the colour burst from a video signal as when interrupted they take a finite time to re-synchronize when reconnected. In addition, a supply of mixed sync pulses derived from the video signal by the decoder must also be provided for the colour monitor (which has a relatively long synchronizing time) and for the field pulse counter if the system is to start.

Exposure determination

The active exposure time is fixed according to the number of television fields required — usually two — and is therefore 1/25 second. Although the camera shutter may be open for longer than this, the television screen only lights up for two selected fields of that duration. A series of experiments, with the camera lens set to *f*4 and using Agfa CT18 reversal film rated at 50 ASA, showed that picture whites at a brightness of 85 cd/m^2 reproduced well without undue tonal compression, and shadow detail was optimum with the monitor black level set a little high. It was not easy to measure this increase in black level because it amounts to a very small figure. Because the shutter is open for longer than the active television exposure, this black level increase tends to produce a fogging exposure. This was not found troublesome with reversal film and can certainly be cancelled out in a negative/positive method of photography.

Applications

It is possible to apply the principle of this electronic shutter to domestic receivers by using the timing pulse from B_4 either to gate the YRGB or RGB signals to the picture tube or video amplifiers (after synchronizing information has been extracted) or by applying a blanking signal to the tube. Problems are likely to be encountered, however, with the response time of the e.h.t. stabilization circuits and the loss of field interlace which may accompany this. This problem was present on some picture monitors, as illustrated in Fig. 8. To be sure of obtaining precisely the correct picture it would of course be necessary either to use a second receiver or to arrange that the signal is extinguished at the start of the initial 40-ms delay. We see the time when a domestic television receiver could have a camera flash socket at its rear together with a switch marked 'tv' and 'photo' that will enable the enthusiast at home to get first class photographs off his television set.

The benefits of a reliable method of television stills photography was soon realized by production staff who now use this equipment to obtain stills from video taped programmes.

The ability of being able to select and photograph one single television field is particularly useful in recording the effect of pick-up tube lag.

The motion-capturing ability of such a photographic set-up is determined by the television pick-up tube being used and the television field repetition rate. A complete broadcast television picture is transmitted in 1/25 second, as in Fig. 8(c), which in common with motion picture films is fast enough to convey the appearance of continuous motion from a series of such pictures. One field of a televison picture will have a stopping speed of 1/50 second — which can be selected on the electronic shutter — but of course with only 312½ lines. Such effects as smear and lag, visible with today's generation of photoconductive pick-up tubes, will reduce the sharpness of moving pictures still further.