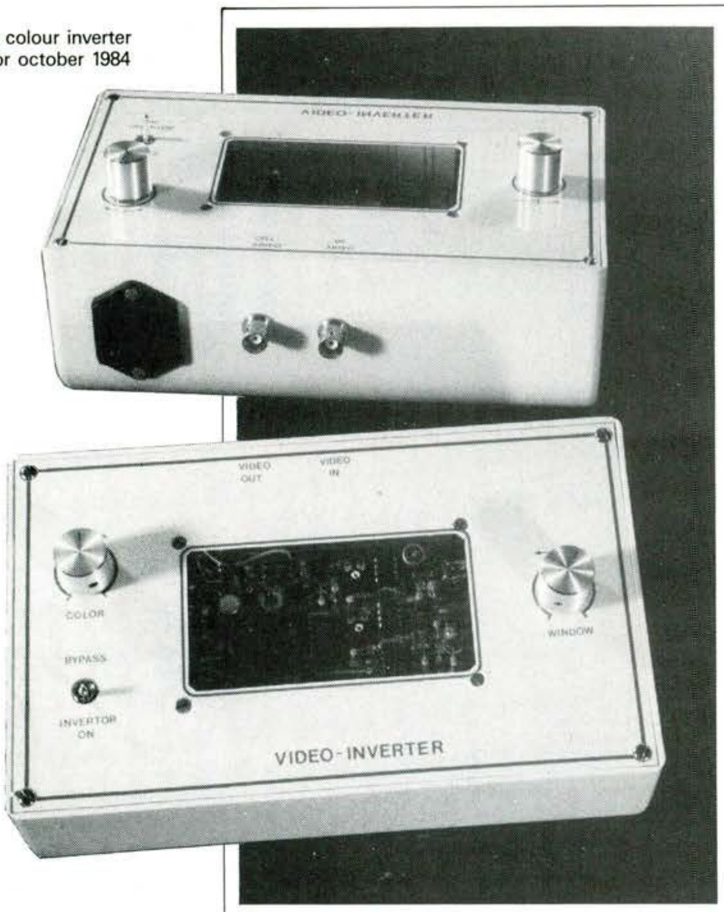

video colour inverter

with a host of other interesting facets

Inverting the phase of video signals causes interesting effects on the screen. As proprietary equipment for this purpose is expensive, the low-cost inverter presented here may be of interest to many of you. The unit offers the choice of inverting the composite colour (= luminance + chrominance) signal, or the luminance (black and white information) signal only.

The inverter is of interest to three groups of people: video recorder owners who want to change the image on their television screens, video camera operators who want to incorporate trick images in their work, and amateur photographers who want to view their negatives as positives.

Depending on the setting of the relevant switch, the circuit provides normal, that is, non-inverted, images (which means that the inverter may be connected permanently), or inversion of the luminance and chrominance signals, or inversion of the luminance and adjustable inversion of the chrominance signal. The range of adjustment lies between full inversion and near-normal: the setting of the relevant control, P2, depends on the required effect and individual taste.

Applications

It should be noted that the inverter functions on the composite colour signal. Its input and output are therefore suitable for use only with equipment where this signal is readily available, for instance, via an A/V socket or BNC plug. This is, of course, no problem with modern video cameras, VCRs, and television receivers. Moreover, such a connection is easily fitted retrospectively to most older equipment. If you do not feel confident of carrying out this modification yourself, ask your local TV repair shop.

The use of the inverter as image modifier for video recordings is illustrated in figure 1. Your favourite piece of equipment may, for instance, be co-opted to function as part of a home discotheque. All you have to do is to record some suitable concerts and during playback to switch in the inverter at appropriate passages.

Figure 2a shows a suitable set-up for video camera operators. It is best to use a recorder with an electronic editing facility: the recorder is then stopped at the moment the switch-over from normal to inverted image, or vice versa, takes place, so that synchronization upsets are prevented.

If you are fortunate enough to possess two VCRs (for instance, a mains operated and a portable model), the set-up in figure 2b may be used. The advantage of this arrangement is that filming may be carried out as normal and the image modifications may be inserted during editing of the

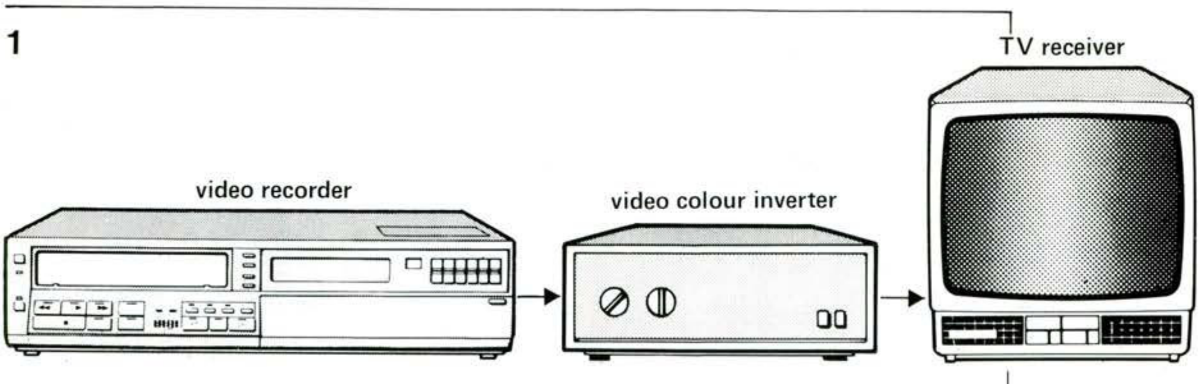

Figure 1. Connected between a video recorder and a television receiver, the inverter may be used for 'magic' effects on the screen.

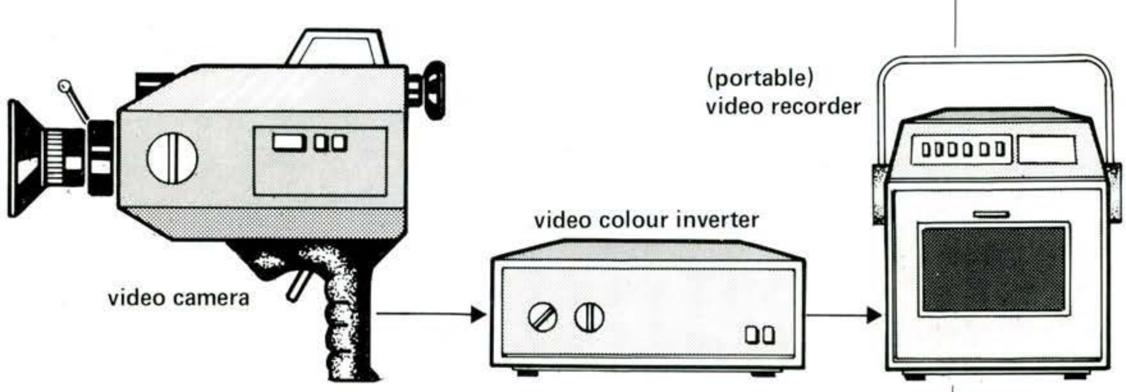

Figure 2a. Connected between a video camera and a VR, the inverter may be used to modify the information being recorded.

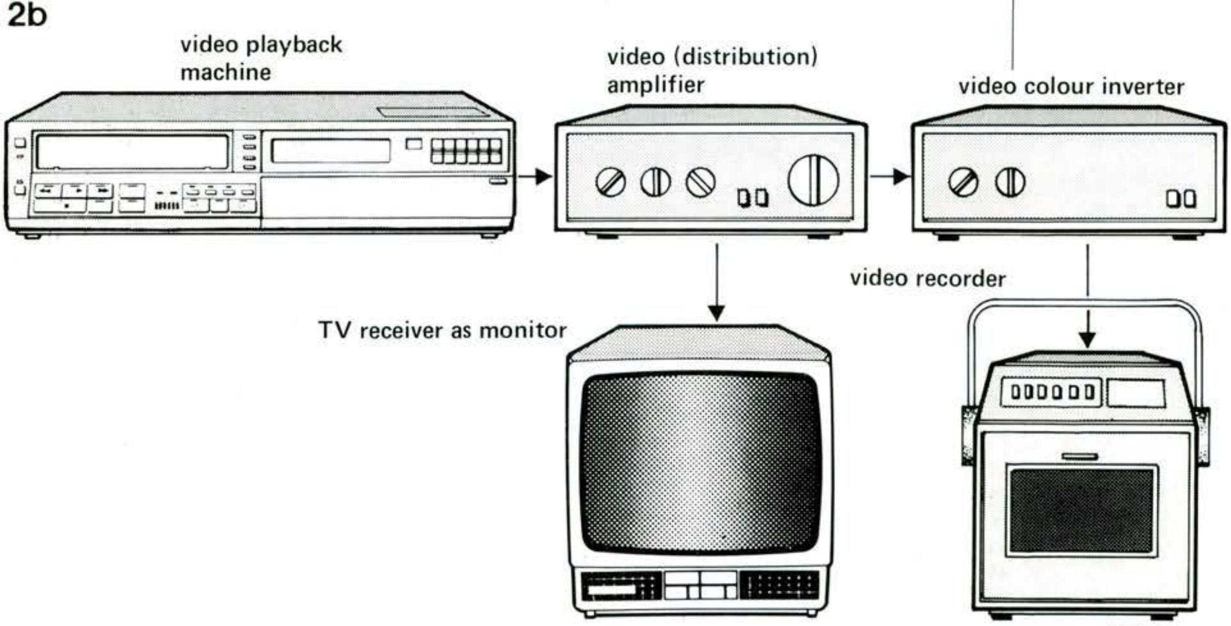

Figure 2b. This is perhaps the most interesting set-up, particularly for video camera operators: it will enable them to modify home-made film during the electronic editing.

recording. The video amplifier (for instance, the video distribution amplifier featured on page 12-36 of the December 1983 issue of Elektor) serves not only to compensate for losses in the recording and playback chain, but also to provide the possibility of using a TV receiver with A/V socket as monitor.

A suitable configuration for amateur photographers is shown in figure 3 which is self-evident, but has two important limitations. Firstly, the set-up is restricted to black-and-white negatives because it would be quite difficult to compensate for the orange mask on the negative, and, secondly, the video camera must be of

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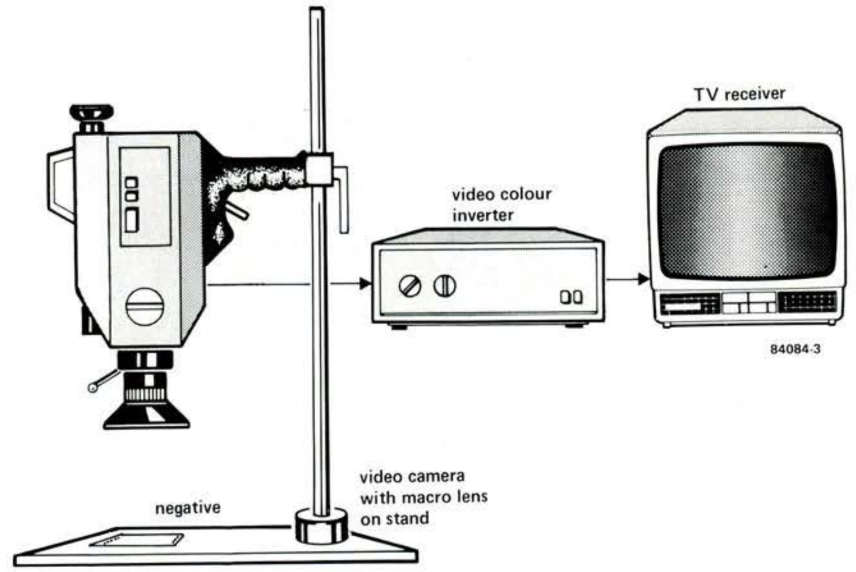

Figure 3. A further application enables black-and-white film negatives to be viewed positively on the screen.

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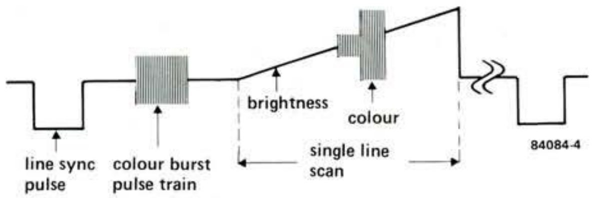

Figure 4. This illustrates the basic composition of a line scan. Luminance and chrominance are firmly interwoven. Note that this representation and that in figure 5 is purely schematic: viewed on an oscilloscope it would look quite different!

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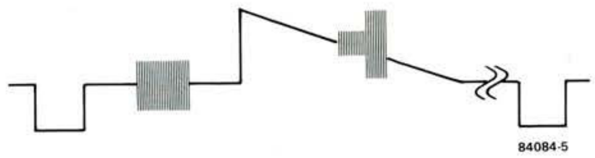

Figure 5. Same information as in figure 4 but with the single line scan inverted.

reasonable quality and be fitted with a good macro lens to ensure usable results.

Video signal

We have no intentions of embarking on a full course in video technology but will restrict ourselves to those aspects which are important to the circuit. The single line scan shown in figure 4 illustrates normal traversal of the composite colour signal. If we want to invert this signal without affecting the other functions of the TV receiver, it is necessary to invert the line scans as shown in figure 5. Both the luminance and the chrominance signals are inverted, because the chrominance signal is 'interwoven' with the luminance signal. If the phase of the colour burst signal is also shifted by 180°, the colour information returns to normal while the luminance signal remains inverted. How this is achieved will be explained in the circuit description.

Circuit description

Switch S1 in figure 6 switches the inverter in, or out of, circuit. With S1 in position as shown, the incoming signal is applied via input network C1-C2-R1-R2 to a clamping circuit formed by opamp IC2 and diode D3. The input network is necessary to transfer the signal from the camera or VR undistorted and present it with the right impedance. Unfortunately, it causes the signal to lose its d.c. off-set which is required for the proper functioning of the inverter. The clamping circuit reintroduces the off-set by pulling the lowest (most negative) component of the line scan to 0 V.

Because the clamping circuit has a high-impedance output, it is followed by buffer (voltage follower), IC1. The output of IC1 is available at pins 2 and 6 and is divided into two.

One part of the output is applied to comparator IC3 which regenerates the line

sync(hronizing) pulse (available at pin 7). The leading edge of this pulse triggers monostable multivibrator IC4. This monostable controls the actual run-off via electronic switches ES1. . . ES3. Switch ES4 is controlled direct by the output of the comparator, which we will return to later in this article.
The other part of the output of IC1 is applied across colour saturation control P1. The Q output of IC4 is at logic 1, which keeps switch ES2 closed, until the end of the colour burst pulse train. With colour inversion switch S2 in position 1, the signal from P1 is then applied to the non-inverting input (pin 1) of opamp IC6 via ES2; the phase of this signal is therefore not (yet) inverted. When the monostable changes state, output Q goes low and output $\overline{Q}$ becomes logic 1. Switches ES1 and ES3 are then 'on' and ES2 is open. The signal from P1 is applied to the inverting input (pin 14) of IC6 via ES1, so that the phase of the composite colour signal at pin 7 of IC6 is shifted by 180°. At the same time, ES3 applies a reference voltage from voltage divider P3/R9 to the non-inverting input of IC6, ensuring a correct and positive signal level at the output.
When S2 is set to position 2 and P2 is turned fully open (wiper at M), the colour burst signal is phase-shifted 180° by the action of T1. The colour information at pin 7 of IC6 is then shifted a total of 360° and is in phase again with the incoming signal.
It is evident that both inverted and non-inverted colour burst signals are present across P2 and this makes it possible for the degree of inversion of the colour information to be adjusted as required. In other words: colour may be continuously changed from normal to fully complementary; with P2 at the centre of its travel, there is no colour.
The line sync signal must, of course, be fed to the following circuit (TV receiver or video recorder) non-inverted and this is ensured by T2 and ES4. The switch is controlled direct by the output of comparator IC3.
Transistor T3 and resistors R16, R17 ensure a correct output impedance of 75 Ω.
The power supply is a conventional, voltage regulated ±5 V circuit. As the negative line is not loaded as heavily as the positive, the value of C13 may be rather smaller than that of C12.

Construction and calibration

If the printed circuit of figure 7 is used, there should be no special problems in the construction. The compact design enables the unit to be installed in a neat case. Amateur photographers should use presets in the P1. . . P3 positions, and this arrangement is also advisable for disco applications (so that not everybody can play around with the inversion settings). Others should find it advantageous to use normal potentiometers and fit these onto the case; connections between them and

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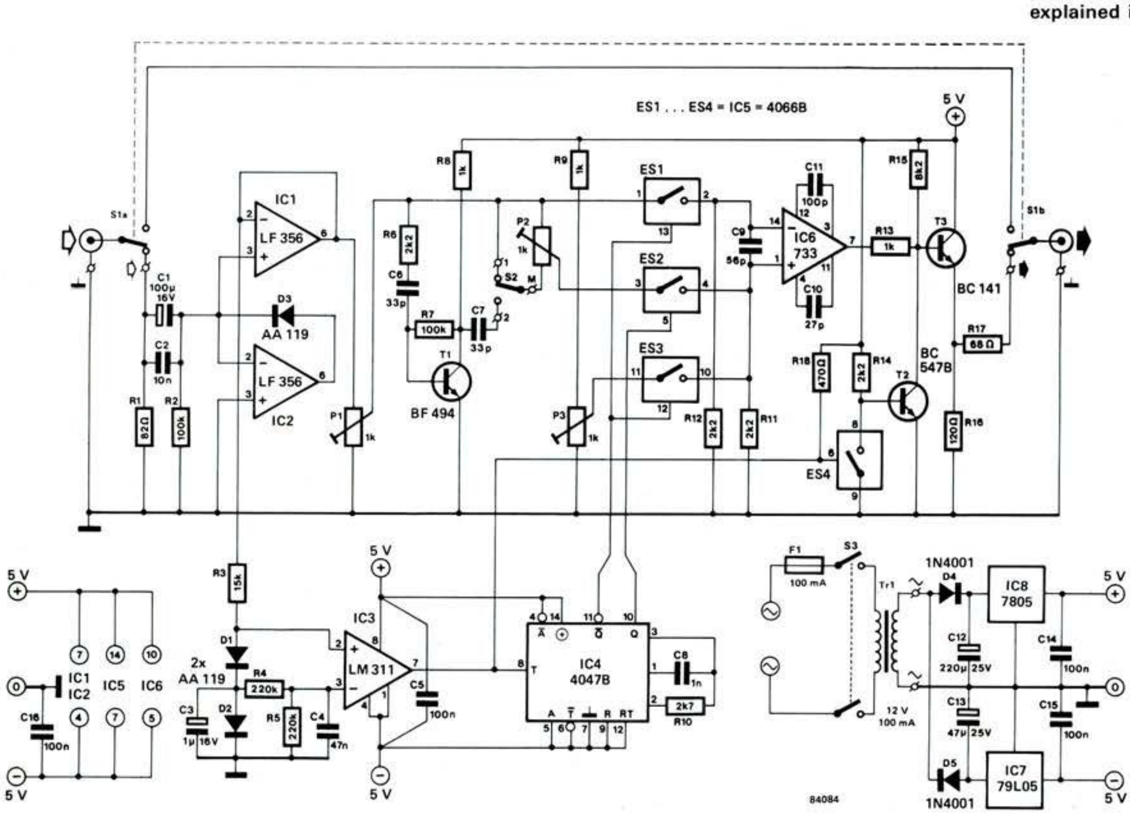

Figure 6. The circuit diagram of the inverter: possible extensions are explained in the text.

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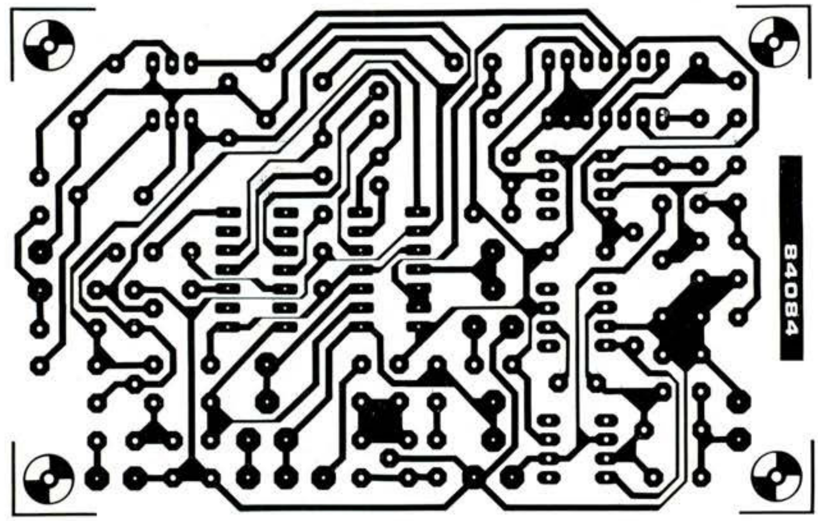


Figure 7. Component layout and track side of the printer circuit board: its use makes construction of the inverter a fairly simple matter.

Parts list

Resistors:
R1 = 82 Ω
R2, R7 = 100 k
R3 = 15 k
R4,R5 = 220 k
R6,R11,R12,R14 = 2k2
R8,R9,R13 = 1 k
R10 = 2k7
R15 = 8k2
R16 = 120 Ω*
R17 = 68 Ω*
R18 = 470 Ω
P1,P2,P3 = 1 k preset or potentiometer*

Capacitors:
C1 = 100 μ/16 V
C2 = 10 n
C3 = 1 μ/16 V
C4 = 47 n
C5,C14,C15,C16 = 100 n
C6,C7 = 33 p
C8 = 1 n
C9 = 56 p
C10 = 27 p
C11 = 100 p
C12 = 220 μ/25 V
C13 = 47 μ/25 V

Semiconductors:
D1,D2,D3 = AA 119
D4,D5 = 1N4001
T1 = BF 494
T2 = BC 547B
T3 = BC 141
IC1,IC2 = LF 356
IC3 = LM 311
IC4 = 4047B
IC5 = 4066B
IC6 = μA733
IC7 = 79L05
IC8 = 7805

Miscellaneous:
S1 = double-pole change-over switch
S2 = single-pole change-over switch
S3 = DPST mains switch
Tr1 = mains transformer 12 V/100 mA secondary
F1 = fuse, 100 mA, complete with carrier
printed circuit board 84084
case
two BNC or A/V sockets*

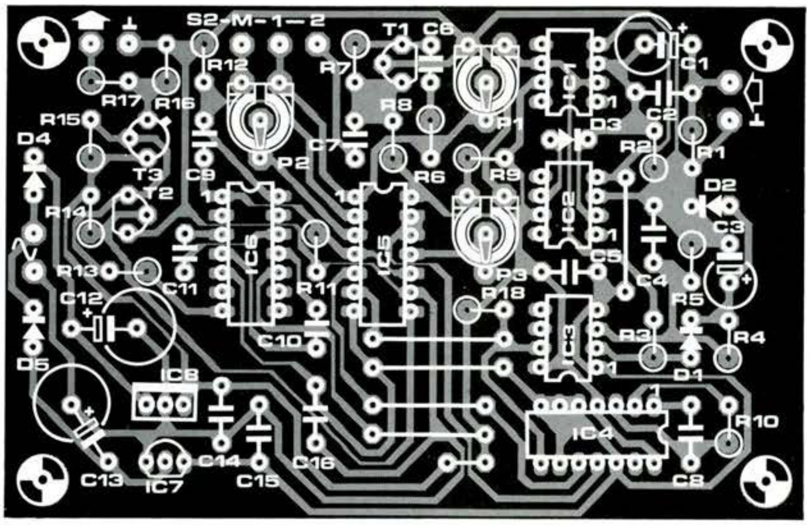
Optional:
R16 = 82 Ω
R17' = 68 Ω
P4 = 1 k . . . 100 k potentiometer, linear*

*see text

the printed circuit should be made in screened wire with the screen connected to earth. Where potentiometers are used, it is convenient to provide a graduated scale around, or a skirt under, the control knob.
The type of input and output connector depends really on the equipment the inverter is to be used with. BNC connectors are very convenient and easily fitted but lose their advantages if adapter cables become necessary. If you use A/V sockets, interconnect all pins, except 2 (= composite colour signal), and connect pin 3 to the nearest earth point in the circuit.
Calibration is relatively simple and requires a video signal source and a test card (this may, for instance, be one recorded from a broadcasting station). Set switch S1 to position 'inverter on' and S2 to position 1. Controls P1 and P3 should then be adjusted to give rich colours and a good contrast respectively. Finally, set S2 to position 2 and check that colours can be continuously changed from normal to complementary by P2.

Other interesting facets

For another of our experiments we needed one half of the screen image inverted and the other half normal. This requires a lenghtening of the time IC4 is triggered and this is achieved by connecting an additional preset in series with R10: the switch-over to inverting then takes place sometime during the line scan. If the trigger period is further extended, inversion does not take place until the *next* line scan. This gives the interesting picture of alternate normal and phase-inverted lines. Making the trigger period longer still (a 100 k preset in series with R10) causes the effect to be visible over one part of the screen image only. The additional preset is connected as shown



S1 = inverter in/out
S2 = colour inversion in/out
S3 = mains on/off

P1 = colour saturation
P2 = colour inversion adjustment
P3 = contrast
P4 = trigger period control (see text)

in figure 8.
As the inverter is relatively inexpensive, particularly when compared with commercially available models, it is quite feasible to connect two or more of them in cascade. We think that four or five of them so connected will function without any problems, although we have not built so many prototypes ourselves and cannot therefore prove it. Such a set-up offers so many possibilities for achieving trick effects that it is impossible to envisage them all: we'll give you two.
When two inverters are connected in series of which only one inverts the colour, the resulting picture is normal as far as black-and-white information is concerned, but the colour is inverted.
The second example is illustrated in figure 9. Here, the onset of the first inverter is arranged so that one part of the picture remains normal; the second part, in the centre, has the black-and-white information inverted. The second inverter inverts the inverted black-and-white information and inverts the colour. The overall picture will then show: normal — black-and-white inverted — colour inverted. This all presupposes that both inverters are fitted with the additional preset P4.
For really accurate settings, you could use multi-turn presets or potentiometers, but this is really a matter of cost. In our experience, the inverter can be calibrated very well with just fingertip control.
A final tip: if you want to monitor the modified image being recorded, reduce R16 to 82 Ω, connect a 68 Ω resistor, R17', in parallel with R17 as shown in figure 10, and add a socket as appropriate.

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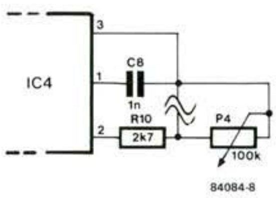

Figure 8. This shows how an additional preset may be connected in series with R10 to extend the trigger period of IC4. The facets which become possible by this simple means are explained in the text.

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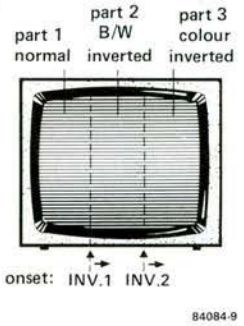

Figure 9. When two inverters are connected in cascade, and both are fitted with the additional preset shown in figure 8, this sort of trick becomes possible.

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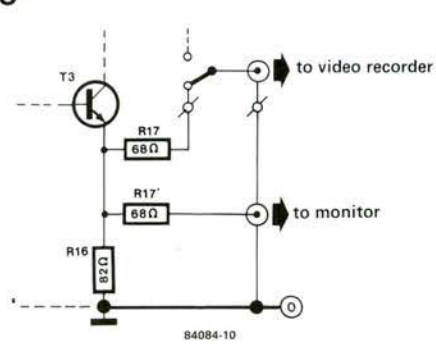

Figure 10. A small modification as illustrated makes it possible to monitor what is being recorded.