ARCHITECTURE MACHINATIONS

A weekly newsletter of the Architecture Machine Group, Department of Architecture, M.I.T., Room 9-518, Lee Nason, editor.

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IN THIS ISSUE:

HARDWARE DEPARTMENT NOTES by Andy Lippman

By now, everyone has seen the TSD mounted on the Imlac screen. That is being improved by our new mechanical wizard Mike Slezak and should be installed on the face of the 3A (large) Imlac this week. Instronics has updated their receiver board logic and they are shipping us the new card this week. When Steve installs it, you can expect a large improvement in the response of the tablet.

In the meantime, beware of scratching the glass. Once it is scratched, the tablet is ruined: it will always return an echo from the scratched portion. I realize that you have to press hard on the face to get a readout, but bear in mind that this will improve with time. If you slightly moisten your finger (a finger bowl will be provided by Dick Bolt), when you touch the face, the readout will be more reliable.

Both Larry and I will be in New York for much of next week at the National Computer Converence. I expect to be back Wednesday night. In the meantime, there will be no one here who can effectively cope with the hardware problems as they come up. Steve has volunteered to try to help, and will act as liaison between all of the users and us in New York. I expect to call daily at around 2:00 P.M. and try to help as much as possible over the phone.

We are all aware that there may be problems with the 85. There are sporadic disk errors and DCS faults. We don't yet know the origin of these problems, and we have no basis with which to attack them yet, so any help will be welcome. Bear in mind that Seth is planning to remove the disk from the 85 when the new system comes up shortly, and therefore it may not be wise to duplicate the four day effort we made last time the disk errors got excessive. Feedback on this point is especially welcome.

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SOFTWARE NOTES by Seth Steinberg

There is a new command to save the editor's buffer when you bomb out of it. Type SED followed by the name of a new file for the saved buffer.

MAGIC 5 is "coming along". It should take another week or two with all the bells and whistles. Any wish lists? Now is the time.

FOREIGN CORRESPONDENT

The following is a letter from Paula Mossaides and Mike Miller which we received this week from Montreal.

Nicholas and fellow Arch Machers --

Talk about the liesure life! We've befriended one waiter and a wine steward -- what else could we possibly need?

The Metro is neat -- but I miss the screeching of steel on steel. Maybe the rest of the world will catch up to this city someday.

We're off now for more fabulous French food.... Thinking of you all furiously pounding at your consoles!

DOCUMENTATION by Lee Nason

The new revised better-than-ever PL/1 MANUAL is on the stands. The major update is a new Chapter 5 which you may want to glance at.

We are currently revising the MAGIC COMMANDS manual (formerly the MAGIC REFERENCE MANUAL) so if you have anything to offer, please do so soon. After that is finished, work will start on the MAGIC PL/1 SUBROUTINES manual which has had extensive revisions recently. If you need some of the information included in these revisions, see me.

Finally, Chris Herot's An Extension to the MAGIC Graphics Software is hot off the presses. Copies are now on file for your perusal.

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NICHOLAS IN GREECE

As most of you probably already know, Nicholas Negroponte departed Boston this weekend for a summer in Greece. He has promised, however, to send A.M. stuff at irregular intervals so life will go on as before.

I will be requesting that some of you write major articles for A.M. over the summer issues. The tentative assignments are as follows:

Date	Major Contributor	Minor Contributor
June 13	Larry Stewart	Andy Lippman Chris Herot
June 20	Steve Mann	Chris Herot
June 27	Guy Weinzapfel	Seth Steinberg Larry Stead
July 5	Dick Bolt	Steve Lang Andy Lippman
July 11	Paul Pangaro	
July 18	Chris Herot	William Donelson
July 25	Mazzie Madiera	
August 1	Andy Lippman Seth Steinberg	Larry Stead

If you have a problem with any of these dates, see me and we'll revise them.

EXPLORING COLOR AS SPACE

The following pages are a reprint of Chuck Libby's article Exploring Color as Space: a Computational Synthesis. *The final page of this issue is a color print of various of the slides used in illustrating this article.*

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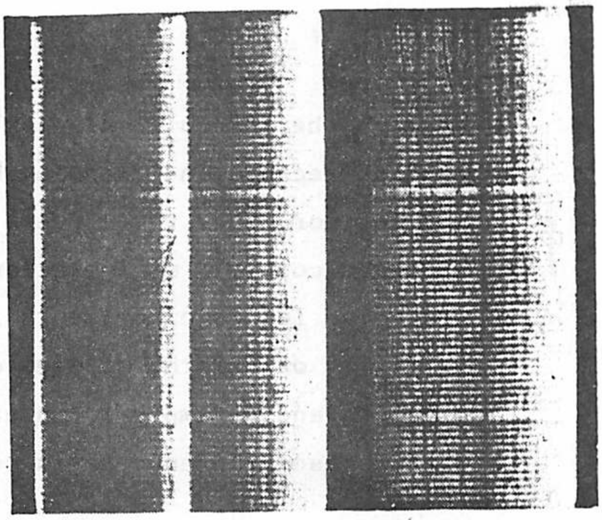
ABSTRACT

We have been experimenting with the hypothesis that the intelligence of the eye can not be accounted by its properties as a passive receptor; that it must be coupled to a data processor operating at some level lower than the conscious. The hypothesis is not new. We think that we have a laboratory particularly well equipped to work on it.

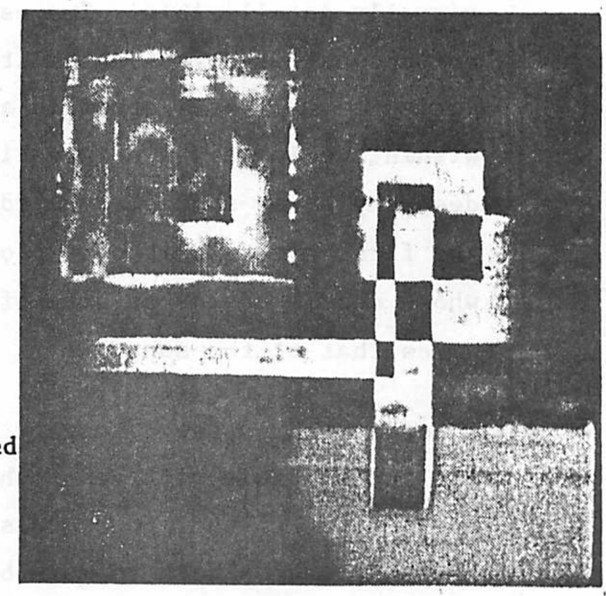
The XDP is a computer controlled color display. It can generate 32000 colors and show any one color at any designated place on a 100 x 100 grid. We have used past years to produce software that will move and transform color displays richly and easily.

The internal logic of the computer permits us to consider a color as a three dimensional point in the space of all possible colors, and to think of the properties of perception as properties of the geometry of color space as they are modified by data processing. The color computer therefore provides a rich laboratory in which to simulate human color perceptions.

We are experimenting with different bases of reference for the color space, with the possibilities of devising a metric for the space and on some ways in which the eye can produce colors by extrapolation and interpolation.



Fluorescense



composition - early 100□

*All color images taken from the XDP display

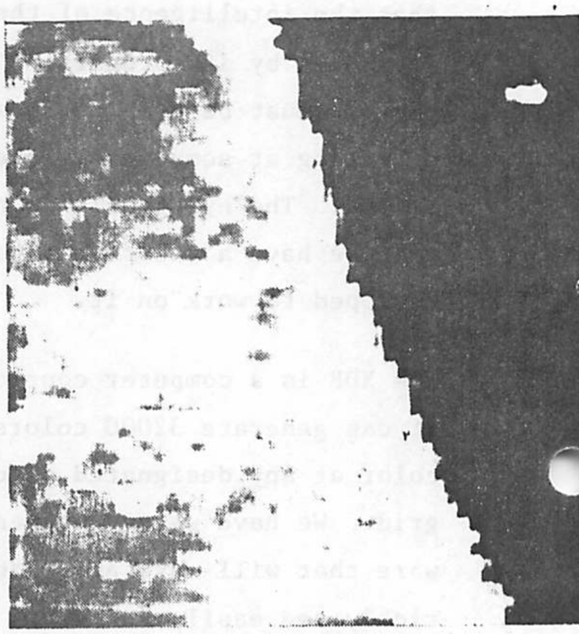
ONGOING:

Work on the XDP color display in the School of Architecture and Planning has been underway for more than three years. Early studies in image control, manipulation, and representation led to experiments in the diffusion or mixing of colors, studies of color complements and attempts to understand the basis of fluorescent phenomena in certain images.

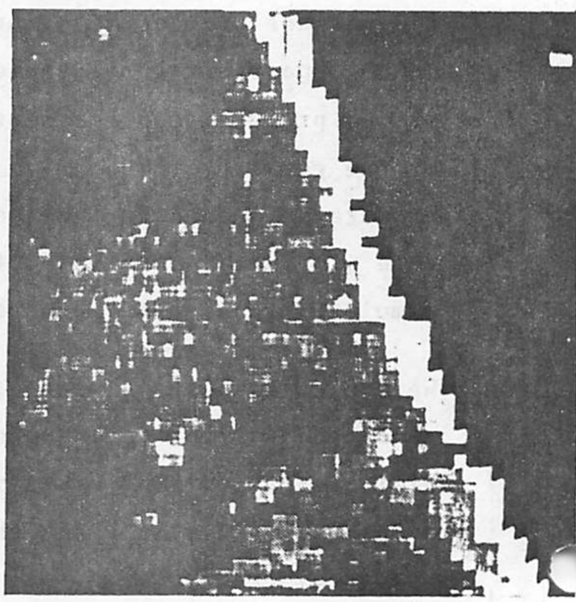
Much of this early work has been applied in attempts to make images containing known data visually intelligible. Images of the earth's surface acquired from satellites can be transformed to emphasize specific aspects of detail within the image. One investigation of a deep sky X-ray source revealed visually for the first time a pair of exploded supernovas, whose debris covers an area of sky thirty times that of the sun.

In order to represent imagery in a compelling and intelligible way, color should be literate, even eloquent, therefore, this work has invariably led us back to more basic investigations in color itself.

Some of these studies are important to color theory as well as interesting. They suggest many ways of thinking about the domain of color, some new, of which all are now easily explorable.



ERTS-1 · Salisbury, Mass raw data



enhanced for marsh detail

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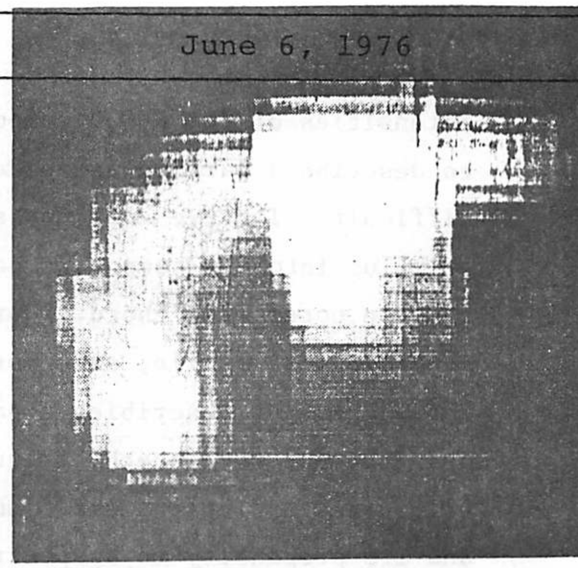
One set of experiments within this period is particularly important. The complete specification of an individual element in a color image requires three components. The description used by the hardware itself is determined by the color phosphors in the television tube: red, green, and blue (R,G,B). The intensity of each of these phosphors determines a unique composite shade. Other reproduction media have a similar structure; for example, color offset printing requires that the density of at least three transparent inks (usually a magenta, cyan and yellow) be specified at each point in the image. The (R,G,B) television monitor components are assumed orthogonal, or independent of each other. This orthogonality is limited by the purity of the phosphors. Independent of purity, however, we can describe the space of attainable color as cubic as shown in figure 1.



SAS-3 satellite - X-Ray supernova

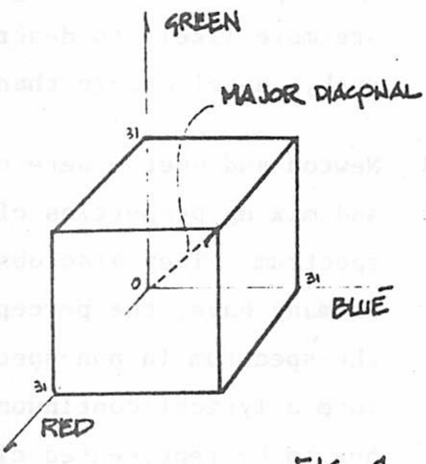
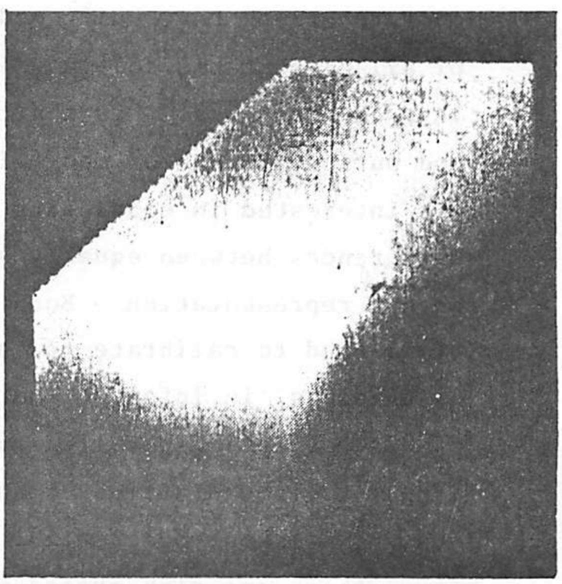


FIG. 1

Any point contained in the cube is displayable on the XDP. The range on each axis (R,G,B) is comprised of the integers from 0 to 31 - off to maximum intensity - in each phosphor. These increments are non-linear, i.e., the difference in perceived brightness between levels 1 and 2 is not the same as between 16 and 17. A representation of the outer faces of the cube is shown.

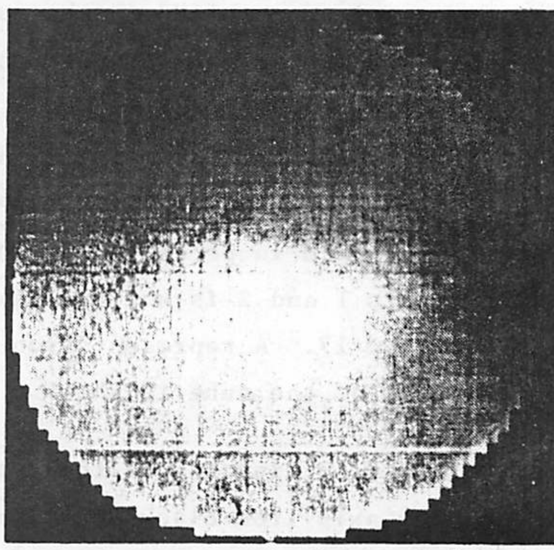


RGB cube - outer faces

The major diagonal of the cube presents the grey axis from black to white, a calibration provided by the hardware. It is possible to become semi-skilled at specifying the intensities of the R,G,B components necessary to describe a particular shade. It is also difficult. The eye does not separate a light stimulus into its component parts as the ear can the notes of a chord. Our verbal, perhaps physiological skills, seem more attuned to the process of describing a particular color hue (chroma, wavelength, frequency), its overall intensity (brightness, luminance, lightness) and its propensity to a spectral saturation (purity, greyness or pastelness), than to a description in components of red, green and blue. We are more likely to describe a color as a dark, pastel orange than in its RGB components.

Newton and Goethe were concerned with order and mixing properties of components of the solar spectrum. They also observed and recorded, as many have, the perceptual connection of the spectrum in non-spectral purples, which form a lyrical continuum of hue and allows hue to be represented circularly.

Many theorists have built models of the space of all presentable colors using this circularity. Munsell based his charts on energy and purity in each of many given hues; Ostwald was interested in eqùalizing perceptual differences between equally spaced points in his representation. Both systems are still used to calibrate new pigments. There is evidence, in infants, that categories of hue perception parallel and precede adult linguistic organization of hue. [Bornstein, Kessen, Weiskopf-Science:191 1975]. Therefore, there are rich precedents for thinking



circular organization of hue

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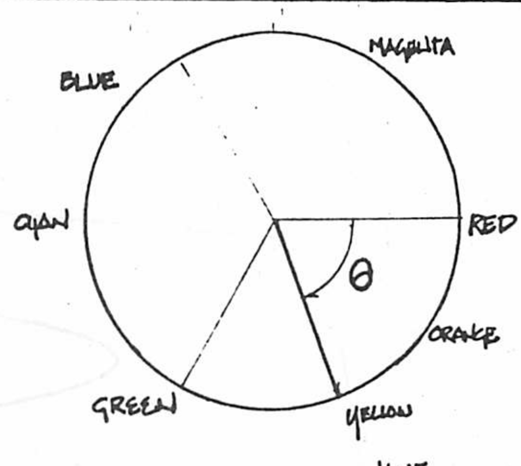
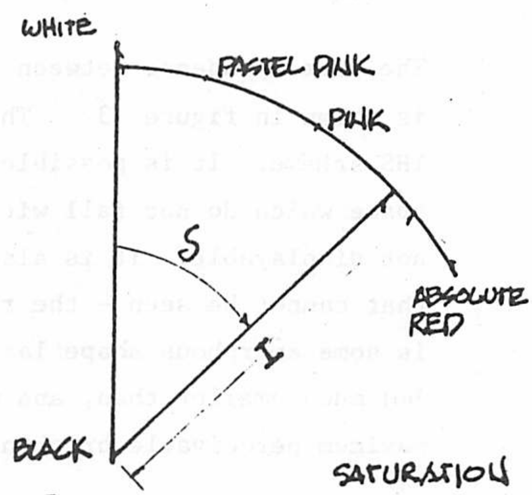
about space of colors in many ways, each of which provides special insights to some of the properties of the space, and suggests explorations structured to the particular description. We now have the tools easily to explore the space of color in these and other ways. The computer can be and has been programmed to understand these descriptions and quickly move from one to another, and to display results of manipulation or conceptualizations within any reference scheme.



4 HUE

In addition to the (RGB) axes, a second scheme of descriptions is implemented on the XDP: intensity, hue and saturation (IHS). The scheme can be visualized as the set of transforms necessary to map the RGB co-ordinate descriptions into a new geometric reference expressed in spherical systems coordinates, the components of which are as follows:

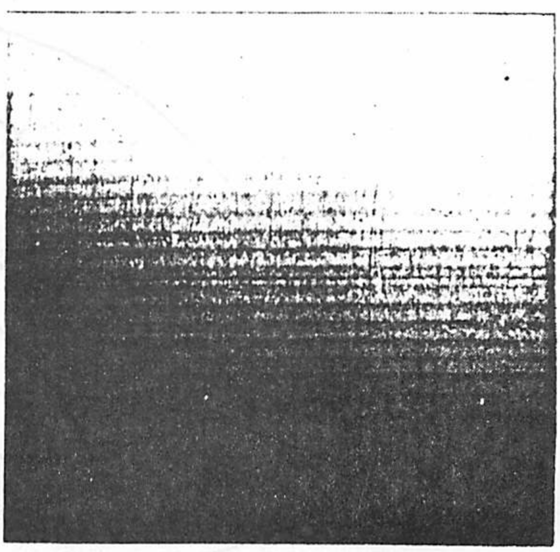


5

--Hue is a circular continuum of the spectrum, with blue and red connected by the purples. It is specified as an angle measured from red in the horizontal plane.

--Saturation is specified by an angle representing deviation for the vertical axes which is from black to white. An equal saturation surface is a cone in the color space, with its point at the black origin.

--Intensity is specified by the length of the vector I, or the distance from black. Equal intensity surfaces are described by hemispheres.



blue-yellow meridian sectio

Putting these components together results in the following view:

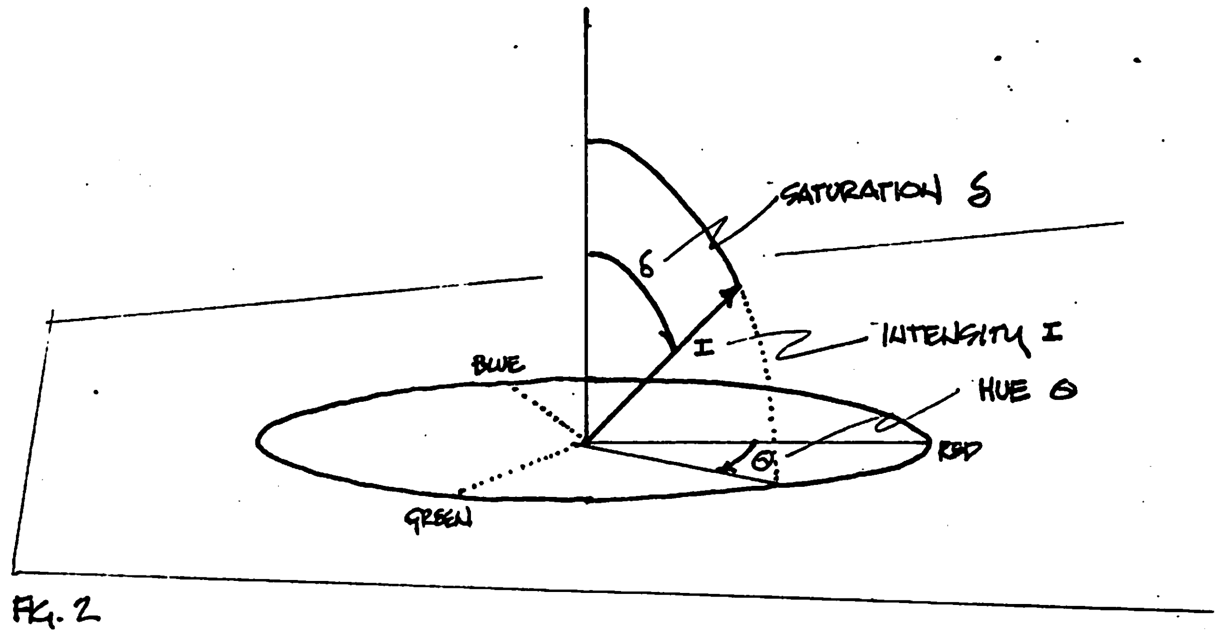


FIG. 2

The correspondence between the RGB and IHS descriptions is shown in figure 3. There are shortcomings of the IHS scheme. It is possible to specify places in the IHS space which do not fall within the RGB cube and are thus not displayable. It is also possible to specify places that cannot be seen - the realm of all visible sensation is some amorphous shape larger than the XDP cube but much smaller than, and within, the hemisphere of maximum perceivable brightness.

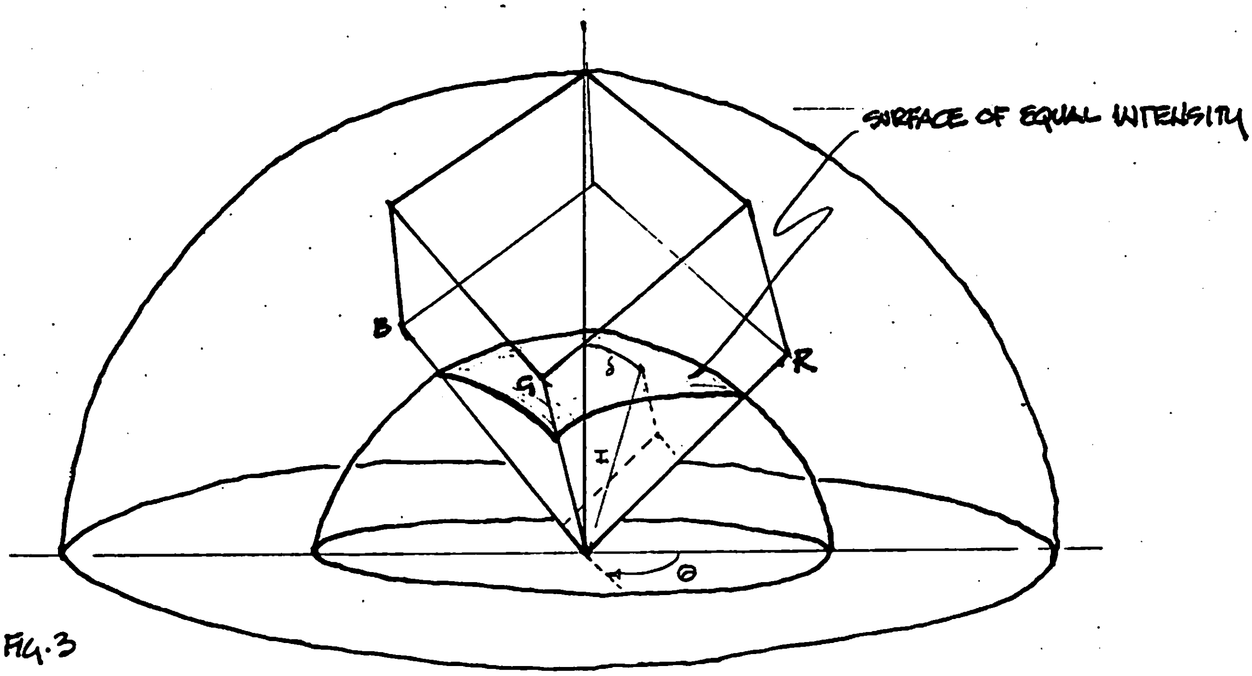


FIG. 3

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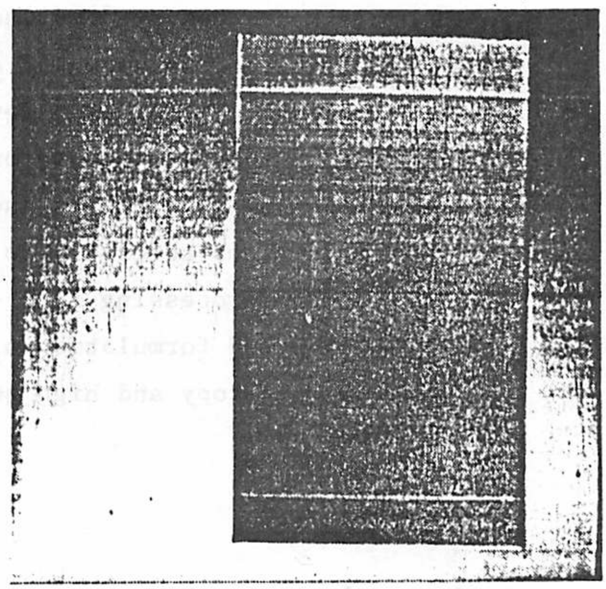
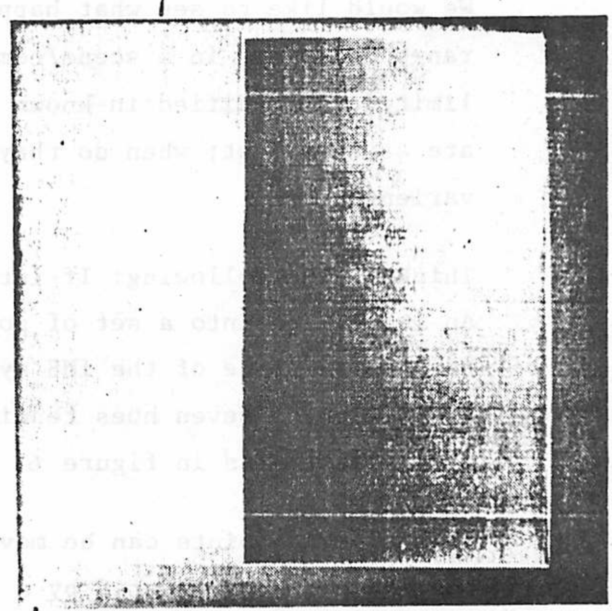
There are physiological difficulties with both descriptions; hues close to green are subjectively brighter than others, and the discrimination of mathematically equal intervals or spacings is not uniform - we have little discrimination in cyan regions compared to red-orange. Some of these effects have been studied by others and it is likely that other description schemes will adjust to these phenomena. Our own experiments have shown that the IHS scheme is mathematically better suited for predicting certain phenomena, such as finding a color mid-way between two others, than is the RGB description.



test image - window complemented



hue rotated -60°

Both specification schemes are implemented and interchangable on the XDP support systems. Both are used, and each suggests experiments in which unique parameters of the reference base are systematically altered in ways appropriate to the parameters. For example, we have filmed the transformation of an image such that each point in the image is held at constant intensity and saturation but is slowly rotated through 360° of the hue circle. The concept and the implementation are simple; the effect is orderly, smooth, and totally disturbing. It is not in the realm of things ordinarily seen nor expected, and we are constantly challenged to make visual sense of the sequence, or perhaps to learn and recognize it, as it does have meaning.

INTENTIONS:

We would like to see at least two kinds of things happen in this effort. The first is a continuation, extension, and expansion of experiments and studies underway which seek to explore the space of color. Two such experiments are described; several are underway, many are contemplated. A second is the building and connecting of elements and pieces of the hardware systems necessary to support the entire image processing flow - from initial acquisition and formulation of image to a final, palpable hard copy and high quality representation.

EXPERIMENTS:

Interpolation

We would like to see what happens when the range of colors in a scene/composition is limited and modified in known ways. When are aspects lost; when do they remain invarient?

Think of the following: If intensity is ignored, an image maps into a set of points in the horizontal plane of the IHS system. For example, a spectrum of seven hues tending toward pastel might scatter as in figure 6.

This plot of points can be moved so that the image is represented by a restricted

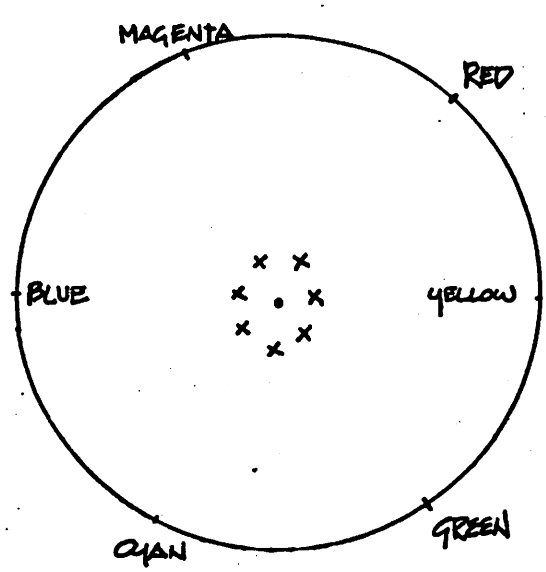


FIG.6

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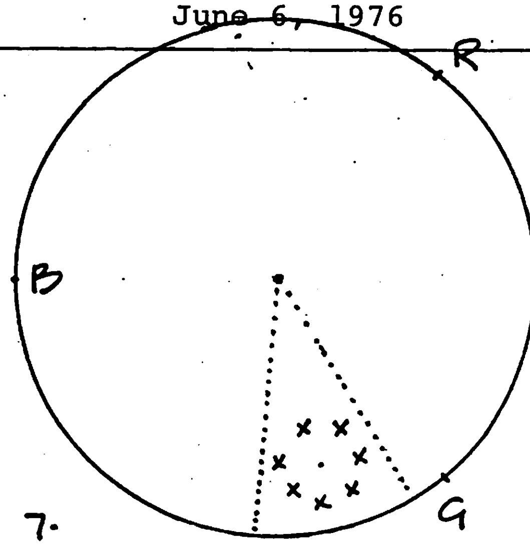
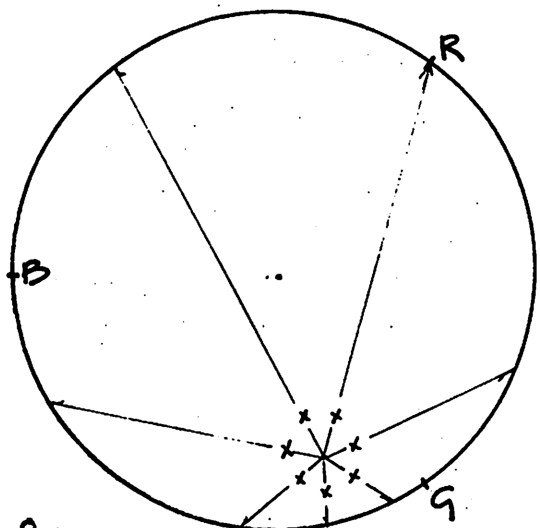
range of hues. In the case of figure 7 this range is from cyan ⟷ green



7.

A hypothesis of the first experiment is that the viewer will continue to perceive the relationships of hue present in the original image; in other words continue to see a full spectrum. This will occur through interpolation or extrapolation of the differences available in the representation which regain much if not all of the original spectrum. The linear extensions in figure 8 suggest how these points might be perceived in hue.



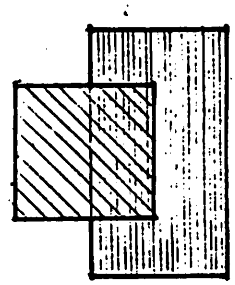
8.

If we could understand the conditions under which this phenomena is true, such an effect could be helpful in expanding the apparent range of color relationships in a medium limited to restricted color values, such as particular printing inks.

The experiment suggests others dealing with the conditions under which the effect fails, and a better understanding of how it works. It has a strong similarity to some principles underlying the two-color experiments of Edwin Land during the 1950's, and offers potentially greater control over the effect.

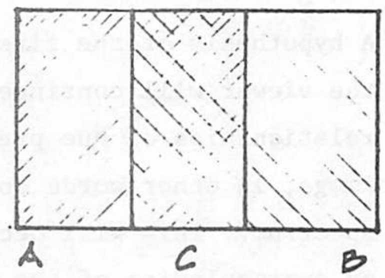
<u>Transparency</u>:

We can describe a set of studies of the phenomena loosely known as "transparency", or the apparent interaction of two or more surfaces such that they are perceived through one another as independant entities.



9.

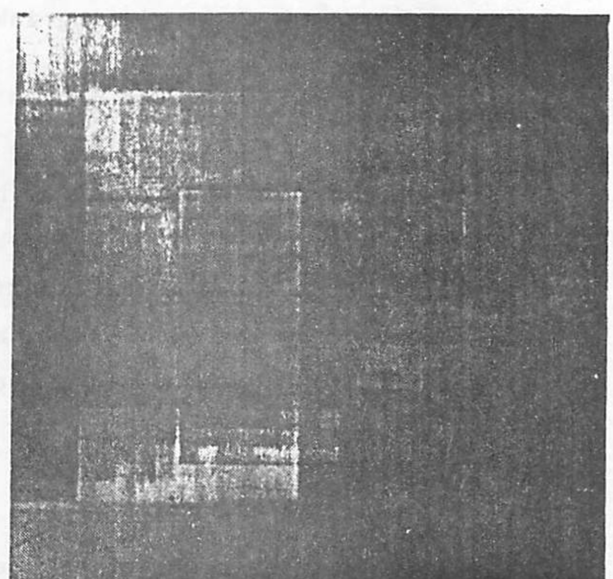
The surfaces or spaces need not be simple, either in shape or color content. At "transparent" points in such an image only one color value is presented to the eye, and yet this color is interpreted as two or more components, often accompanied by a separation in space. The effect is totally dependant on context, but the context can be simple, for example two panels overlapping to form a third.



10.

A wide range of color values can be specified for the center panel C while maintaining the appearance of transparency for particular A and B values.

Some of these effects suggest physical analogs, such as the interaction of two filter gels, or a translucent glass overlapping a patch of color. These phenomena are not random: it is possible to find rules to compute for C a color value which generates a specific illusion or transparent effect, and we have done so in some cases.



early transparency tests

The creation of transparency is not in itself a goal. We wish to explore some of its aspects, and to be able to use it. The phenomena suggest patterns of dimensionality not present in the specification of color values, and in some sense not present in the image itself, but only in our interpretation of it. It is this interpretation of image that we study when we attempt to understand transparency.

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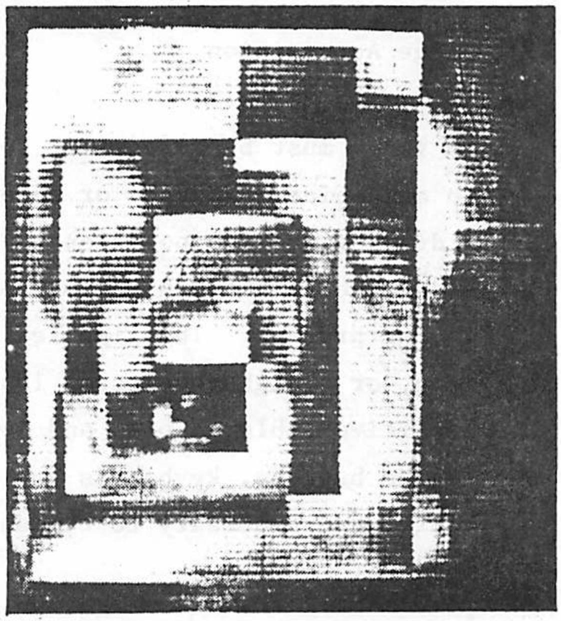
EQUIPMENT:

Early work on the XDP consisted of devising and evolving the software tools for the control of the image display and the ability to move about and display portions of an image, to create and compose an image quickly and intentionally from a repetoire of manipulations such as: specifying a color shade for a particular portion of image, adding or subtracting a shade, forming the complementary hue and intensity, mixing color shades of adjacent areas into one another, saving and recalling in another place a selected portion, and so forth. Most of these early conceptualizations of image process can and should be incorporated into the hardware of new systems.



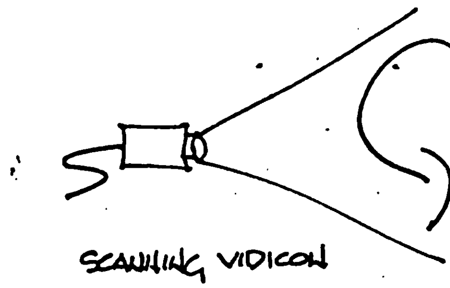
complements -

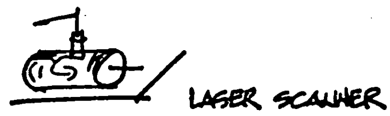
The equipment itself was constantly modified with buttons, joy sticks, light pens and other interaction devices to facilitate these operations. Connections to other machines, direct to the Interdata facility of the Architecture Machine Group, and through telecommunications to any of MIT's main computing installations, allowed computationally more elaborate investigations of image manipulations. The equipment necessary to continue and extend these studies is simple and available. Some of it exists already.

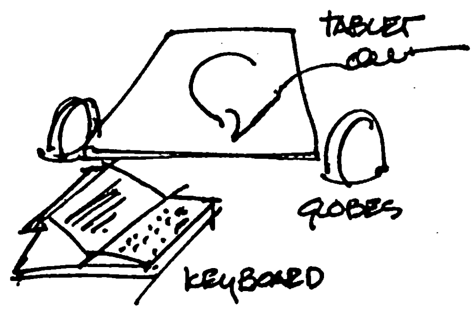
Simplified, the groupings of equipment are:

Image Acquisition

An image must be coded in a form understandable to a machine. A scene or an existing photograph, a drawing or a composition to be created are among the sources which must be easily available to the process. This implies a scanning vidicon, or a high resolution laser scanner, sensitive tablets, pens and joysticks as well as the buttons, keyboards and other devices useful and necessary to communicate with the process.

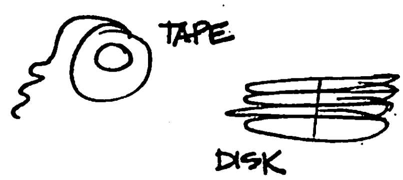






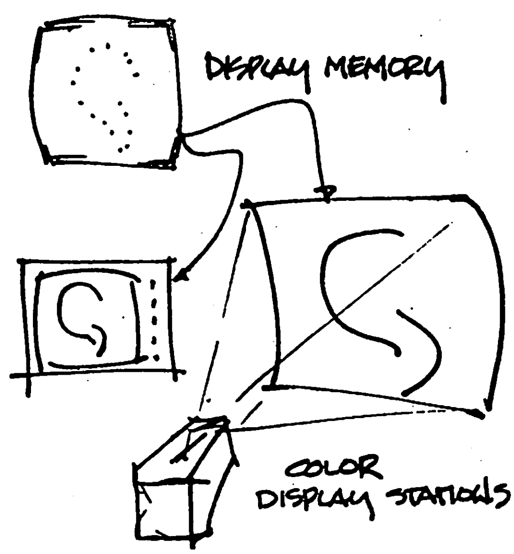
Storage and Retrieval

The apparatus for storing images once acquired is also necessary. These are conventional digital storage devices such as tape and disk systems intimately connected with the processing systems, and video image storage systems.



Display Systems

The images must be viewable, which requires display devices and a memory system fast enough to support the display. There are a number of system features which should be incorporated in this section. The viewable image area should be as highly resolved as possible. A nominal area of 512 x 512 points is possible and practical. This does not necessarily fix the size of the image to be worked; we may see only a portion or an aggregation of a more extensive image, or we may wish to zoom in upon a much smaller section of image. The



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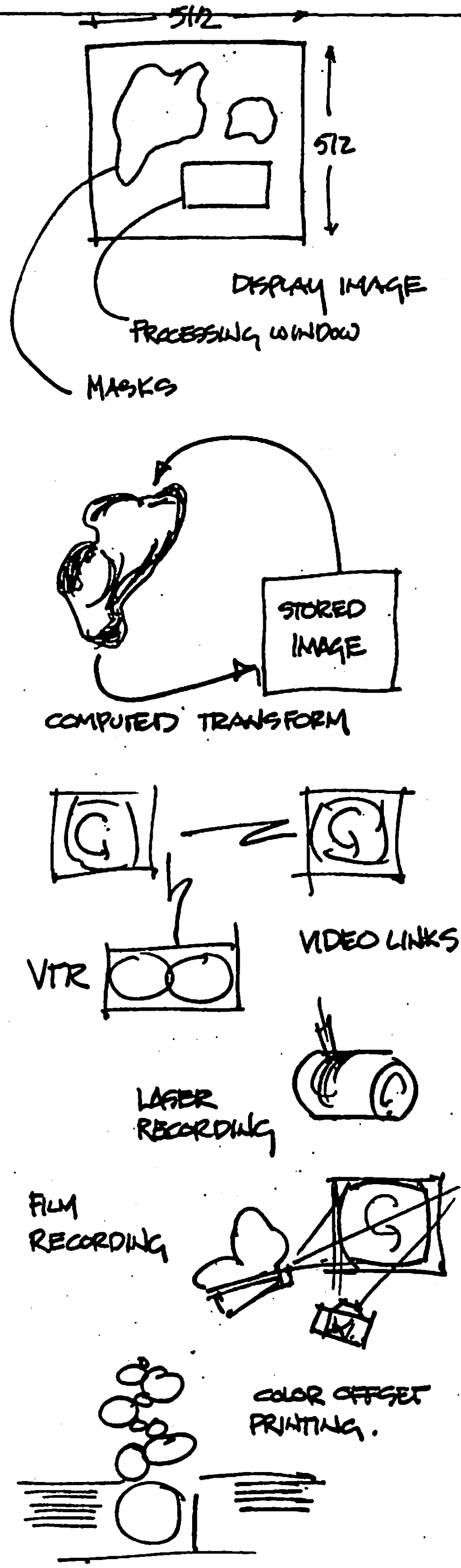
equipment should also allow the description of areas within an image for selective processing. These areas might be rectangular windows or arbitrary shapes or masks. The specification of color at each point within the image can be accomplished in many ways. A fully explicit scheme for each point which uses three dimensions should have at least 16 bits (how these are assigned is arguable). Therefore the memory system must be at least 512 x 512 x 16 bits, and more bits at each point would be useful for masks of pattern description.

Image Processing and Computing Capability

Closely integrated to the display are the processing functions at the heart of image manipulation. This requires locally a fast mini-computer and the systems software on which to build the tools for image manipulation. Connections to other computing installations are important because they allow access to a wider range of data and systems tools. They are also simple to implement and should be available.

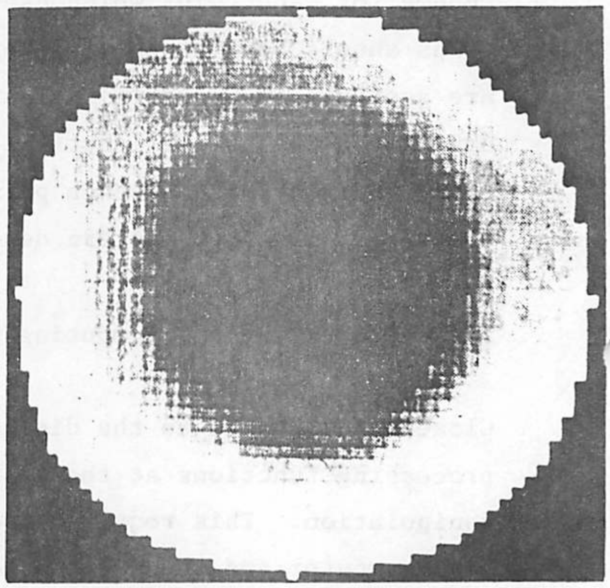
Image representation and recording

Explorations in the video medium need not be recorded only in video, nor should they be. An important need for palpable and quality hard copy imagery has been demonstrated in the systems now in use. High resolution laser recording to film is one approach, enabling offset printing; direct film recording of a monitor image is another.



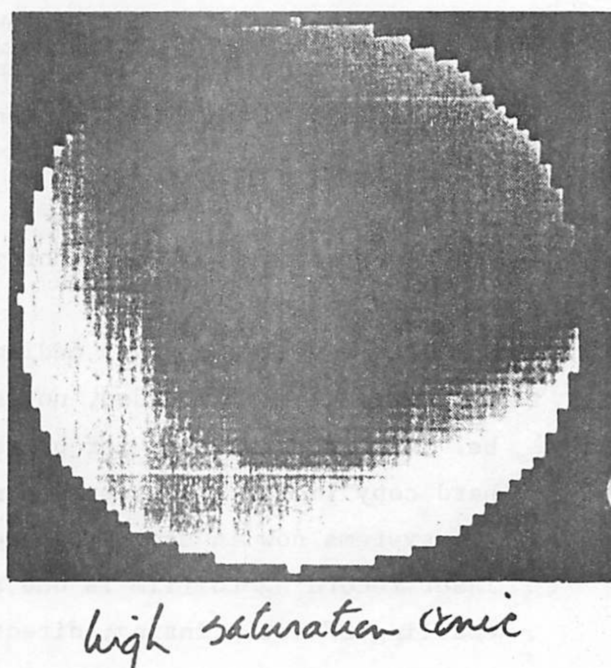
POTENTIALS:

Our interests center on the use and potential use of color in the realization of image, and involve the study of manipulation of color and its description. The opportunity for such study using digitally computed video imagery is unique. The medium is efficient and fast. Its explicit description of image creates an experimental environment which allows repeatability and accumulation of a knowledge of effects and phenomena. Beyond these considerations, and far more important, is the notion that virtually any conceptualization of what an image might be, or how it might change, can be realized.



low saturation cone section

Herein are image manipulations which can be accomplished in no other medium, for which there may be no physical analogs, and perhaps no visual or intellectual precedents. In this sense, it is a pure medium: it is limited only by our ability to conceptualize verbally about things visual. This is an acquired skill, as much as the use of brush, palette and canvas, and will be seriously influenced by past experience.



high saturation cone

It is evident that completely new ways of thinking about approach to image formulation will materialize. A simple example: imagine a filter gel placed in front of portions of a scene and waved about. The action of the filter is to make all color behind increase in saturation or purity. This cannot be

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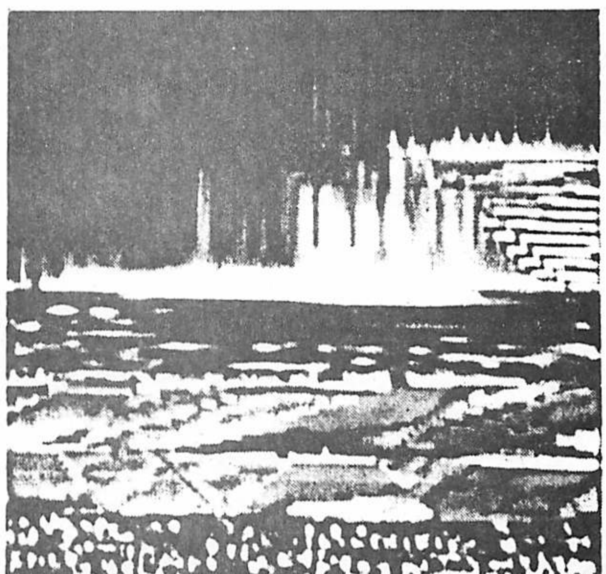
done physically, but is trivial to program and is furthermore visually intelligible, though it has not previously been seen. It suggests that an enormous resource of visual intelligence remains untapped. We intend to see what this might be.



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