DIGITAL TECHNIQUES IN TV PRODUCTION :

THE EXAMPLE OF A COLOUR VIDEO TO FILM RECORDER.

Foreword

In this paper is described a colour video to film recorder system usually named kinescope, which makes use of digital techniques for the modulation of electrooptic devices, real time processing of colour video signals, field store for interlace removal . The reason for having search for this new techniques is a trial for solving the most important problems of existing kinescope, the low lumination of the film and the necessity of a special camera in some cases, the very high speed horizontal scanning in other cases, and in all cases the great difficulty of rereading by a Telecinema.

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ESSENTIAL FEATURES OF THE SYSTEM

It was decided to design our kinescope forgotting, for a moment the classical solutions, taking into account only the particular specifications.

Analysing the major problems of existing kinescopes we saw that it was due to the point by point addressing of the picture. To avoid it two solutions exist :

Addressing simultaneously all the points either of one image or one line. At the moment the display of one image by independantly adressed points in color is not technologically possible.

The materialisation of one TV line is already possible with at least two techniques that will be discussed later on.

This solve many difficulties :

The points of the whole line being lighted simultaneously, one can use a full line scan, i.e. 64µs, to illuminate the film instead of 80ns. And the horizontal scanning difficulty is avoided, the remaining vertical scanning being quite simple.

The materialisation of the TV line can be done by the juxtaposition of electroluminescent diodes of each colour, or of optical switches modulating the light of three lamps adequately filtered.

As various technologies are usable it was decided to design a method of modulation at the electrical level as independant as possible of the particular nature of the choosen transducer. The simplest way is to use a time width modulation at a constant level.

This method of modulation joined with the fact that, as all the points of a line are simultaneously lighted, we need to memorise the amplitudes of all the points of one line, leads directly to the use of digital techniques. These gives rise to an important feature of the system, the capability of being used with digital TV.

As a consequence of this capability we are able to avoid another problem of standard kinescopes : the field interlace. In fact we can delay one field and record the full frame during the time allocated for one field and so use a standard film camera.

We will now describe in detail the system obtained on these bases.

SYSTEME ARCHITECTURE

On the figure 1 is given a block diagram of the system. Starting from a video signal issued from a camera or from a video tape recorder, we first find an adaptator for having, whatever be the source, a R, G and B signal. Then various processes are applied to the signal in order to adapt it to the digitalisation. A lagarithmic correction, then a colorimetric matrix, finally a physiologic correction for which a law has been determined, allow to reduce the number of binary elements necessary to encode correctly the TV signal.

So are obtained one luminance signal Yand two chrominance signals C_1 and C_2. Y, C_1, C_2 are then tranformed by an analog to digital converter in 3 binary words, of seven or eight bits each depending on the picture quality desired.

Then a digital processing is applied to the binary word. There are 2 pruposes for this processing : one is to do the inverse of the analog processing i.e. matrixing and non linear corrections, the second is to take account of the particular nature of the film and the sources used to light the film. The transfert caracteristics of the film vary from a production to another and the colorimetric points of the sources evolved in time. So it is necessary to have a programmable digital adjustement in the matrixing and in the non linear correction.

After this block we came back in pseudo R, G, B signals as indicated on the figure 1 except those signals are digital.

We then reach a block named modulator which function is to memorise the binary words associated with all the points of a line, the input being a sery composed of 1 word for each color and each point, then to transform them in a signal of variable pulse with addressing in parallel a full line of electroptic transducers.

The next block is the visualisation composed of as much individual electro-optic transducers as the number of color points on a line.

Then is found the scanning which could be as simple as a miror oscillating at the field frequency.

We have left aside two blocks which are related to the one field delay line, used to destroy the field interlace.

We will now describe in detail the solution adopted for the three essential points of the system : the modulator, the visualisation and the delay line.

THE MODULATOR

It should have been possible to put after each point memorised an amplitude duration converter, in order to obtain the duration modulation. It's a too heavy and too expansive solution. We preferred a direct modulation method, obtained by a special circuit described on the figure 2.

At each visualised point of each color is associated a shift register with parallel inputs and a sery output ; the number of input is the number of binary elements composing the word encoding the analog signal.

The registers are loaded one after another with the words associated with each point.

When a sufficient number of points have been loaded all the binary elements of same weight are simultaneously shifted toward the output by a special clock so that they simultaneously adress the electro-optic transducer of the correspondant part of the line.

The clock giving the rythm of the shifts is sketched on the figure 3. It has as much pulses as there are binary elements in the word of the code. The duration between two pulses is twice those between the first pulse and the preceeding one. If a logical 1 is present at the output of the shift register the corresponding point of the line is kept lighted during a time interval proportionnal to the weight of the binary element considered. Two examples of the principle are given on figure 3.

In fact the sum of the duration during which the transducer are lighted is proportionnal to the digital value of the signal associated with the particular point. If the observer of the light is an "integrator", as a film or a human eye for example the lumination obtained is proportionnal to the analog signal associated ad with the point.

RESOLUTION AND SAMPLE FREQUENCY, WORD LENGTH AND NUMBER OF GREY LEVEL

At this point it's necessary to discuss the sample frequency. As a matter of fact it is strictly related to the number of transducer on the line and so to the resolution obtained on the film. If a 16mm format is choosen, and if we admit that a resolution of 60 t/mn is far above the limit resolution of color standard film, the number of point on a line should be near 600. The most commonly used sample frequency in digital TV, 12 MHz, give 624 useful points per line. A 10 MHz sample frequency would have given 500 points per line which is stil acceptable. In any case the important point to note is that the choice of this frequency has no influence on the principle of that system but only on the physical realisation of the line., i.e. the number of transducers. So the system could be very simply adapted in the eventuality of the introduction of digital television.

The second point to discuss is the number of reproducible levels. We choose a 64 levels gray scale on every primary color as a good compromise between the system simplicity and the picture quality coanted. This choice leads to code words of six binary elements in the design of our system.

THE ELECTRO-OPTIC TRANSDUCER

We can now go back to the optical part of our kinescope. If a duration modulation is used, and if 64 distinguishable levels are wanted, during one half a line (as it will be explained later), the lowest level should correspond to a duration of 500ns and the upper level at a maximum duration of 32µs.

So we must find electro-optic transducers which change of state in a hundred of nano seconds and which can be obtained up to 600 in a small volume. At the moment the components choosen are electroluminescent diodes : they can switch in less than 100ns, they can be very small, (some 100µ). In order to design the source, at each point of the line must be associated three diodes of each color red, green and blue.

If it is easy to find red, and green diode, the problem is more intricated for blue diode. They exist at the laboratory stage in USA and in France, but they are far from to be commercialised in large quantity.

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This difficulty has been solved by the use of a special film ; a film manufactured by Kodak for false color photography. It is a color inversible film whose sensitivity curves are sketched on figure 4. The first layer is sensitive to infrared light and give after inversion a red picture. So if the red signal is fed into the infrared diode, then the green signal into the red diode, finally the blue signal into the green diode, a normal red green and blue picture can be created.

On the figure 5 can be seen, the sensitivity curve of each layer and the relative position of the used diodes. The green diode emits at 560nm, the red diode at 650nm, and the infrared diode at 820nm.

A full color line can be obtained by placing side by side some 80 modules such as the one presented on figure 6. This possibility as been tried but lead to a too complicated optics for the light collection with optical fibers and so one. So it has been decided to realise separately three lines of each color.

The diodes being as dense as possible on a line ; with 624 diodes of 400μ width this give a line of 26 or 27cm. The mixing of the three colors is obtained by ordinary dichroic mirrors, and the registration is not too hard, because it is a line registration and not a picture registration. In this case the light collection is simply done by a normal lens which forms the image of the line on the film by the use of the scanning mirror.

VERTICAL SCANNING AND FIELD INTERLACE

The two classical method adopted until now to solve the problem of field interlace are either the recording of only one field per picture or the use of a fast pull down camera with a mirror oscillating at the frame frequency with a cut off of a millisecond. In the first case the resolution is not kept, in the second case the high price of fast pull down cameras, and their pour reliability are a great problem.

As this point we can take benefit of the use of digital techniques. As a matter of fact one observes that the mirror scans all the picture during one field and so describes the space allocated to two lines during one scan line (64ps).

In order to maintain the initial resolution we can address the optical line only during 32μs in order to record a given line of a given frame and then use the 32μs left for addressing the line just following of the alternate field. This is possible only if one dispose at the correct instant of the information of this field. This leads to the introduction of a one field delay line as indicated on the first figure. A field permutator handles the information coming from the direct way or the delayed way.

So with this method for destroying the field interlace, we can use a normal camera and a mirror oscillating at field frequency but with half time occultation, which is far more simple to design.

STATE OF THE REALISATION - DESIGN PROBLEMS

At the moment, after having verified the validity of the fundamental assumptions on which the system is based, i.e. the duration modulation, use of infrared film for false color, use of diodes on film, we have built, partly or totally certains parts of the system.

The modulator works for 64 points of the three colors, and the complete building is in progress. The field memory is designed and its realisation startes. The programmable matrixing is just put into service jointly with the colorimetric matrixing in order to study the value of the various coefficients.

For the electro-optic head we had studied the first disposition and conclude on it's difficulty. Three lines of the second disposition are now under construction.

We are come up against a difficulty with the diodes because of the dispersion of their carateristic. For the system to work it is necessary that, if the same signal is present all along the line, the diodes emit the same light in a percent ; this is strictly impossible even if a severe selection is done among commercialy avalaible electroluminescent diodes. So we have been obliged to connect with each diode a resistor by which the light emitted by the diode is adjusted at the fabrication.

The resistors are made by thin film technology and are adjusted by methods commonly used in "customer designed"circuit manufacturing. Reliability tests are in progress that show that if the light emitted by the diodes are adjusted at a given instant, it can be maintained in a percent for more than 100 hours of continuous working.

Future

The two main problems of the electrooptic head were :
- the inhomogeneity of the light source
- the fact that the component which modulates and emits the light is the same.

So we have search for an electrooptic component having all the caracterics wanted in switching speed density ..., but which will act only as a light modulator. While he curse of our study, electrooptic PLZT ceramics fabricated in some firms such as Sandia Laboratories in USA, Pleyssey in England or Thomson CSF in France have reached these caracteristics. But they are still in laboratory stage and made by small quantities, (we have obtained lines of 64 points) and the switching voltage between transparent and opaque states is still to high. Nevertheless , it is hopefully for the future a solution for replacing with many advantages the electroluminescent diodes line, if used with three light sources adequatly filtered.

CONCLUSION

In conclusion, we have designed a colour kinescope based on new principles and well suited to digital television. The principal assumption made have been tested, and complete system.is now under construction. It is expected that this system should help in the solution of the main problems of existing kinescopes. But at this stage of realisation we cannot be sure that we will not come up against other unknown problems. To decide of the future of our equipement, the experiment must be brought to his end.

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FIGURE CAPTION

Figure 1 : Global structure of the kinescope.

Figure 2 : Equivalent integrated circuit for the modulator.

Figure 3 : Clock giving the output rythm.

Figure 4 : IR film transfert.

Figure 5 : Wavelenght sensitivity of the IR film.

Figure 6 : Eight points module.

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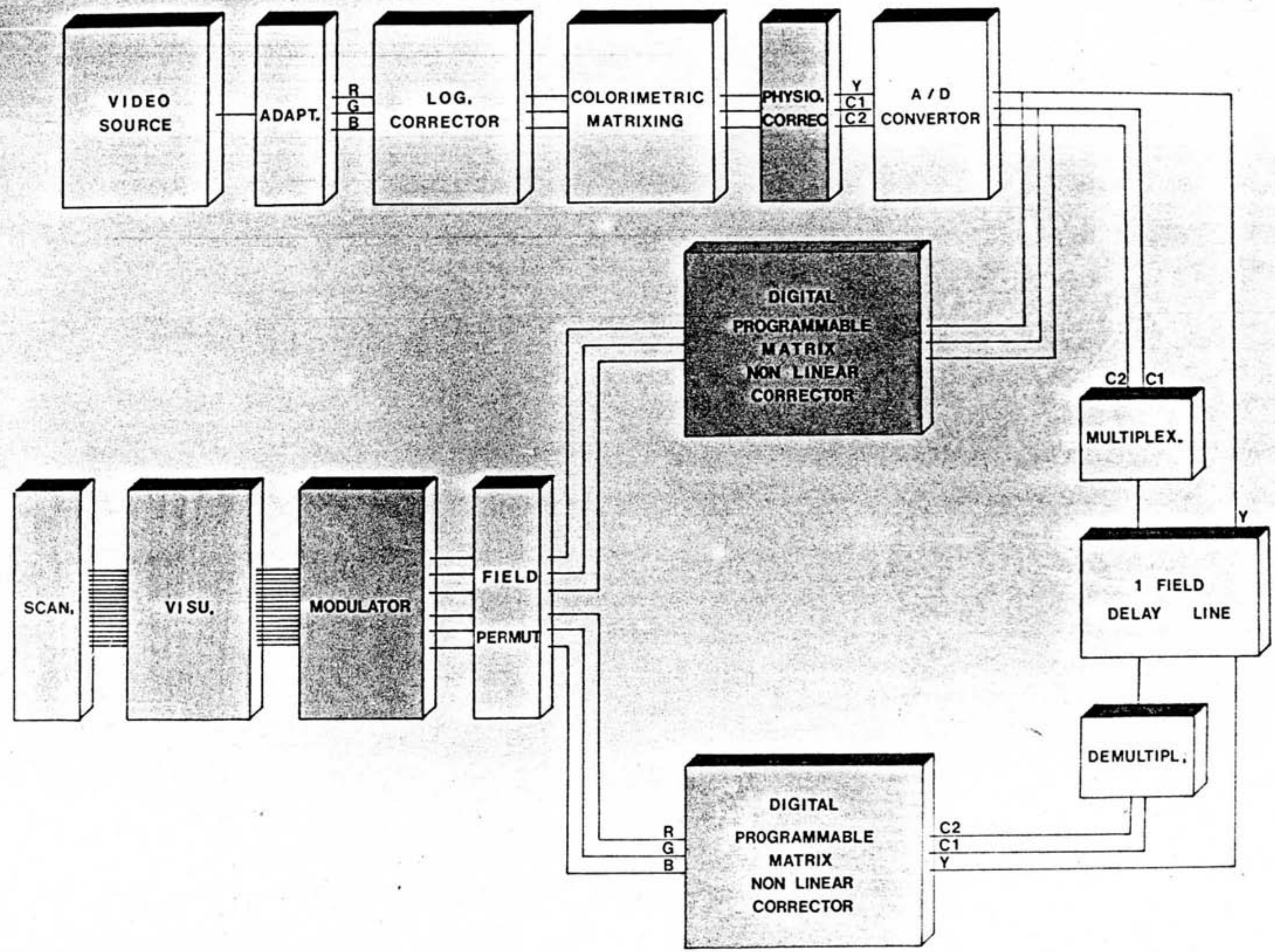
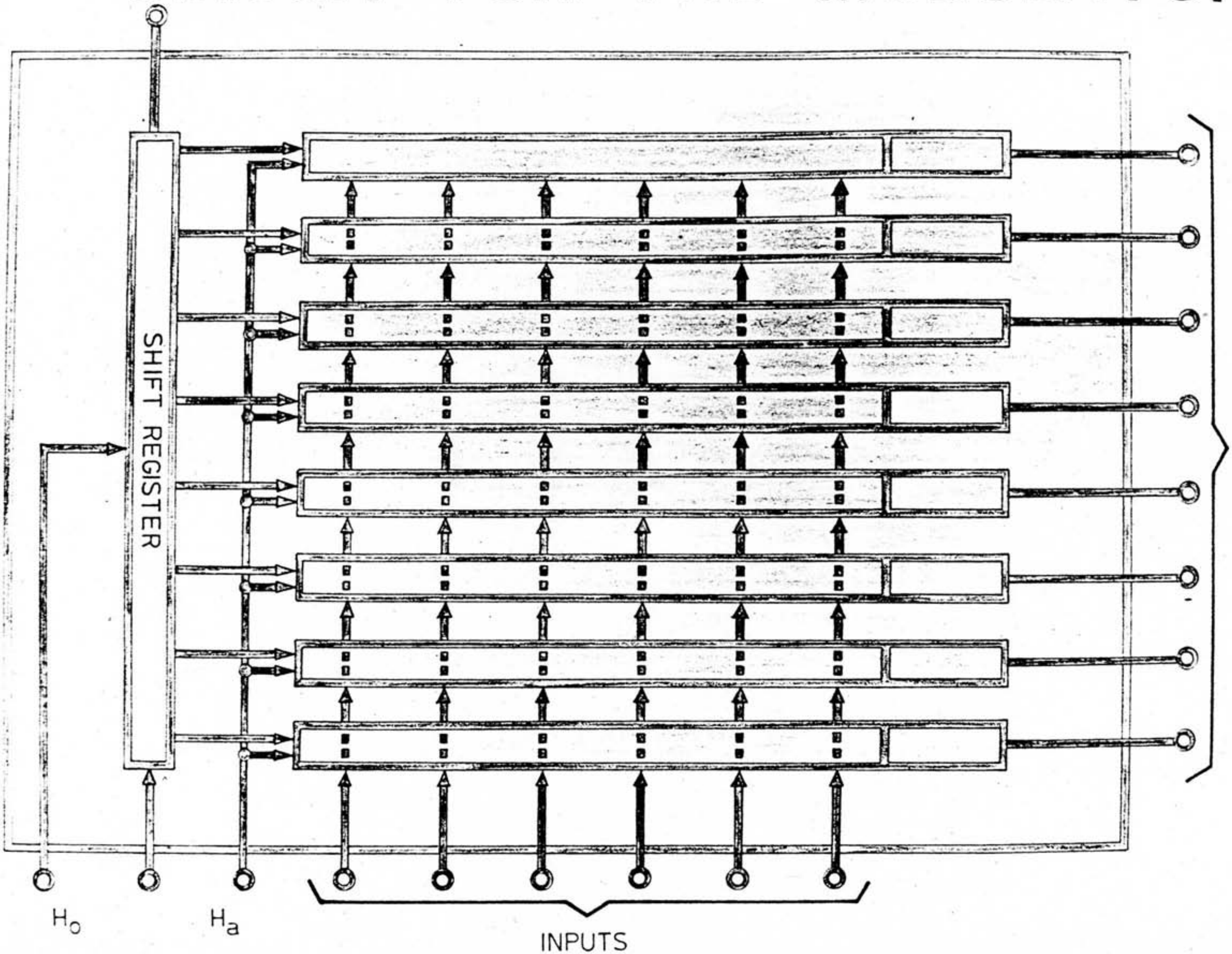


FIG 1 GLOBAL STRUCTURE OF THE KINESCOPE

FIG. 2. EQUIVALENT INTEGRATED CIRCUIT FOR THE MODULATOR



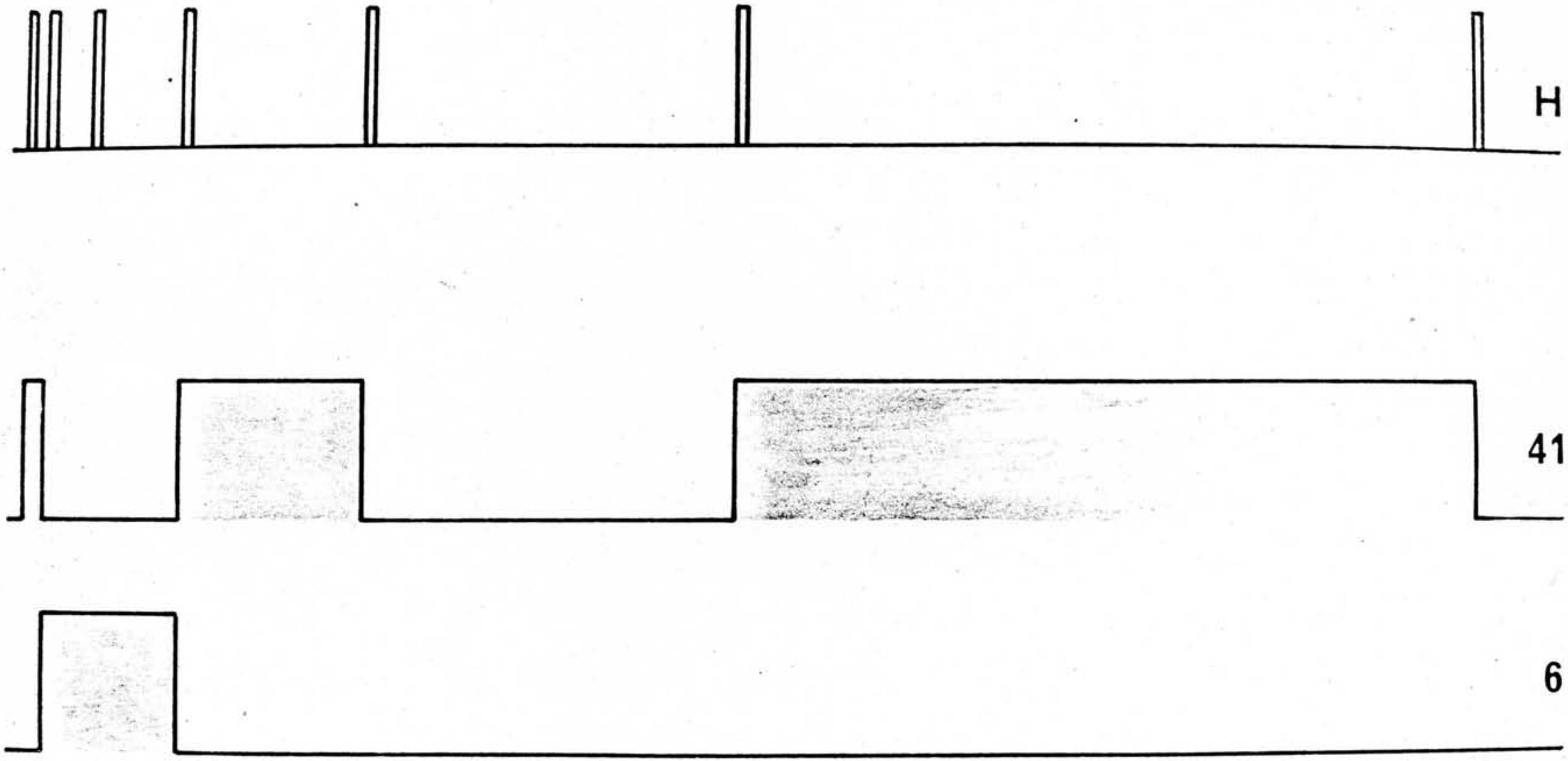
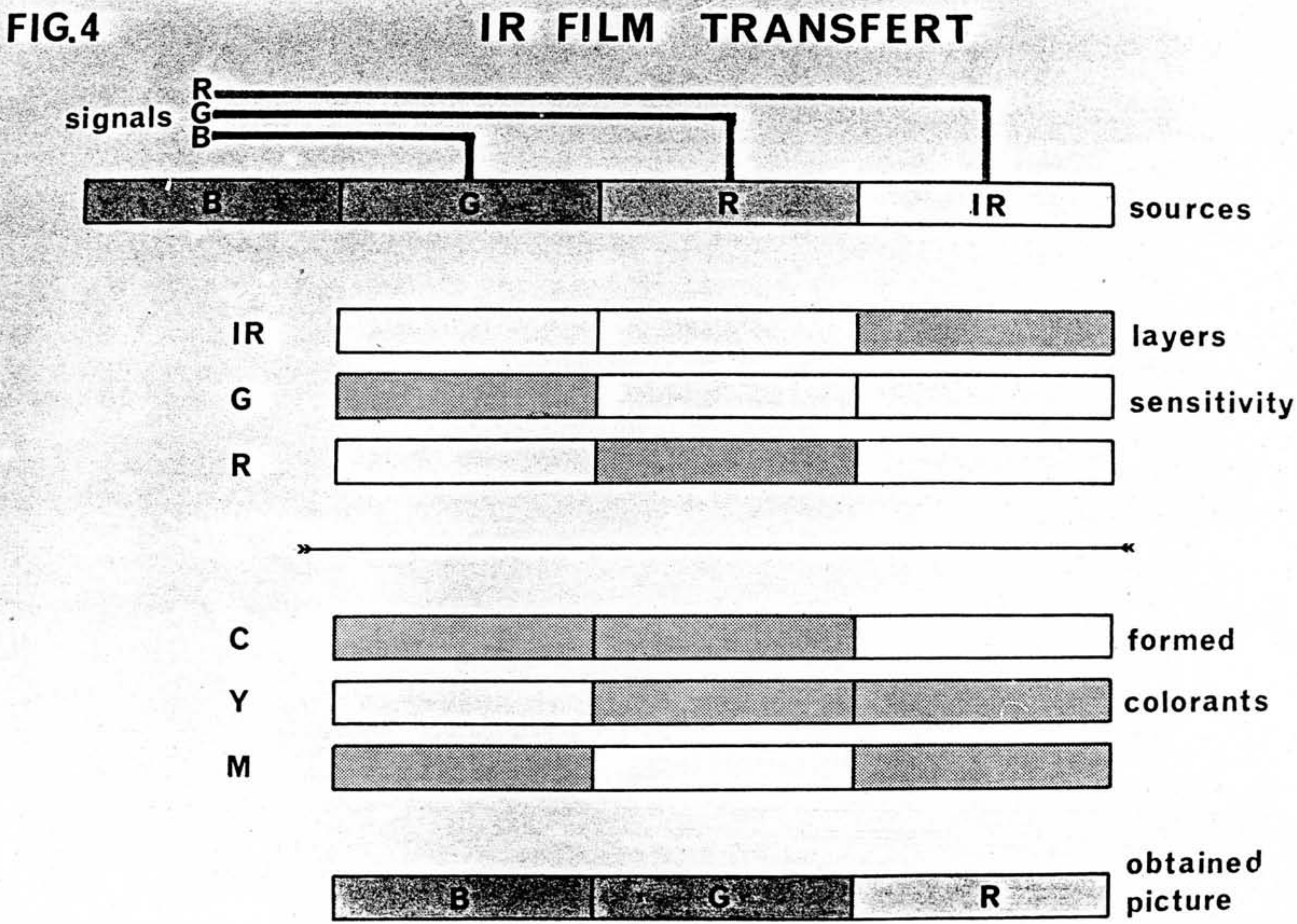


Fig.3 CLOCK GIVING THE OUTPUT RYTHM

FIG.4


IR FILM TRANSFERT
signals
R
G
B
B
G
R
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sources
IR
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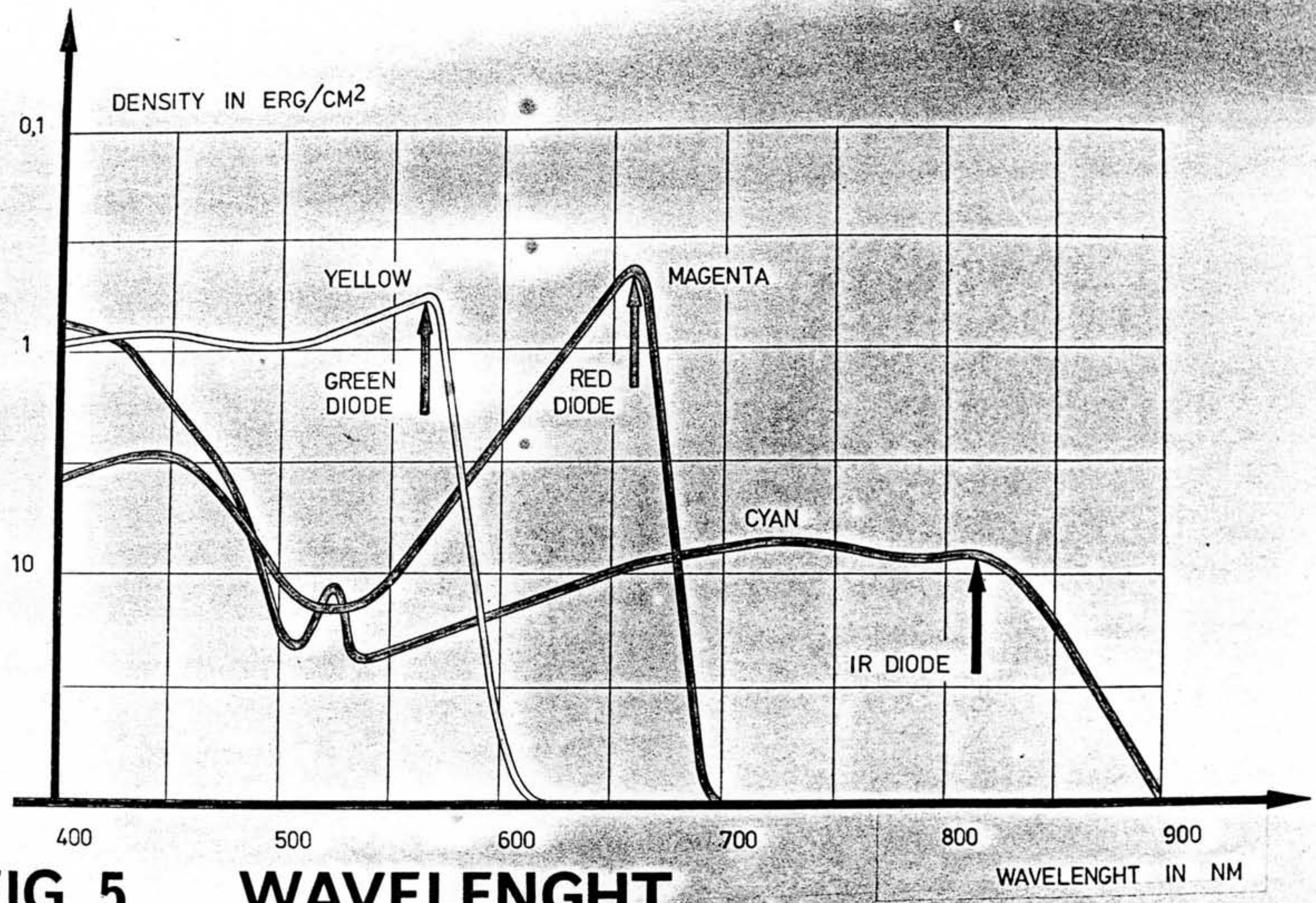

FIG. 5 . WAVELENGHT SENSITIVITY OF THE IR FILM

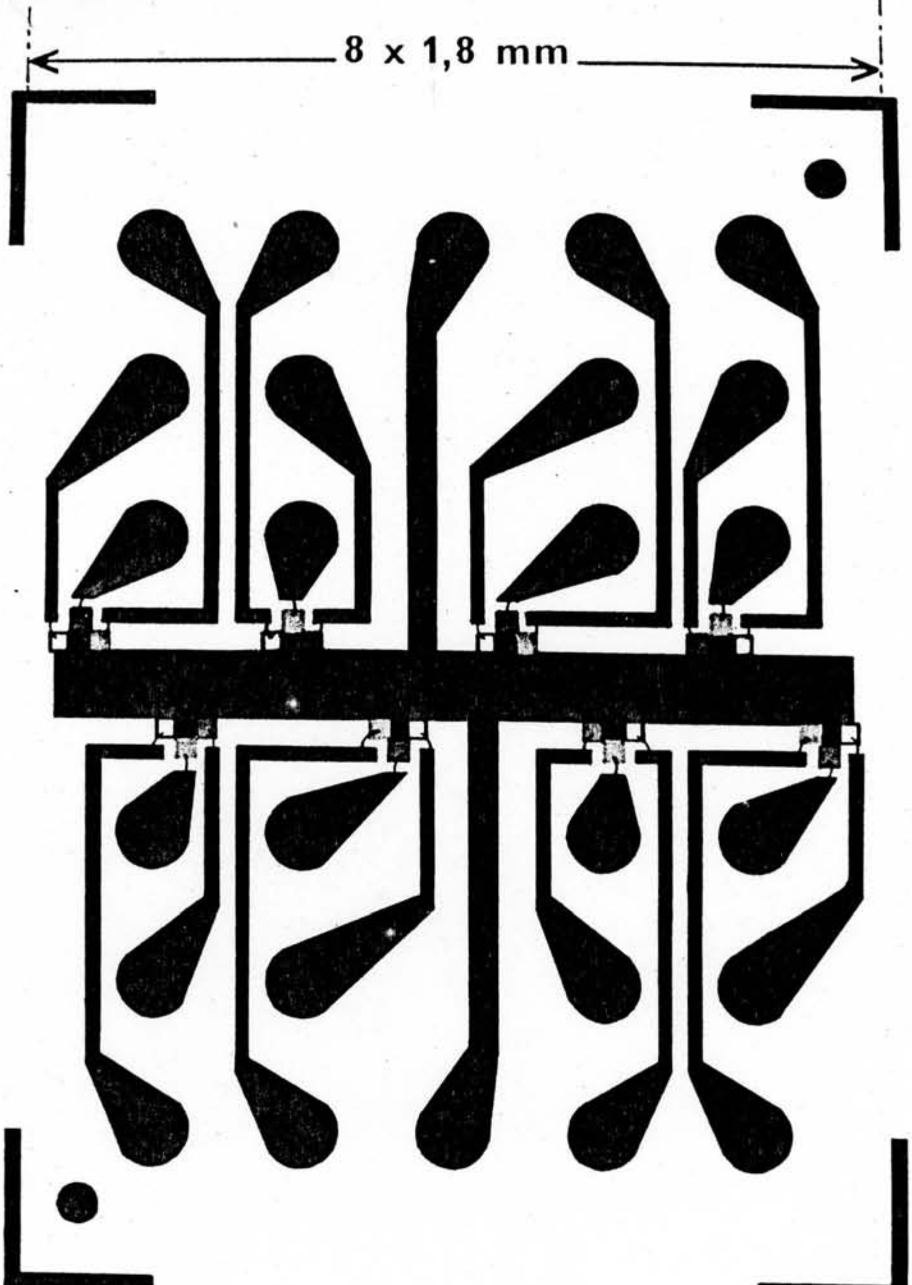

FIG. 6. EIGHT POINTS MODULE