Report on Technical Research Conducted
at the
National Center for Experiments in Television

Direct Video: An Electronic, Camera-less Method for Generating Color Television Images

A Summary of the past years research and proposals for further development of this work
or

how i spent the past year and some $15,000 in san frnacisco and would like to keep on doing so.

submitted by
stephen beck
septmeber 15, 1971

or How I spent the past year
(and some $10,000 IN SAN FRANCISCO

~~Direct Video~~ • Report on Research Conducted
at the National Center for Experiments in Television
~~into~~ electronic, cameraless television images
D-V, and method for prod-
~~also containing~~ proposals for ~~further~~ development
Summary of past progress over ~~the~~ past year and
of this technique
subnitted by stephen c. beck

~~having~~ now spent one year at the center let me now survey the
progress ~~that~~ has been made with direct video and at what now
exists in the way of both theory and hardware. In addition
let me propose further research designed both to increase the
vocabulary (?) of direct video images as well as to facilitate
the process of interacting with the instrument and producing
images. Further refinements in packaging and construction.
hardware coupled with documentation, both technical and will
operational, including video-guide tapes, ~~through should~~ result
in a versatile tool for image generation and manipulation.

Survey of years activity
initial task of Construction and procurement of an electronic research
and circuit design laboratory. Obviously a necessity for
doing serious work.
Image capabilties which were the result of work done ~~the~~ since
Fall of 1969 ~~at the~~ while I was attending University of Illinois with my own
home ~~electronic~~ laboratory and a zentih color tele vison set.
Much of the work there was with audio modulation of ~~the~~
color intensities using electronically produced sounds to
obtain precise and controllable display patterns. It is
with essentially this equipment which i began to expand
here at the center. The system consisted of a television
set designed to accept red, green, and blue modulations
alongdwith a variey of modulating sources and a matrix
patch switch to interconnect different sources to a
color mixer with a 500 khz bandwith. But the beginnings of
a theory for realizing a general system of generating and manipulating
images where present and with these beginnings my year at the
center got off.

Video
~~A few~~ tape records of these early images were made using the
color camera encoder in a modified way so as to accept
inputs from direct video machine #0. ~~Most of~~ these represent features of color color features
with inputs from the buchla electronic mucis synthesizer played
by ~~R~~ichard Felciano as well as camera direct video sources.
"D.V." owned at this time by Bruce
go ntsc with telemation color sync generator and three m encoder.
development of voltage to position converters and simple reference
circuits. three color color mixing board. tape images in
"one lonely friday night" towards end of december 1970
one form source and two colr mixing boards with four independent
voltage to position conversions possible.. closely working with
~~R~~ichard this equipment, mostly in breadboard form, was used to
realize "a point of inflection" at this point video bandwith was
~~full~~ 4 mhz and the full potentials of direct video as an
image forming tool were beginning to reveal themselves (heavy)

"you can't always get what you want
but if you try sometime you'll find
you get what you need..."

Having spent the past year at the national center let me now survey the progress which has been made with direct video as well as to describe what now exists in the way of both a theory for image generation and circuit hardware for ealizing this theory. In addition, let me propose further research designed both to increase the vocabulary of direct video imagery as well as to facilitate the process of manipulating the images. Continued refinements in packaging and construction hardware along with technical and operational documentation will result in a versatile toll for image generation and manipulation.

Survey of years activity

Upon arriving at the center the initial task which i faced was to procure and construct the necessary equipment for an electronic circuit research and design laboratory, obviously a necessity fordoing any serious work. In addition to this step it was also necessary for me to modify the color camera encoder so as to convert the ~~equipment~~ image capabilities that I didhave into ~~a-NT~~ standard color television signals.

What image capabilties I did arrive with were largely the result of work done since the fall of 1969 in ~~a~~ my home laboratory using a modified Zenith color television receiver. At that time i was working in the electronic music studio at the University of Illinois and ~~most of the~~ images were produced with audio frequency modulation of color intensities

1. Signal output is NTSC standards ~~composite~~ color video with ~~the bandwidth of direct~~ video processing amplifiers of ~~4 Mhz.~~ having a -3db bandwidth of 4 Mhz;

2. System has genlock capabilities.

3. Black and white camera signals or vtr playback may be used as source signals in addition to the cameraless electronic image sources.

4. ~~Circuit modules~~ large parameter are voltage controlled and compatible with Bu hal electronic music instruments as well as other electronic signal sources.

5. Image generating section of instrument is independent of video system standards. video inputs to the instrument consist of the system sync and drive ~~pulses~~ along with blnking pulses. system output is RGB video parallel signals may be used with PAL 625 , Secam 825, or PAL 400 with ~~readjustment of internal controls and use of~~ suitable sync source and encoder.

6. Prototype is fabricated out of aluminum frame with smoked plexiglass control module panels and Vero circuit cards. Circuit cards are housed in card racks while control modules are located on the top panle of the frame. Easy chagnge and modification of circuitry and control module elements is thus attained.

More specifically, here is a general description of the present hardware.

control pulse signal sources;

(10) 4 independent color chord mixing modules for determining hue, saturation, andbrightness of image elements. Both positive and negative color functions are controllable in an RGB mixing format with the Y signal being matrixed in the encoder. (an additional channel for control of Y is optionally addable.) angular rotation of control knobs is the analog for varying saturation of each of the primary hues.

(2) 1 quad mixer module with 11 switch selectable inputs, elementary texture control in the form of a video signal integrator, and gated output stages which provide the "key" function. Inputs are selected with a digital thumbwheel swiths, while master level controls adjust the output level of the channle by being rotaed. the outputs of the mixer module feed the color chord modules directly. a toggle switch activ tes the integrator with the time constant of integration being adjustable with a rotary knob. anothe r toggle is available for future preview use. each channle also has a gate input for turning the output of that channle off with the application of a logical 1 pulse level to the gate input.

(3) 1 dual video processor module consisting of two

Electronically produced sounds were used to obtain precise and controllable display patterns. It is essentially these techniques which I began to develop upon arriving at the Center. The early system (direct video machine #0) consisted of a television receiver modified to accept red, green, and blue (RGB) modulations along with a variety of modulation sources, a matrix pacth switch for accomplishing interconnections, and color mixing controls which fed mixing amplifiers having a 500 kHz (kilohertz) bandwidth. This equipment , and the beginnings of a theory for [redacted]n generating and manipulating images were the beginnings of my ~~relationship~~ stay at the center.

Video tape records of these early images were made and include " Initioation Rite" and "DReam Rite I,II", both color 1" tapes. These studies represent color textures and movements made in collaboration with Richard Felciano who played the Buchla Electronic Music Synthesizer as on source of images. The distinction between audio and video was beginning to evaporate. During these first weeks it was brice Howard who [redacted] Named what he was seeing: "Direct Video".

During the remaining part of 1970 significant advances were made, including full NTSC standard video with a telemation sync generator and a 3-M brand encoder, development of voltage-to-position converters and simple reference signal sources, and monochromatic color mixing boards using RGB mixing. Towards the

at this time the abovementioned circuiry is undergoing evaluation and has been operating rleiably since the end of july. ~~certain~~ minor errors have shown themselves and the next phase of design is to rework the circuits which are at fault. m re on this topic later.

pack gin

the major ~~distinction involved~~ in devising apackaging scheme for decision the prototype instrument ~~resulted in~~ was to implemant separate circuit and control modules. In this way either elemement of a particular function may be modified or repaired without distrubing the other. The primary disadvantage of this method is the interconnection wiring ~~between the modules~~. Not only is such wiring laborious to ~~execute~~ but it also introduces unecessary lead length between panel connections and circuitry. However, no problems have been encounted with this method and it already has served several times ~~to ease a~~ in making modification or change.

The unit itself is housed in a frame with a sloping top panel the frame is fabricated from im lok aluminum extrusions. inside the frame is the sync generator, encoder, system power supplies, and circuit board housings. On the top panel are located the control modules. $\frac{1}{4}$"x 6" smoked plexiglass ~~modules~~ panels form mounting surfaces for control transducers, switches, and signal connections- module signal modes.

dimension + main space for additional circuitry;

evaluation of the instrument frmae is that it is a good unti for further prototye development. the plexiglass panels allow for internal panel illuminations as well as to provide an interesting contrast to the aluminum and chrome metal. the dimensions of the unti make it some what awkward to reach certain location on the control panel but the instrumen is entirely operable from a chair at the front panel.

documentation

now that an operational instrument has been achieved it remains to formalize notebook data into suitable technical and operational mannuals. This is a necessary step into providing for others to learn how to operate the instrument as well as to service and mainatain it.

~~at this point i shall declare that~~ it is not unreasonable to me that this documentation remian theproperty of stephen beck? (me)

documentation will take the form of schematics and technical descriptions of the instrument circuits. in addition, a series of pictorials and diagrams, along with perhaps video tape guides to operating the instrument and understanding the processes involved in generating different images should provide the foundation of ~~training~~ instuctions for direct video operation.

form — including: the establishment of geometrical contours on the display surface; determining the "order" of geometry, as points, lines, planes, and illusions of perspectives fixing angles and curves and thier orientation with respect to the raster axis;

motion — essentially, the time rate of change of position of elements of form; translation, rotation, of geometrical elements;

texture — establishment of brightness contours in the video signal, that is determining the intensity gradient [redacted] of image componenets;

color — determination of the hue, saturation and brightness of image elements;

These theoretical notions are now incorporated in a prototype direct video instrument. Some one dozen control modules are interconnected with circuit cards to provide a voltage controlled system of image generation. Before describing the contents of the protype instrument let me mention some general technical and operation aspects of the instrument:

1. Signal output is NTSC standards color video. Direct video processing amplifiers have a -3 db bandwidth of 4 MHz and the entire system is genlockable to external video.

2. Image parameters are voltage controlled and compatible with Buchla Electric Music Box modules as well as other electronic signal sources.

3. Black and white camera signals or VTR playback signals may be introduced into the instrument for use as image sources in addition to electronically generated images.

4. Image generating section of instrument is independent of video system standards. [redacted] Inputs to the instrument consist of the system drive, blakning, and sync pulses, [redacted] while the outputs are parallel RGB video signals (Y channle optional). Instrument may be easily used with PAL 425 or 625 line formats, SECAM 625 or 815 line formats, high resolution color or other video formats simply by using appropriate sync sources and encoder and adjustmen to f internal calibration controls.

4) development of non- libear waveform processors to provide a larger vocabulary of contours including circular,aexpondntial, and parabolic contours in addition to the present linear and sinusoidal- contiuous and sicontinuosu - contours achievable.

5) more elaborate reference signal generators to be used in conjunction with voltage to p sitin conversters andthe two previous elemetns to produce more complex images, with no restricitions to center or edge symmetries a dn with elemetns of rotation and voltage controlled position s.

6) construction of additional signal processor elememts such as algebraic combinors for addition and subtraction and analog multipliers for voltage controlled image manipuoation

7) better line and point generators. circuits which are less noise susceptable and which have slope correction factors designed to make a continuous sweep from horizontal to vertical while maintaining an apparent line width continously.

8) construction of additional geometrical unit region processors. with vertical interval switching to allow for abrupt image changes without transients being visible .

9) random voltage sources 10/ texture elements- shading and modulatio n

the following projects are of the second development category, process oriented circuits and hardware:

a) further development of joystick controllers, both two and three dimensional types. one problem with these controllers is that the output voltage cotains low frequency noise produced by the potentiometers supplied with the sticks. this problem is easily solved by wither using cermet pots or a simple integrator circuit.

b) develolment of touch sensitive keyboard controlls

c) exploration of biotransducers- alpha wave, blood pressure, various other body function to control voltage transducers

d) development of sequnetial control voltage techniques for production of time sequences of images. the structure would be along the following lines: to generate control voltage contours an N cell macroregister operable a groups os independent microregisters each containing 6 independent cell control voltage settings and 6 setable state switches. each cell has associated with it a duration time and a tfansisiton time which determines the duration of a monotonic change in voltage from one cel to the next.

both analog and digital techniques may be utilized to produce a register which can be preprogrammed with either knob settings or other storagemedium and which will also "learn" a given passage by following the operations of a human operator.

such techniques logically lead to

e) implementation of a small scientific control computer (along the lines of a control data corp. PDP-8) to store operations determined by the oprator.

f) useof a video magnetic disc for storage of video information such a method would provide for real time rotation of image components , a difficult operation due to the linear scan of the television raster.

in addition, it appears to me that the most general tool for realizing any given image is a pen in the hand of the operator + cursor thus, it would be useful to implememtn a data tablet or light pen stylus to provide for direct entery of graphic information into the electronic system.

package a nd hardware

developments in this area are designed to produce a more compact instrumnet which is easily constructed and maintained. in addition, once printed circuit masters and panle silk screen masters have been designed many instruments may be assembled at minimum cost and design.

a) implementation of printed circuit masters so that control and cicuit master modules are one integrated assembly. also, circuit isolation is improved and construction is easily performed even by those who are not highly skilled in electronic technology and practice.

b) in many control functions the replacement of rotary controls with linear controls will provide for more precise operation and reading of the state of the instrument.

c) the goal is to house a complete system in two of three portable packages of suitcase size with due aesthitic and operational consideration given to the design.

documentaiton:
further compilation of schematics and pictorial diagrams of
a) circuit design and layout.

b) circuit explanantions

c) control module pictorials

all of which lead up to the productions o

d) an operating mannual and video/ audio tapes which explain how to use the instrument wisely.

e) 4 simple reference signal sources, horizontal and vertical- edge and center references (the center references ~~being voltage controllable~~ may be modulated)

These signals are used primarily in the voltage to positions converters and as texture shading elements.

f) 8 voltage- to-position converters arranged in two independent arrays each array having 2 reference signal inputs. Each converter has a switch to select the input references and accepts either contour signals or control voltages as inputs. Outputs are two independent complimentary pulses which are used to generate regions, lines, points, and curves in in conjunction with the 3 following image processor modules:

g) 1- octal geometric region processors. Eight independent binary operators which accept two inputs and deliver three independent AND/OR function outputs. Used to process regions and produce points.

h) 1- quad geometrical unit generator for producing lines and points. Two modes of operation allow for producing vertical to near-horizontal lines and horizontal lines. Line width adjustable with module control or external control voltage. Input operation provides for outlining of regions on leading, trailing, or both region edges. Outputs are two independently switchable complimentary pulses.

i) 1-prototype geometrical contour source consisting of a voltage controlled triangl/square waveform oscillator which is phase-locakble to either line or field rates.

j) oscilloscope monitoring cicuitry which allows various parameters of the instrument to be measured and observed.

Also used are two lab signal sources which serve as wideband oscillators for additional contour sources ar as control voltage sources for parmeter variation.

At this time ~~this~~ the circuitry ~~has been~~ is undergoing evaluation and has been operating reliably since the end of july.

conclusions

since the first conceptions of direct video occurred to me more than two years ~~ago i have seen~~ a great deal of progress has been made . the theory of constructing ~~an~~ images has proved quite viable as a means for producing ~~images with a~~ large vocabulary. the essential ellements of a direct video instrumen which I have been able to realize this past year are working out very well. in general, the approach seems to merit further research, and i can best describe my experiences with direct video by telling you that images i have had in my head (have visualized internally) for these past two years ~~are beginning to appear~~ on video monitors.

~~immediate thrusts~~ goals for this year will emphasize finish for ~~further~~ work ~~will occur in~~ expanding the image vocabulary to include circles and smooth curves, more completely developing texture and shading ~~elements~~ (functions) and ~~concentrating on~~ improving process controls and transducers. the voltage controlled format will allow easy interface of a wide variety of transducers and cotrol devices. ~~if~~ if i ca be given continued ~~resources it will be possible~~ to develop this instrument into a truly versatile communicative tool. this coming year should also see the emergence of other personalities expressing themselves in a crude, but sufficient, direct video medium.

Documentation

Now that a working prototype instrument has been completed it remains to formalize notebook data into suitable technical and operational mannuals. This information will allow others to maintain and service, and to operate the instrument. ~~Such-doe~~ Little has been done done this year in formally documenting the work, but I have given much thought to the methods and modes of presentation, especially for the operating mannual. It is important that the technology not interfere with a clear and rational explaination of the way direct video operates.

Technical data will consist of schematics of circuits, pictorials of circuit layout and fabrication, and descriptions of how and why circuits operate in relationship to forming image components.

Operating data will, of necessity, consist of a distillation of the technical data as well as a description of the process so as to be understandable to non-technically orient ed people. (that is the crux of the problem) In addition to written descriptions of the various modules and their functioning and inteconnection, a video tape companion guide which elucidates some of the fundamentals of video image formation and their relationship to direct video would be part of operational data.

Proposals for further development of direct video.

Additional research into direct video falls into five categories:

1. Circuit development designed to increase the image vocabulary of direct video;
2. Circuit and hardware development oriented to facilitating the process of combining image elements into dynamic progressions, including both transudcer design and implementation of sequential control;
3. Packaging improvements, including smaller modules in an integrated enclosure and full use of printed circuit technology;
4. Documentation of technical and operational information;
5. Further development of the theory for image generation and manipulation.

Specific projects which I would like to develop include the following topics:

category 1

a* improved video bandwidth of output stages (mixer and color mixer) with voltage controlled gain factors. an eight channel system with 10 Mhz bandwidth would allow for quite complex image generation.

b* development of voltage controlled color mixers, which would provide programmed color transitions in addition to the present mannual mixture. linear controls would relace present rotary controls used for determing saturation. full RGBY mixing for complete contol of precise color. ~~nine color chord modules~~.

c* construction of more geometrical controur generators with phase locakable features so as to provide stable images. amplitude, fraquency, a and phase modulation functions under voltage control to provide for manipulations of image contours.

d* development of non-linear waveform processpors to increase the vocabulary of contours to includecircular, exponential, parabolic, and random in addition to the presently available linear and sinusoidal contours.

e* elaboration of the present reference signal generators to be used in conjunction with the elements of c and d to produce more complex contour manipulation, with no restrictions on center and edge symmetries. phase, frequency, and amplitudemodulation to allow for rotation and perspective spaces.

f* construction of additional signal processor elements such as algebraic combiners for addition and subtraction of control signals and analog multipliers for voltage controlled image manipulations.

g* improved line and point generators. circuits which are less noise suceptable and which have slope- correcting factors designed to make a continuous sweep from vertical to horizontal while maintaining a constant line width and not be coming segmented

h* construction of additional geometric ~~unit~~ region processors ~~with vertical interval~~ to provide for more complex interaction between image components.

i* development and construction of more elaborate textural and shading elements. it is possible that additional contour sources will also serve as shading elements.

j* implementaiton of vertical interval switching where feasable so as to ~~allow for continuous change of images~~ make switching transients 'invisible'.

The following projects are process oriented circuits and hardware:

a* further development of joystick controllers, both two and three dimensional types. one problem with these controllers is that the output voltage contains low frequency noise produced by he potentiometers supplied with the sticks. smoother action can be obtained by substituting cermet pots or by an integrator.

visual readout of volteg level would be desireable.

b* development of touch sensitive keyboard controls.

c* exploration of biotransducers as control devices, including alphawave, blood pressure, ekg, and other body and mental function to control voltage transducers.

d* devlopment of sequential control techniques for production of time sequences of images. the structure of such techniques would be along the following design to generate control voltage contours:

> an N cell macroregister, operable as groups of independent microregisters, with each cell containing independent control voltage settings and state switches. associated with each cell is a duration time and a transition time which determines the rate of a monotonic change in control voltage from one cell to the next.

both analog and digital techniques would be utilized to produce a register which would be programmable with either knob settings or other other storage media but which also could "learn" a given passage by following the moves of a human operator playing the passage. numeric and symbolic display of register states would provide visual determination of its states.

such techniques lead logically to:

e* implementation of a small scientific computer such as PDP-8 or equivalent to execute control instructions delivered by the operator.

f* use of magnetic disc for storage and retrevial of video information. such a device would provide interesting image manipulations, including rotation and most manipulations achieved with computer image generating schemems.

g* implementation of data tablet or light pen for direct entry of image components into the electronic system. such a method would enhance the most general method of relaizing an image, which is to draw it!

Package and Hardware

Development of packa ing is desingned to improve the prototype into a more compact instrument which is both easy to construct and maintain, and comfortable to operate. Once a set of printed circuit master and panle silk screen masters are prepared many instumnets may be constructed. Specific developments include:

a* design of printed circuit and panel slik screen layouts so that con$rol and circuit functions become integrated units. also, circuit performance is enhanced by better isolation, and construc ion is easily perofrmed by those who may not necessarily ~~have~~ be hoghly skilled in electronic technology and practice.

b* implementation of linear controls where feasable in place of ~~r~~tary controls, which will provide more precise control of such functions as color and motion as well as to improve reading the state of the instrumment.

c* architecture of system to provide for housing of units in integrated units which are aesthetically and operationally fine. units may be completely enclosed and of moderate dimensions so as to make them portable.

Documentation

Most goals for documentation are listed in the summary section on page 10. Essentially, the categories of work include/ compiliation of

a* circuit designs and layouts, schematics and pictorials;

b* circuit operation explainations;

c* control module pictorials and specifications;

which lead up to the production of an operating mannual and ~~audio~~ video tape guides which explain how to use the direct video instrument wisely.

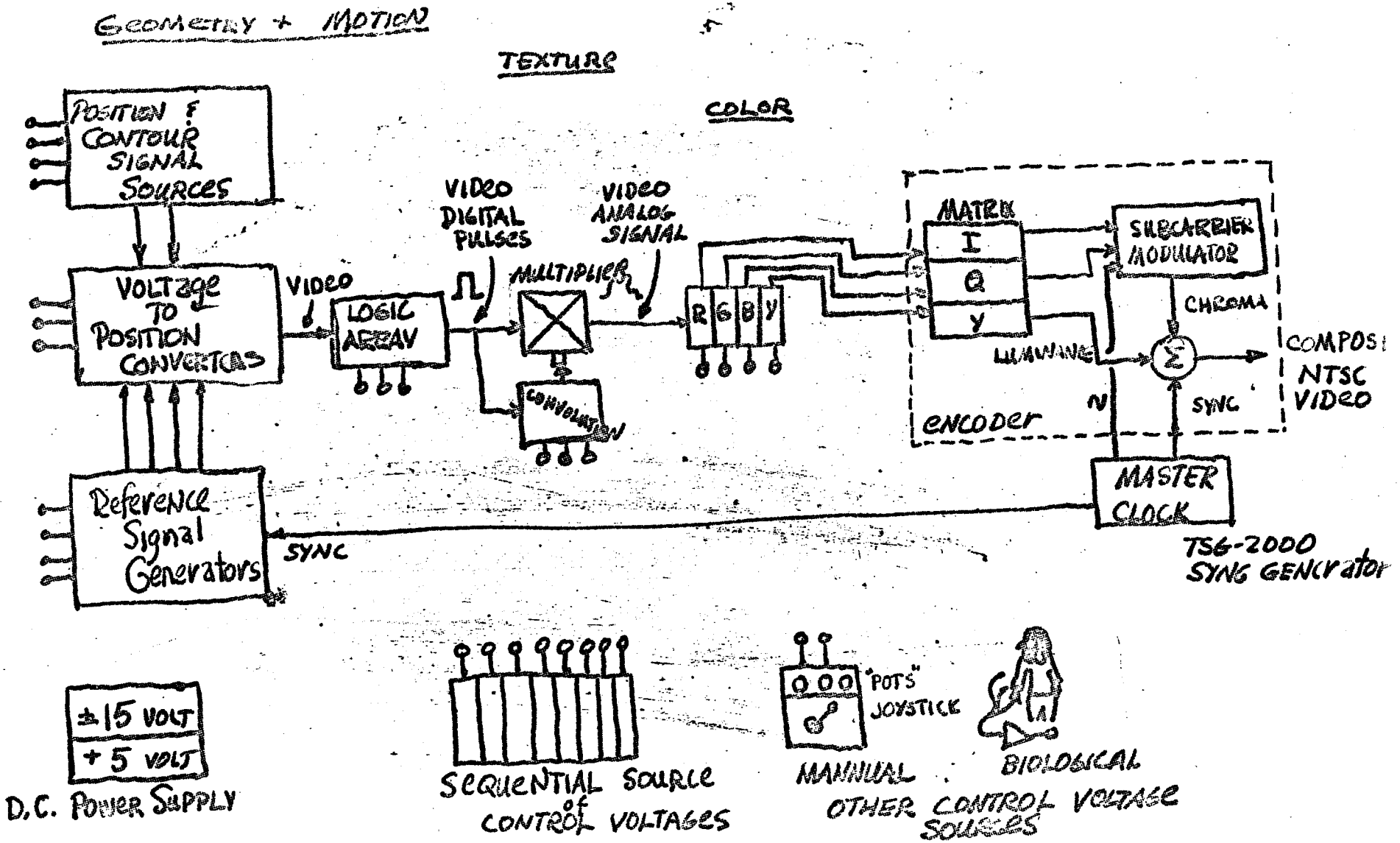

FIGURE 1 : DIRECT VIDEO SYNTHESIZER SYSTEM BLOCK DIAGRAM