A VIDEO PROCESSOR

by

Jack J. Campbell

Submitted in Partial Fulfillment

of the Requirements for the

Degree of Bachelor of Science

at the

Massachusetts Institute of Technology

September, 1978

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Chairman, Departmental Committee on Theses

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Abstract

The purpose of this thesis (project) was to design and construct a video processor capable of producing a number of useful effects. The design is such that the processor can be used between any two edit video tape recorders as well as in live systems. The circuit can be easily interfaced with external devices to produce additional effects that a user might want to create. The big advantage of this processor over most others is that it works with video tape recorders directly, without a time base corrector or any other external equipment. A waveform monitor is useful in setting up the device, but is not necessary.

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Title: Professor of Cinema
Head of the Film Department, M.I.T.

TABLE OF CONTENTS

(TABLE OF CONTENTS continued) Page

HISTORY OF PROJECT AND LIST OF SPECIAL EFFECTS

The first thing I had to decide on was what kind of effects I wanted the processor to have. I had seen other processors and I had some ideas myself. I also discussed with various video artists what kinds of effects they would like to see. The following is a list of effects which I decided might be useful. I did not design and build all of the circuits for these effects because of time and money limitations. Definitions follow on the next page.

* Multi-level Keyer (voltage controlled)
* Inverter
* Variable High Filter
* Variable Low Filter
* Mixer (voltage controlled)

  Function Generator (for mixing and modulating)

  Colorizer (voltage controlled)

  Cartoonizer

  Edge Generator

* = designed and built in final processor

DEFINITIONS OF THE SPECIAL EFFECTS

Multi-level Keyer - This is an electronic switch which has one control input, n selectable inputs, one output and n-1 threshold adjustments. The video signal control is constantly compared to the threshold voltages. When the video level is below all of them, input 1 is connected to the output. When the video level is below all of the thresholds but the lowest, input 2 is connected to the output, etc., finally if the video level is above all of the thresholds then input n is connected to the output. Voltage controlling the thresholds with an oscillator or with audio would cause the images to have wavering edges.

Inverter - This is an inverting amplifier which creates a negative picture. (i.e. blacks become white and vice-versa).

Variable High Pass Filter - This is a single pole high pass which has the effect of turning everything gray except for edges.

Variable Low Pass Filter - This is a single pole low pass which has the effect of cutting down resolution at the high cutoff settings and has the effect of smearing at the low cutoff settings.

Mixer - This allows the summing of a number of signals. (Either video or oscillator signals or whatever).

Function Generator - This is a sine, square, triangle wave oscillator, which can be used with the mixer or Keyer. (.1 hz - 1 MhZ. variable).

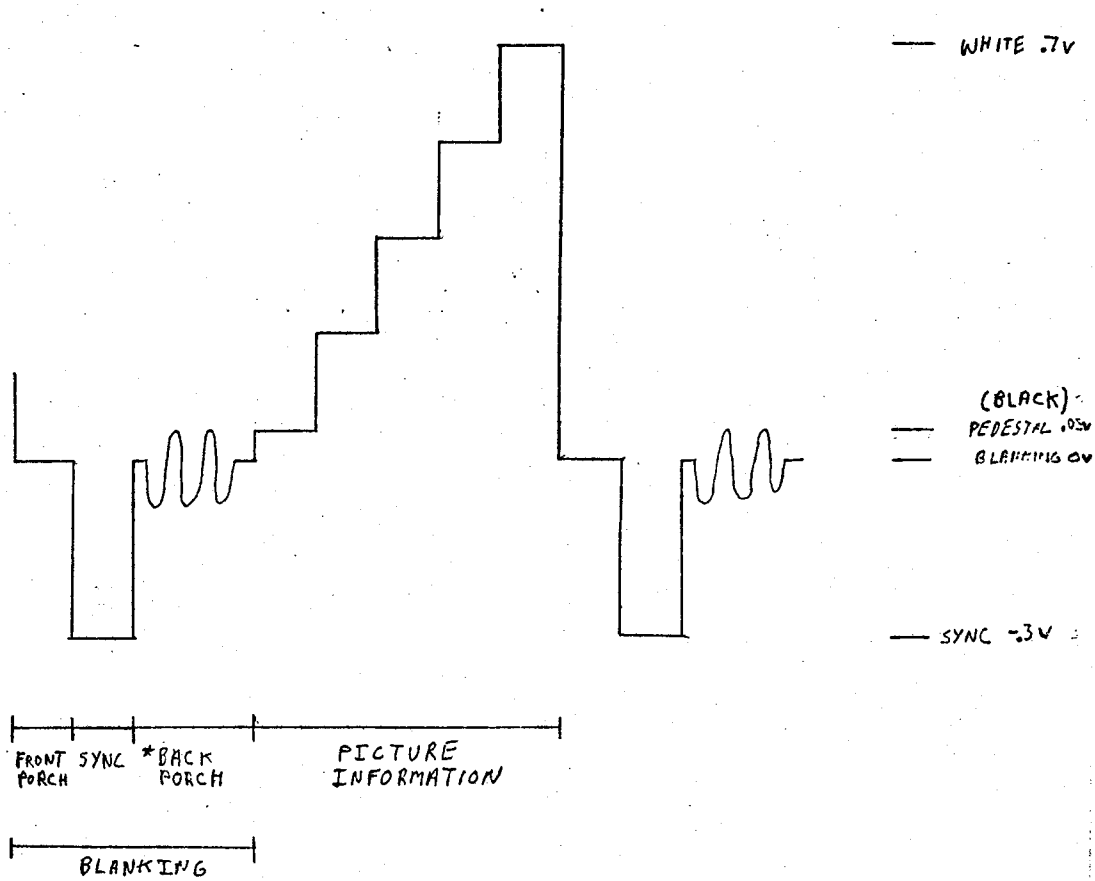
Colorizer - This is a circuit that allows one to put color on a black and white signal. A voltage controlled phase shifter could allow you to put different colors onto different levels of brightness.

Cartoonizer - This is a combination of the multilevel Keyer and the colorizer. This allows you to break up the video signal into a number of regions, with no detail in each region, just controllable grey tone and controllable color.

Edge Generator - This is another offshoot of the Keyer. Whenever one of the layer thresholds is crossed, the switch switches but only for a preset amount of time after which it switches back again.

REASONS FOR A NEW SPECIAL EFFECT GENERATOR

Most special effect generators (S.E.G.) only work with live video signals. The reason for this is that when you're working through a S.E.G. all of the video signals arrive in sync. The S.E.G. usually has a blanking and sync input so that the sync and blanking are unchanged by any of the effects. Say, for instance, one wanted a negative video picture. If one simply inverted the total video signal, a television would not accept this. The sync pulses, instead of being downward, would be upward. A S.E.G. however would just invert the video and leave the blanking alone. The problem with a tape input to a S.E.G. is that it gets no separate sync and blanking pulses so it doesn't know which part of the video signal to leave uneffected. What my processor does is detect the blanking and leave the video signal alone during blanking.



* BACK PORCH IS SHOWN WITH COLOR BURST

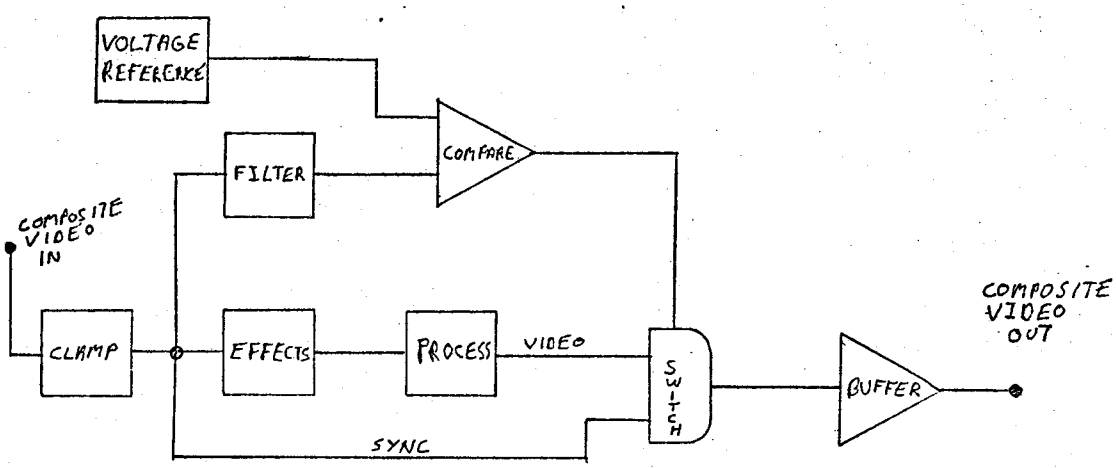
VIDEO SIGNAL WITH GRAY SCALE

FIG. 1

THEORY OF OPERATION

The idea is to separate the sync and blanking and burst from the picture information. To do this the blanking level has to be clamped to a constant voltage so that the video signal can be fed to a comparison circuit. This comparison circuit controlls an electronic SPDT switch. When the video signal goes above blanking the switch toggles and lets the processed (effected) video through. When the video signal is at or below blanking level the switch toggles again and sends the original sync and burst and blanking through to the output. There are two problems involved with this method of separation. One is how to clamp the blanking level to a constant voltage. The other is what happens during color burst which is the only part of the composite video signal that goes both above and below blanking.

The first problem is solved non-ideally by clamping the sync tip instead of the blanking. This is theoretically as good as clamping the blanking because the sync tip should be .3 volts less than blanking level. This is not always the case so an adjustment is necessary with input video signals that have sync levels other than .3 volts P/P. The second problem is solved by filtering the 3.58 MhZ color signal out of the video signal that is used to control the switch. This way the back porch will simply be at blanking level.



BLOCK DIAGRAM OF PROCESSER

FIG. 2

INTRODUCTION TO THE CIRCUITRY

On the following pages are the schematics of the processing amplifier. Here are a few notes concerning these schematics.

1. I.C. supply connections are not shown.

   All Op-Amps are + 15 and -15 volts.

   The comparaters and switches are +6 and -6 volts.

2. Op-Amp compensation capacitors are not shown.

3. Op-Amp bypass capacitors on the supply are not shown.

4. Power Supply Schematic is not given.

Op-Amps used for different purposes

Wide-Band	CA3100
High Input Impedance	TL081
General Purpose	LM318

Other I.C.'s used

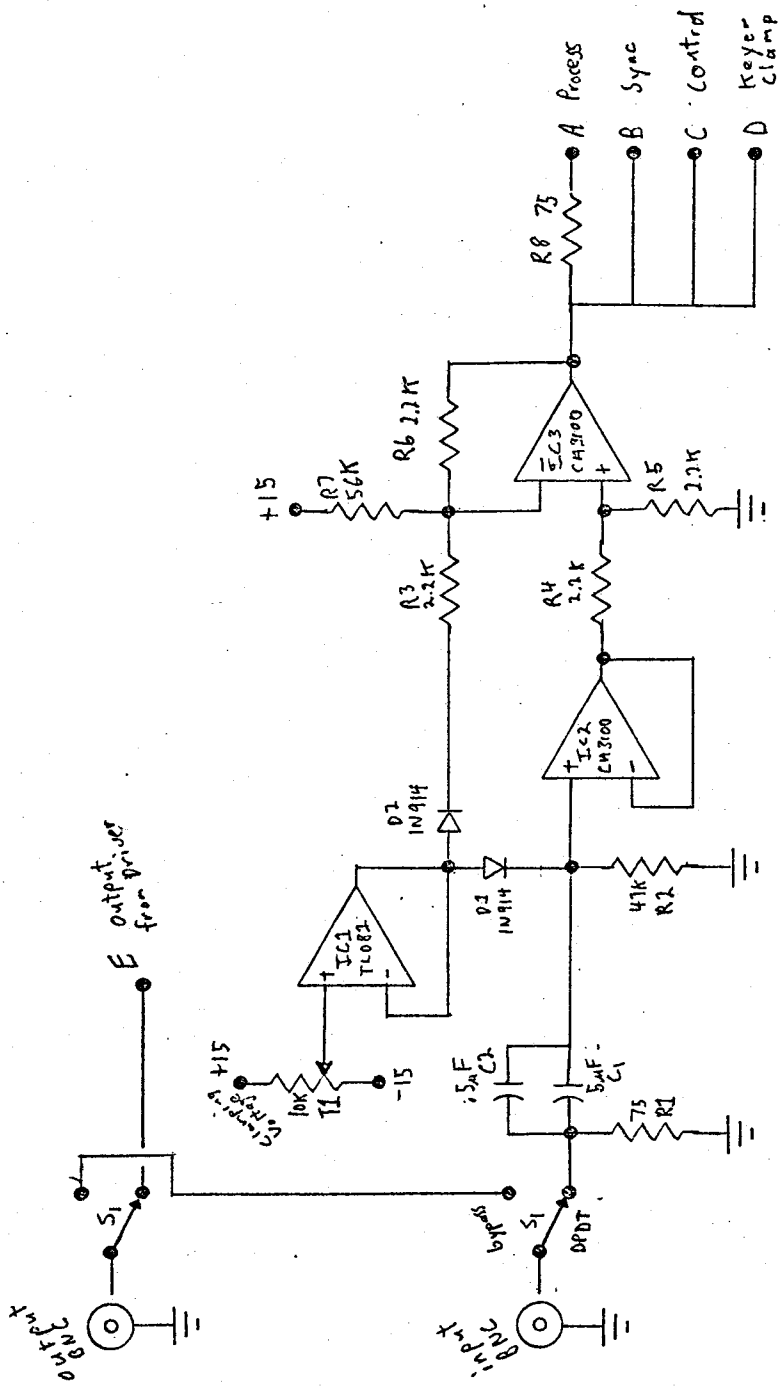
High Speed Complimentary Output Comparater	UA760
Quad Analog Switch	CD4066

Transistors used

General Purpose, high frequency, low noise	NPN MPS6515 PNP MPS6519

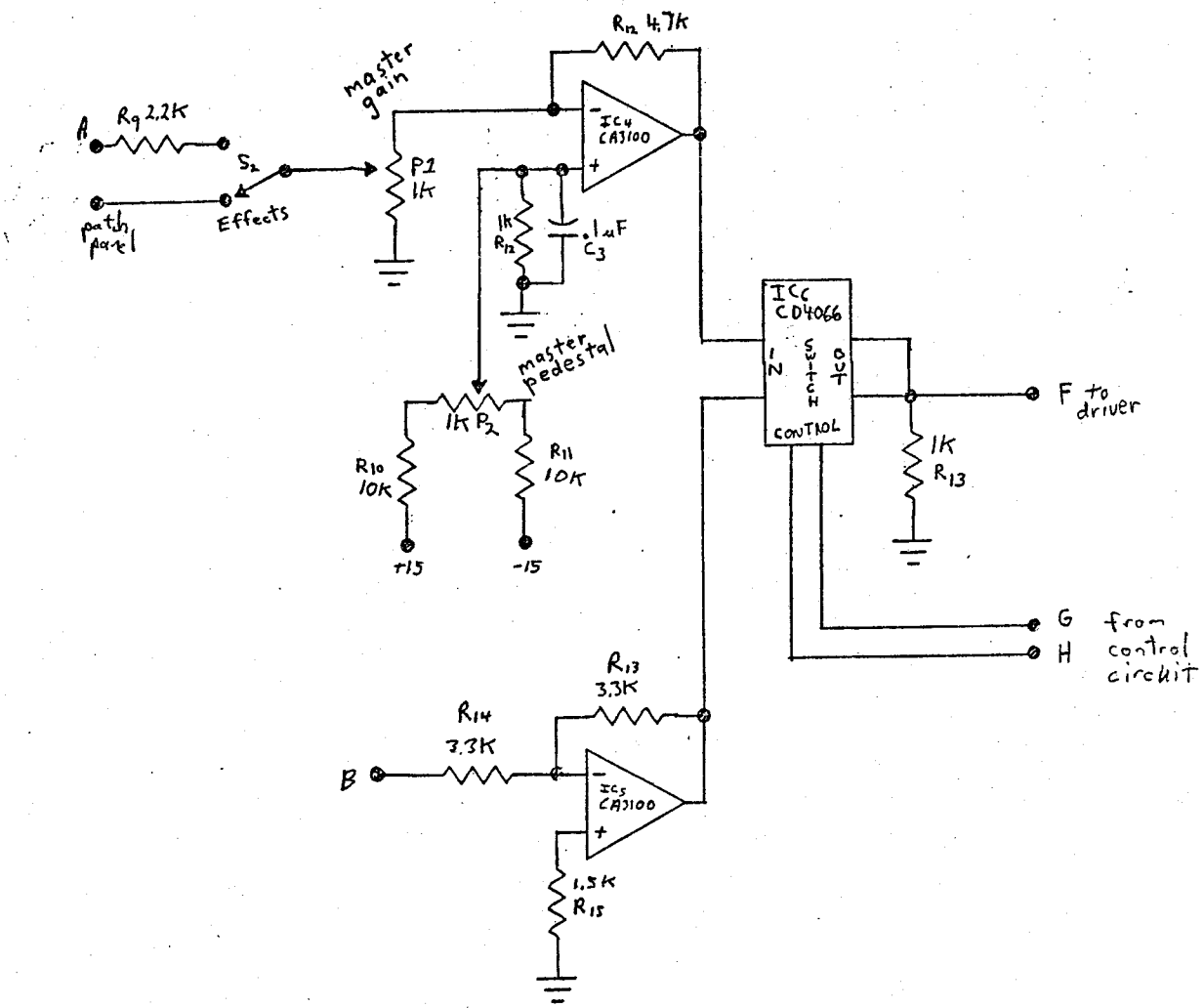
Resistors used

All resistors are 5% 1/4 watt.


A Process
B Sync
C Control
D Keyer clamp
R8 75
R6 2.2K
R7 56K
+15
IC3 CA3100
R5 2.2K
R3 2.2K
R4 2.2K
IC2 CA3100
D2 IN914
D1 IN914
E output from driver
IC1 TL082
47K R2
+15
10K T1
-15
.5mF C2
5mF C1
75 R1
S1
bypass
S1
DPDT
OUTPUT BNC
INPUT BNC

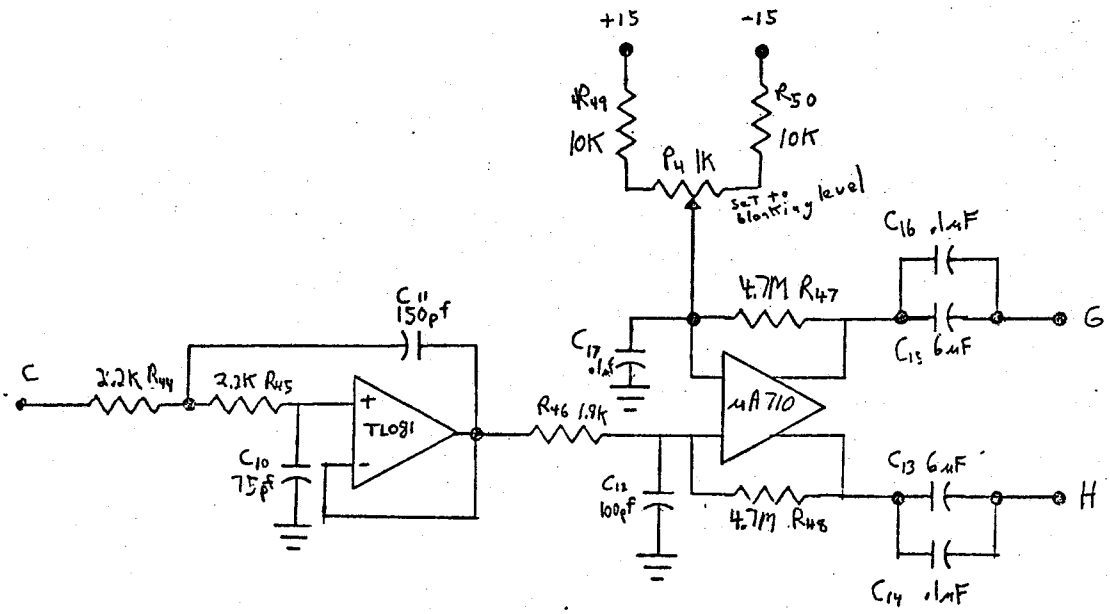
Clamp

FIG. 3



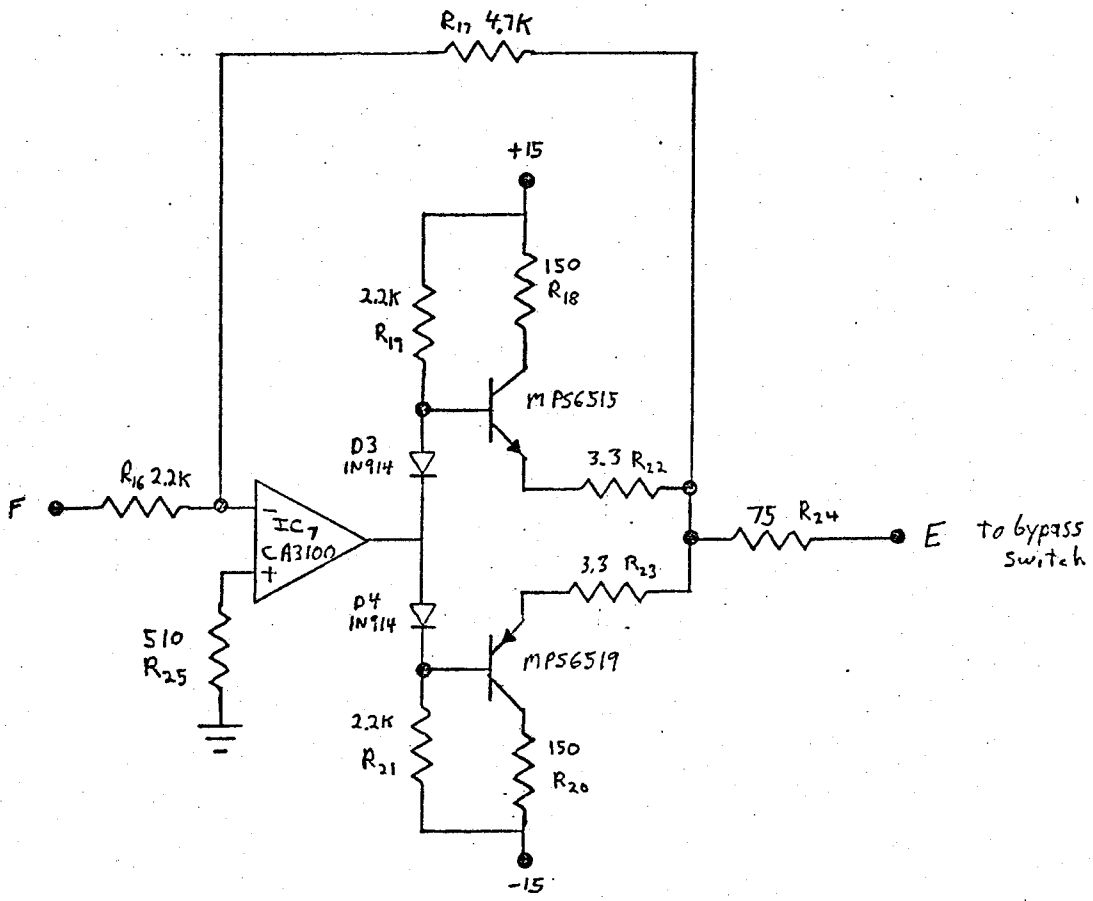
Processer

FIG. 4



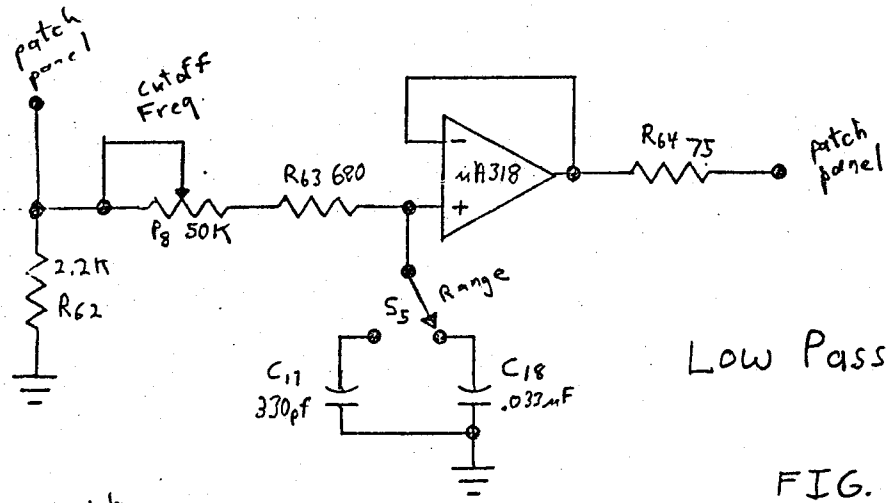
Switch Control
For Processer

FIG. 5



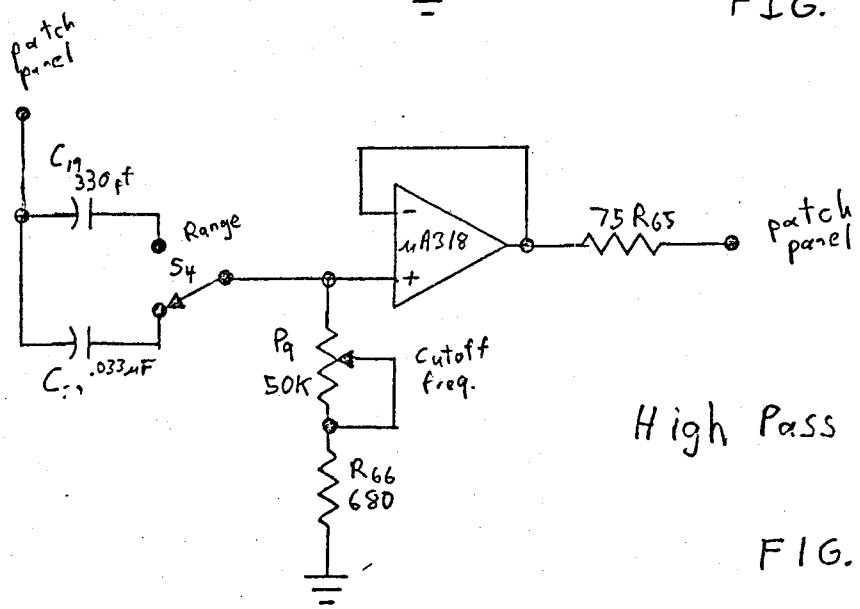
Output Stage
(Driver)

FIG. 6



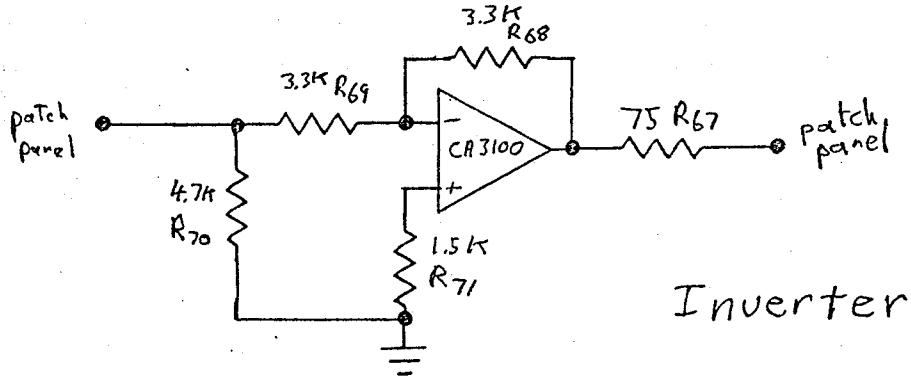
Low Pass Filter

FIG. 7



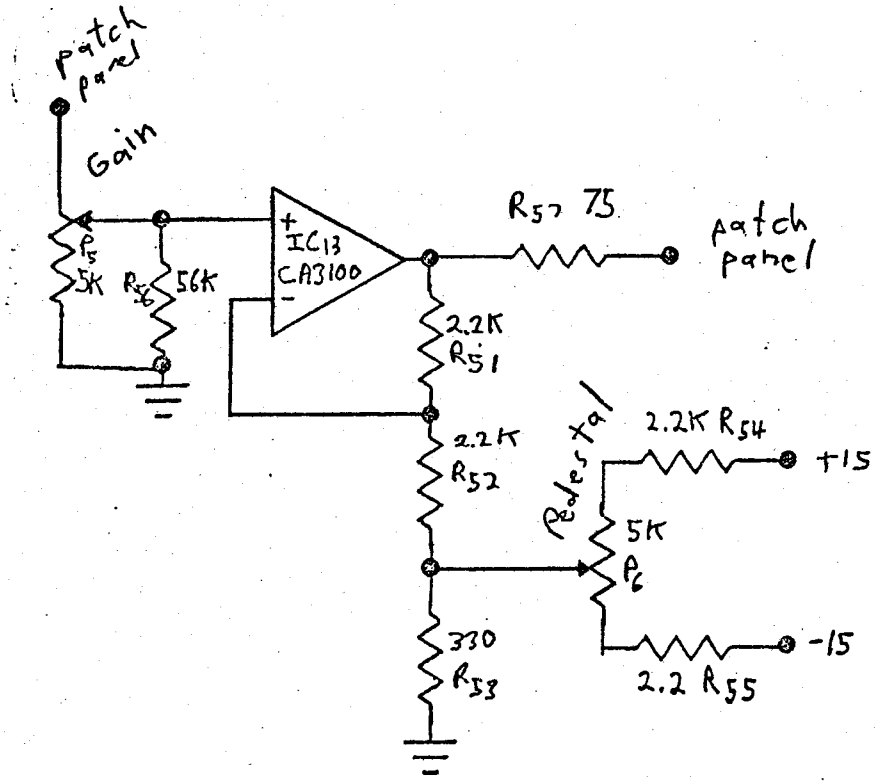
High Pass Filter

FIG. 8



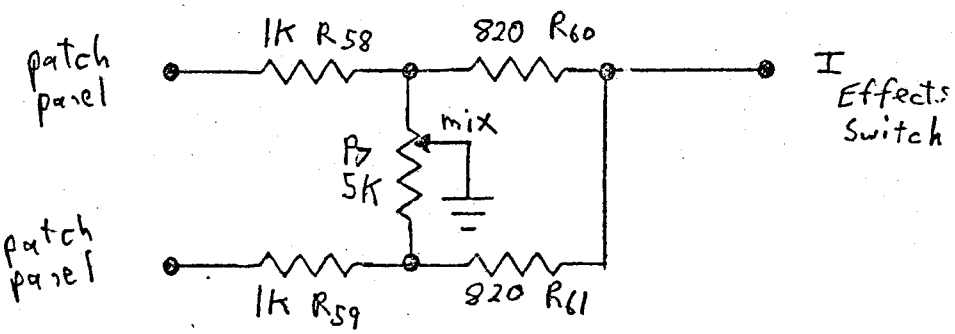
Inverter

FIG. 9



2 Amplifiers With DC and AC Controls

FIG. 10



Mixer

FIG. 11

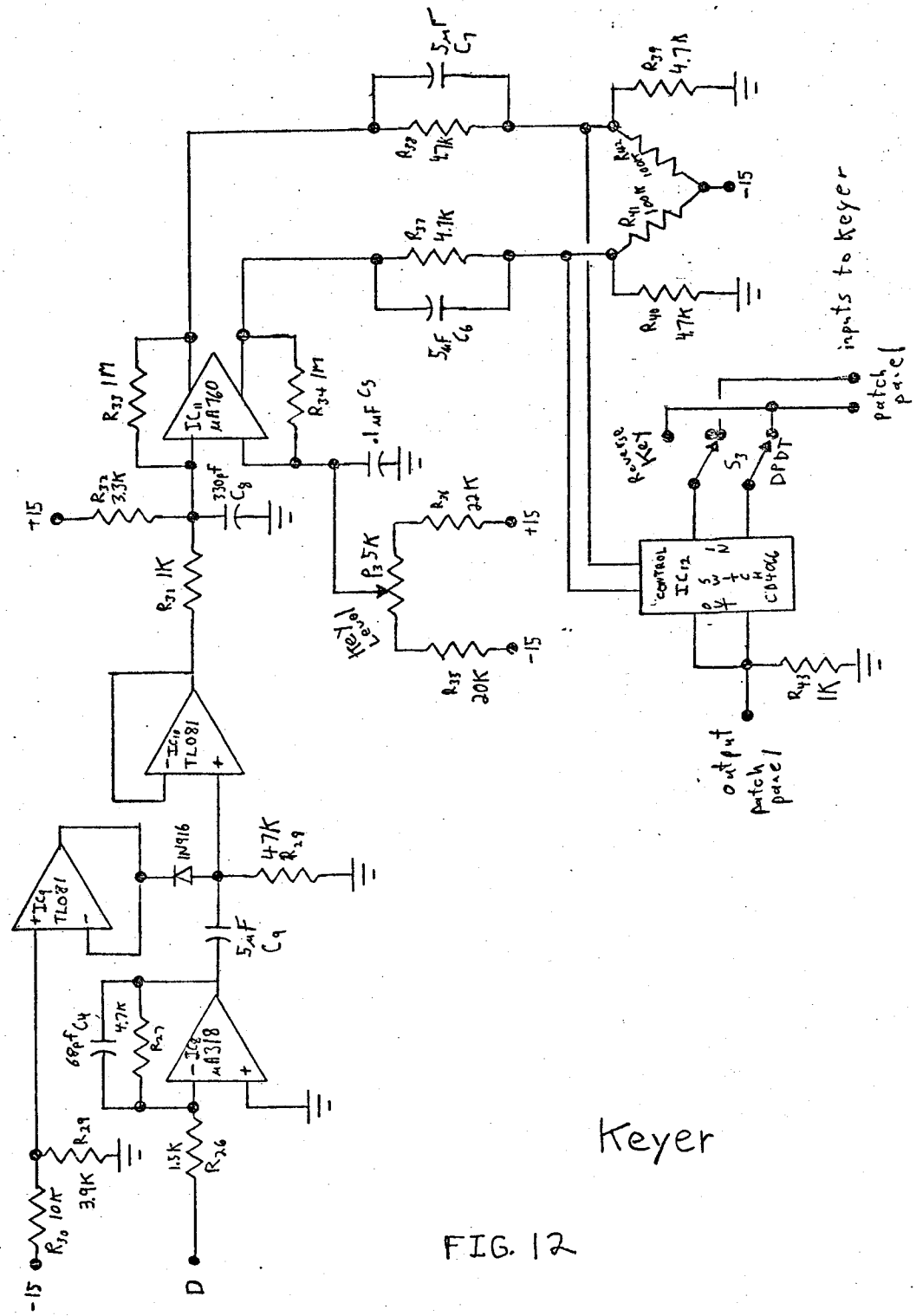

inputs to keyer
patch panel
output patch panel
Keyer
D
-15
+15
IC11 μA760
IC10 TL081
IC9 TL081
IC8 μA318
IC12 CD4066
1N916
Reverse Key
Key Level
DPDT

FIG. 12

BRIEF CIRCUIT DESCRIPTIONS

Fig. 3 This is a basic diode clamping circuit except that diode D1 isn't connected to ground, but to the low impedance output of a voltage follower. (IC1)). This allows one to vary the clamping voltage by adjusting trimmer T1. The clamp seems to work optimally with T1 adjusted to approximately 3.5 volts. R_2 and C_1 determine the time constant of the clamp. $R_2 \times C_1 = .2$ secs. C_2 is used to improve the high frequency response. IC3 is used as a subtractor to subtract the D.C. clamping voltage from the clamped video signal. This puts the blanking levelt at approximately 0 volts.

Fig. 4 This is the master video control circuit which comes after all of the effects. The video and sync are inverted here, fed to the switch and then to the driver. This gives separate control of the sync part and the picture part of the video signal.

Fig. 5 This is the control part of the sync and blanking separator. First the color information is filtered. Then the filtered video signal is compared to a D.C. reference voltage which is set manually to slightly above

blanking. When the video signal goes above blanking the comparator switches and causes the electronic switch to switch and change outputs.

Fig. 6 This is a standard push-pull output stage with a gain of 2. Diodes D3 and D4 are used to reduce crossover distortion. The transistors used are high frequency, low noise signal transistors similar to 2N3904 and 2N3906.

Figs. 7 & 8 The low pass and high pass filters are single pole and variable, both in two ranges. 10 hZ - 8 KhZ, 8 KhZ - 700 KhZ.

Fig. 9 The inverter is a single op-amp wired in an inverting configuration, R_{70} is used to reduce oscillation when there is no input connected.

Fig. 10 This is a non inverting amplifier with an input attenuator to control the gain and a D.C. offset control to vary the pedestal.

Fig. 11 This is a passive two-input, one output mixer.

Fig. 12 The Keyer is best explained by a block diagram, which is shown on the next page.

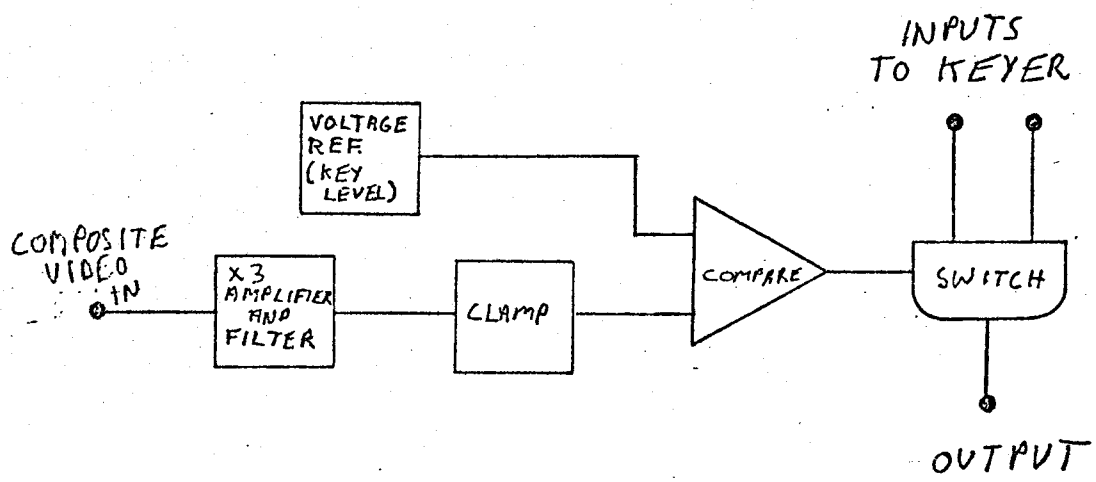
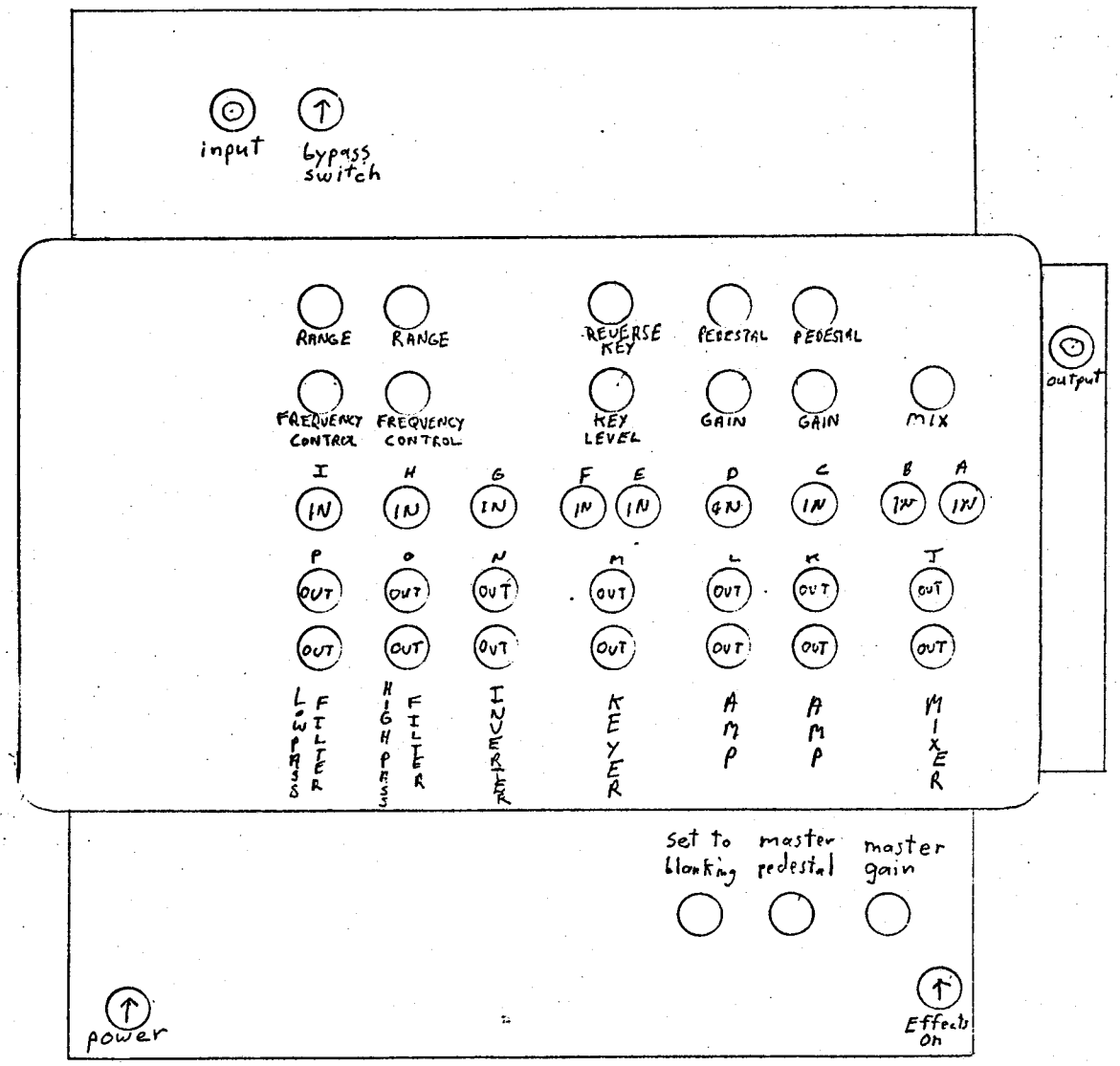

INPUTS
TO KEYER
VOLTAGE
REF.
(KEY
LEVEL)
COMPOSITE
VIDEO
IN
X3
AMPLIFIER
AND
FILTER
CLAMP
COMPARE
SWITCH
OUTPUT

FIG. 13



CONTROLS DESCRIPTION

FIG. 14

SOME PATCH CONFIGURATIONS

negative picture	J-G, N-A
soft focus picture	I-J, P-A
smeared picture	I-J, P-A
two-tone picture	M-A J-C J-D L-F K-E
line drawing picture	M-H J-C J-D L-F K-E O-A
normal picture with whited out whites	M-A J-C J-D L-F K-E
normal picture with blacked out blacks	M-A J-C J-D L-F K-E
part negative, part positive picture	J-D J-C L-F K-G N-E M-A
gray picture with only edge detail	H-J, O-A

PROBLEMS

Most of the problems I encountered had to do with the fact that such a large bandwidth is required for video circuitry (DC - 5 MhZ). This limited me to a few easily available operational amplifiers (Op-Amps). I tried the LM318 and the μA715, but I had bandwidth problems with both of them, and stability problems with the 715. I ended up using the CA3100 for most of the applications because it is easily compensated and less prone to pick up than the 715. I had to insert bypass capacitors at the supplies of all the Op-Amps to retain high frequency stability.

There are a few problems in the final design which I think are worth mentioning. Firstly, the circuit has to be adjusted when the input has a sync level other than .3 volts p/p. This is fine for live signals or unedited tape. When one tries to run an edited tape signal through the processor, where each segment has a different sync level, one encounters problems. The way I could have gotten around this is by clamping to the blanking level. This takes fairly sophisticated circuitry and I did not have time to design or build it. The second problem is that the switching of the Keyer is delayed about 1 μsec. This is due to the delay of the analog switch and the comparator. This delay is not visually apparent unless a fine lined image is on the screen. The way to solve this problem is to insert analog delay lines immediately before the key inputs. Lastly there is no color control. There is very little color shift

going through the processing part of my S.E.G. When one does effects to the video the colors are very strange and interesting, but uncontrollable. To put color controls into the processor would be very difficult and would require complicated filters and phase shifters. Again I didn't have enough time to do this.

CONCLUSIONS

What good is it? Does it have any artistic relevance? The device was originally conceived of to be a useful, accessible tool for video artists. What it does is take a clear, real life picture of an event or scene and change it to a more abstract image. It does this by changing and/or losing some of the information content in the original picture. This, of course, leaves the viewer with an indeterminate image, and so the viewer must use what he sees to realize a new picture. The way the viewer will interpret this new picture will probably be different for different effects. This gives the artist a means for creating various aesthetics which might not be possible with unprocessed video alone.

I would like to see two additions to my circuit both of which I plan to do. One is a color control, preferably voltage controlled. This would allow the colorization or the cartoonization of a black & white signal. The second thing I would like to add is voltage control to all of my effects. This would allow an audio signal or oscillator to control the video resulting in very interesting perceptual effects relating sight to sound.

BIBLIOGRAPHY

Basic Television by Bernard Grob

Thanks to Ken Kantor and Ben Bergery.