"THE TRANSITION FROM THE "POSSIBLE" TO THE "ACTUAL" OCCURS DURING THE ACT OF OBSERVATION"

1

"To the Sight, three things are required,

the Object, the Organ and the Medium."

--Robert Burton, The Anatomy of Melancholy, 1621   I, i, II, vi, 33

MEDIUM — ACTUAL - POSSIBLE

"Medium," from the Latin cognates of neuter adjectival and nominal forms meant "in the center or middle," "the middle,""the meantime," "the interval," "mediator," "arbitrator" or "neutral party." With the Roman concern for administration it also came to mean "the general community," "public good," "general welfare." Curiously, in Old Norse "Midhgardhr" which, like the Latin, is derived from Indo-European "Medhyo," referred to the middle ground between heaven and hell. We, of course, derive the usage medium to describe an individual able to communicate with the dead. With this supposed act of communication, the medium's personality is bypassed, ceases to be active; he/she speaks with the voice and manner of the deceased. The medium dissemples to transparency.

In all these usages, the medium is the carrier, the middle ground, the environment. Air and water, for instance, are two common media for sound. The necessity of substance for the conveyance of messages was posited early: the mistaken notion of the all pervading and intangible ether persisted to the second decade of this century. A statement of Poincare, published in 1905:

> Whether the ether exists or not matters little--let us leave that to the metaphysicians; what is essential for us is, that everything happens as if it existed and that this hypothesis is found to be suitable for the explanation of phenomena. After all, have we any other

> reason for believing in the existance of material objects? That,too, is only a convenient hypothesis; only, it will never cease to be so, while some day, no doubt, theether will be thrown aside as useless.
>
> --Science and Hypothesis, pp. 211-212

A tautology: every medium possesses transparency, its ability to function as a carrier of information. This quality allows the documentary aspect of any depiction. Prior to the mechanical reproduction of photography manual image making in one medium or another (sometimes woodcuts made by photosensitizing the face of the block and cutting according to the photographic pattern) provided the visual documentation of events in periodicals and books. Another form of documentation, albeit a degraded one, exists in program music. More direct forms are, of course, photographic and electronic in process. All media are able to be mimetic, that they are able to render a resemblance of direct experience. Quite often we can speak of a perceptual mimesis: that which resembles direct "unmediated" sensory input. We will limit this to cases in which the structures of the medium are in service to the conveyance of information external to the system. Thus two conditions of application are necessary for perceptual mimesis. First, the particular: the registered has had to have actually happened. Second, the qualitative: the medium must be applied to preserve qualities of the registered in such a way that an adequate representation of normal sensory experience is achieved. Thus, an external phenomenon, such as light or sound, must interact with an interior structure such as random grains on photographic film, the diaphragm/magnetic field of some microphone designs, the scanning structure of the video pick-up tube/ray tube, the holographic time delay.

These statements do present a number of ambiguities, yet it would be difficult to deny the everyday utility of photographic and acoustical registrations INTRUSION functioning as ~~intermediate~~ sensory systems for us all. EXTENDED Marshall McLuhan, in Understanding Media (43) states, "With the arrival of electric technology, man extended, or set outside himself, a live model of the central nervous system itself." The point is not whether we can define sensory experience precisely enough to describe it. Rather, it is a fait accompli millions of times each day that ~~photos~~ snapshots stimulate recognition of past experiences, television shows us what happened on the other side of the world, radio gives us the inflexions of the President's voice. Pictures do lie, of course, but it seems they lie less often than humans, at least in matters of pure visual/aural reconstruction. MuLuhan, in an investigation fundamentally different from ours, goes even further in suggesting that we have developed these forms of mediation out of the necessity to protect our beings from the continual overlaod of multiplicity. Continuing the quote above,

> To the degree that this is so, it is a development that suggests a desperate and suicidal autoamputation, as if the central nervous system could no longer depend on the physical organs to be protective buffers against the slings and arrows of outrageous mechanism. It could well be that the successive mechanizations of the various physical organs since the invention of printing have made too violent and superstimulated a social experience for the central nervous system to dndure.

The internal structures we've engineered determine the registration of phenomena, how they will look or sound. Of necessity a transformation occurs, for in all media the intermediate step alters not only the structure of the external phenomenon--i.e. in video from a two spatial-dimensioned optical projection of a one dimensional energy flow--but also the material of that phenomenon, i.e. from light to current or, in the case of film, to a change in the molecular structure which constitutees the latent image. There is a change of state which determines the possibilities of any medium. The devices which accomplish this are called transducers. Monitors and cameras are transducers: cameras allow external energy to enter the system; monitors allow internal energy to leave as light. All transducers, it should be noted, inherently preserve certain parametters of the "observed" phenomenon. To understand the preservation it is necessary to understand the encoding/decoding translation.

We shall classify ~~transduction~~ the changes of state caused by transduction in the following image paramters. In camera encoding, these parametters must be preserved to maintain transparency. This, to be sure, is not the only possible classification.

1) brightness--the overall light-energy of a scene.

2) contrast--the ratio between the darkest and lightest areas of a scene as well as the number of separate gray levels that are resolved.

3) detail--Those elements which constitute edge, line, texture and volume within a scene

4) motion--all movement and change.

5) color--an acceptable rendition of how we normally preceive color under given lighting conditions.

4a follows

The precise characteristics of the ~~change-of-state~~ transduction is determined first of all by what's physically possible and secondly by utilitarian considerations of economics and transparency. An inevitable value compression occurs in the transduction, affecting the dynamic range of reproducible brightnesses, resolution of detail, limitations of motion, ~~xxxxxx~~ range and types of color.

One thing it is important to realize is that for neither human perception nor video encoding, are these parameteers independent .

(p. 5 follows)

variables. In human perception the ability to perceive color is dependent upon sufficient brightness and is related to but not solely determined by the wavelength of light (at this time there is no satisfactory model of color perception). The discrimination of detail is dependent upon, indeed is often the same as, the contrast ratio of the scene. Similarly, when these phenomena are transduced to the video system, funcitonal interrelations arise which are founded both in the definitive construction ~~mfxrkmx~~ and the utilization of the medium. The latter case, the an operation on a single paramter will affect others becomes apparent to the user at almost the first turn of a dial. In conventional studios, t his factor is responsible for the employment of large numbers of broadcast technicians. ~~In experimental practice, this is~~ IT IS OPERATIVE IN NUMEROUS EXPERIMENTAL PROCESSES, INCL. ~~exemplified by~~ quantizing, debeaming, addition of signals, some uses of keying and colorizing and other operations.

Indeed, the interrelations are so pervasive that it might be possible to formulate a conservation principle in which image infomation cannot be lost buy only transformed within a given system. Color, for instance, inherently reduces detail but can increase apparent contrast. A reduciton of brightness in some conditions will increasw detail. An increase in motion will reduce detail and in some conditions ontrast. Obviously, all this exists within certain parameters determined by the qualities of the particular system and scene.

This is one aspect of a fundamental relaization. As soon s aevents enter the electronic realm their existance becomes dynamic. (light also is a dynamic entity but on a scale so small that it is irrelevant to human and video processes.) What this means for us is that any accurate description of the phenomenon and any mode of control over it must exist dynamically and must be described in dynamic terms. This ~~is a~~ primary relaization ~~and~~ is essential for any description and understanding of electronic tools, processes and operations.

This particular relaity presents difficulties for descriptive language. That is, that we must speak primarily about structures, and that they are dynamic structures means that even the simplest words we bright to describe what we see: image; the qualities of what we see: color, size, shape, shading, are all situated before the mediation, outside the realm of dynamic structures. We have inherited from our normal vision which we, of necessity, take for real (at least on the everyday level) and the necessary corresponding transparency of our own perceptual process (that we can perceive without introspection), which, mimicked in these media, allow a static description to be adequate and largely accurate. And in "normal" video (direct camera-monitor hookups) such a description is similarly adequate for describing the image. But when we supercede the transparent, when the tools becomes potentially responsive to applications not directly located inthe mimesis of sensory conditions, when for whatever reason, we become closer to the electronic process, such descriptions not only become inadequate, but force a conceptual difficulty which, at the very least, makes utilization of these processes more difficult. More significant is that these processes are important in themselves--dare we say that perhaps the mediation of the system really lies in the way it presents to us its own processes--and have important implications to the thought and expression of our time.

"Time frame" is an example of a term we've had to xxx originate because of the particular limitations of our language in describing complex dynamic interactions. More xignxifx significant is that these processes are important in themselves--dare we say that perhaps the mediation of the system really lies in the way it presents to us its own processes--and have important implications to the thought a nd expression of our time.

Of course, satisfactory terms of sufficient precision ~~exist in-the-technical-literature-of~~ for many of the components, processes, andxoperations and effects we shall survey, and it would serve little purpose to create an entirely new descriptive vocabulary of video. (Not only that, but we'd likewise have to reformulate the structure of the English language.) And names, of course, are xxx perfectly good tools to breviate complex descriptions. But it is importnat to realize--and this book is directed towards making e xplicit that realization--that nearly every element of video t akes place in the dynamic realm. The utilization and realization of htefourth dimension in quantities of time invisible to human perception is at the center of video theory and practice. The medium is able to be transparent partially because it is so fast, and it is so fast because it must be transparent. It would, in fact, be possible to describe video as a tool for the observation of micro-events just as one can say that the function of the camera is to transduce macro events (those visible to ~~human perception~~ our senses) into micro events which require this large overlay of technology to decode.

But returning to language, one example of this kind of misplaced

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-8

terminology is keying. Presumably "key" originates from key-hole matting of film, in which a cut out is placed between the camera lens and the scene. A video keyer is able, among other things, to do his by comparing a xxx signal xxxxxxx parameter, usually voltage level, with a threshold voltage and eliminating those portions of the signal at or above the threshold level. The effect of this in video is to make the keyed areas transparent, allowing other images to be inserted into that "window" or the "window" itself to be reassigned an arbitrary gray level.

The basic component of a keyer is a comparator, whose symbol is this:

(diagram)

In keyers one of these inputs is the threshold, the other the key video. Comparators have only two states, on, in which case the signal passes through unchanged, and off, in which case there is no output. In fig. ______ we superimpose an arbitrary threshold setting and the video signal corresponding to the selected line of fig. ______

(photo and drawing)

The output of the comparator is diagrammed in fig. ____ and pictured in fig. ______

(photo and diagram)

As can be seen, a comparator is akind of switch operating at line frequencies. It continuously compares these two levels (as opposed to sampling) during each line scan. Areas are built from repeated line events. Thus, a key, originally the result of a static optical obstruction, refers now to a dynamic comparison of two energy states. Another common form of keying, chroma keying, uses hwat appears to be color to produce transparency. The actual regulator is a phase comparison of two chrominance signals. We will deal fully with thxsx various keying operations later. What is importnt to realize is the state of affairs (actually the dynamic of affairs) underlying nomenclature and description.

One way to appraoch all this is that the processes are the substantive aspect of a dynamic medium. The definitive aspect of painting is paint applied to a surface from which light is reflected to the viewer's eyes. Any exercise which incorporates these elements might properly be sx termed painting. The defining substance of video, however, is not electrons, nor is it the phosphor coated screen. Rather, what defines video is a complex interrelation of numerous timing and processing structures expressed in a predetermined scanning structure activating phosphors on the surface of the cathode ray tube. (Compare, for instance, oscilloscopes, which to not normally have predetermined scanning structures and employ far fewer and less determined timing structures. Yet is is possible to use any oscilloscope as a monitor with the correct input signals.) Those processes which conform video are dynamic processes of triggering, scanning, addition, multiplication, gating, etc. The only structures which might be considered "static" entities are those material structures of the component level, or the magnetic and electrical energy which are the fodder for the system. Even the invariable relationships between the timing structures are just that, relationships, and not in any sense substantive entities.

This is one primary realization: that it is appropriate to describe the pooperties and applications of this medium not pxinx xipiaykxxrpx primarily in terms of substantive entities (that is, energy forces and matter), but requires a recognition of the nature andeffects of relationships and processes. We define process as those timexnxiiiixing time dependent elements which are constituent of system relationships, such as multiplication, phase comparison, triggering, gating, et. al. There are, it should be n oted, two levels of processin video:those which are constituent of the definitive construction of the medium; those which are exploited in the application of it. "Operations" we shall define as those things the user does, which are usually composed of multiple processes. Envelope generation, keying, colorizing, mixing are operations. Sometimes, in simple operations, as in some uses of triggering and multiplication, the process and the operation are one.

A few definitions: video is the applicatdon of electronic energy to the generation, processing and display of electronic energy destined to become light and which exists within a particular d etermined time/sapce structure. To do this, many signals are precisely specified in their shape, duration and amplitude. These we shall call "specified signals" and make up the synchronizations and other utilitarian signals derived or dependent on sync, internal to cameras, monitors, VTRs and signal processors. Other signals, specified only as to limits, we shall call "arbitrary signals". Arbitrary signals include "luminance control," Xx and "chrominance control" which when decoded become picture infomration, and "process controls" which are active shaping and modulating functions generating, forming and otherwise processing the luminance and chrominance ~~xxxx~~ controls.

We call all these controls because that's what they are. It is not difficult to see that specified signals are controls, in that among th other things they time and trigger the porcesses of the electroni beam in the cathode ray tube. Process control is clear also, because these signals variously shape the luminance and chrominance controls. Luminance and chrominance controls, however, represent control functions first, because of the way the video system is structured--necessitated by the phenomena--in that it is not the beam of electrons flying to the phosphors nor the signal which is recorded on tape which is the video signal. Rather the video signal is the modulator of various internal specified signals which produce the image or the ~~magnetic encodings~~ magnetic flux of the tape head. (We shall deal with chrominance later) Secondly, and this is closer to the user, there is in electronic media a generalized correspondence and equivalence between signals. Luminance and chrominance controls are able to become process control and vice versa. The identity of signals is defined more by utilization than by structure. Of course, there are structureal paramters which circumscribe application, but this does not alter the principle and possibilities offered by the basic equivalence.

The conceptual power of cideo derives partly from the unity of the material. No other medium, with the exception of electronic sound, possesses this homogeneity and interchangability. The user has the ability to recode phenomena functionally while maintainung an identity of dynamic elements: what does into the ho-pper doesn't change but what comes out is completely different. Much more will be said about this later, and while this certainly is not the only way to describe experimental video, it possesses 1) fidelity to the ope-ations and tools, and 2) a number of interesting resonances which open new avenues for image making and understanding.

Remembering that identity derives from application we find ourselves already with an operational hierarchy comprising specified signals, which might be described as the formation of the ~~im~~ system structure, and arbitrary signals which can be seen as the ormation of the image content. On theface of the CRT the itme structure translated into space is called "the raster." The raster is the spatial structure in which video events are displayed and is composed of 525 horizontal lines. We can say that it is the translation of time into space becuase the video timing structures have been engineered to establish, or have consequently determined, the spatial attributes of the raster. Among them are its resolution, aspect ratio and certain ways in which it reproduces three dimensional space and moving objects. We can expand this definition of raster to include also unseen scanning, including the normally masked elements of sync and blanking and the non-energized retraces. The raster is the trace of the beam, in on and off states, which is the structue or format of the display. Some methods of experimental video processing, called scan processing, manipulate the image by reshaping--but not retiming--the raster.

The raster derives validity as a concept through the underlying periodicity of video. The scanning is continuous and divided in its spatial locations between two interlaced fields of 262½ lines.

(interlace diagram)

At no time is a full raster displayed, it is rather the sum of its sequential locations, persisting in our retina and to a lesser degree in the relatively slow decay time of excited phosphors (about 1 millisecond) which enable us to speak of it as an entire entity.

One function of the raster is its "time base," which is also used to describe a function in a variety of electronic decoding instruments, most commonly oscilloscopes. In CRT displays the time base is how fast the beam sweeps across the face of the tube and is usually expressed in Hertz (cycles per second) but sometimes in divisions of seconds (e.g. 1 ms sweep). The time base determines how electromagnetic phenomena appear on the face of the tube. For example, we set the time base of an oscilloscope to 1 KHz, which means that the beam travels across 1000 times each second, and input a sine wave of 1 KHz. This situation is displayed like this:

(photo)

If we set the time base to 2 KHz, we get this:

(photo)

The number of times the external signal has time to deflect vertically the horizontal scan is a function of the time base. The external signal hasn't changed, only the means by which we display it. The time base is an important determinant of visualization.

The NTSC standard has two time bases, nominally 15,750Hzfor horizontal, 60Hz for vertical. They have exactly the same effect as those of an oscilloscope except that the external signal doesn't move the beam, but rather alters its brightness. We can input an oscillator-originated square wave into a television monitor and receive these results:

(60Hz photo 120 Hz 180 Hz 240 Hz 15,750 31,500)
(labelled diagram of 15,750 sq. wave)

As the 60Hz signal corresponds to the time it takes for one vertical writing of the screen, and as the signal is on for half the time (1/120 sec.) and off for half the time, we get half the screen black (beam turned off) and half the screen white (beam fully on). As the 120Hz signal can go through its full cycle twice during one vertical writing period, we get 2 dark and 2 light bands, with corresponding effects for 180Hz and 240Hz. For the higher frequencies, during each line there is just enough time for the 15,750Hz signal to go through one cycle, so half of each line is white and half black. As this is repeated continuously and in synchronization with the scan lines, the entire screen is divided down the middle. A similar situation occurs with the 31,500Hz signal, except that it goes through two complete cycles each line, producing 4 vertical divisions of the screen.

Different television systems have different time bases: PAL uses 50Hz vertical and 15,625 horizontal (??); SECAM uses 50Hz vertical and 20,475 (????) horizontal. ((CHECK THESE FIGURES))

Related to the time bases of video is a rather abstract ~~and general~~ but useful concept, the "time frame," which is derived ~~both~~ from both raster and ~~from~~ frame. It is the structure of the signal which is defined by the horizontal, vertical and subcarrier rates and by the moment of ~~their~~ their occurance. As such it is internally relative in that it contains the set of relationships betwenn these signals, and absolute because it refers to a particular structure which is at particular stages at particular moments in time (~~this~~ we can call this the phase). The realization of the time frame is absolutely essential for understanding a wide range of video operations and can be said to be at the center of processes of encoding and decoding.

In a dynamic medium any event is an interaction of dynamic processes. An immense number of examples of this are found in even the simplest system. As a principle this is of such generality and self-evidence as to appear trivial. Nonetheless, it requires statement because it is one key to the understanding of the operations. We will inject another self-evident ~~even~~ concept, this one a tautology: in dynamic media all events are inherently the synthesis of dynamic relations between structures, in which structure is broadly defined as any element which is able to have effect and embidies and is the product of some kind of shaping. Such structures exist on a number of levels and include the simple structures which are constituent of operations mentioned earlier; the formatting structures , existing in both signal encoding and the actuating fields which include the drives and syncs, deflection signals, deflection fields; and the luminance/chrominance control, which controls the beam or beams as well as various simple structures. The time frame is the sum of interaction of the formatting structures. It is the temporal coordinates of the sync signal and the deflection signals which are derived from sync. As a result it gives us, also, a set of positions, relative and absolute, on the raster as measured from the beginning of each line, the field orthe frame.

One easily visualized example of this is the horizontal drift. One way of producing this is byusing a camera as an input in which a horizontal drive of frequency different than the system's is used to control the camera's horizontal scanning rate. Thus, the image is encoded within what we shall call the "content time frame," so that its raster is formed of line frequency, say 15,751Hz and 60Hz vertical. What is happening is that the camera's information is being encoded at a slightly different rate than the normal, so that each line has slightly less time to be completed while the field remains in synchronization because the vertical drive remains locked to the system. (There is a ~~small~~ NEGLIGIBLE deformation of the field here, an extra portion of a line because there is time "left

Vas 17

over" after the completion of 262½ horizontal scans. ~~This deformation~~ is ~~negligable~~.) In the processing of the content time frame the picture infomration is superimposed over the system time frame of 15,750Hz and 60Hz so that the camera's information in its time frame begins to drift across the screen at a rate proportional to the frequency differentce (in this case, one full travel per second). The content time frame is now the content of the resultant display, and the viewer sees a horizontally drifting frame with all optical inforation within it remaining coherent. There are now two frames: the system time frame which is the horizontal and vertical scanning xatke rates and the content time frame composed of the camera's horizontal and vertical scanning rates, the latter contained within the former.

(photo or photos of H drift)

Similar operations can be performed with the vertical alone or in combination wibh the horizontal, with subcarrier frequencies, with two entirely unrelated video sources, etc. Furthermore, this is a concept useful in describing the encoding of any unlocked signal (such as originate with oscillators) superimposed on the system time frame.

To extend this somewhat, one can speak of a content time frame inherent in any video opeation. Timing inforation in conventional systems is distributed to signal sources and processors so that content time frames will precisely match xxh that of the system time frame. Throughout the signal path of video encoding, processing and decoding there aren numbrous independent internal oscillators which are made to lock to each other or a single source

19

so as to operate in precise relationships. This process of locking, which can be violated by the maker at many stages, is in the service of preserving the transparency of the time frame, ~~of maintainign~~ in conventional applications, of maintaining the mimesis of optical conditions.

The time frame is, then, the structure to which information is locked in order to preserve coherence throughout signal processing and final decoding in the display. What goes out will (if deisred) look much like what came in. Coherence, when camera encoding is used, is nothing more than the preservation of the initial relationships of horizontal and vertical coordinates on the faces of both CRTs. What happens then, and this is the essence of video operation, is that the light information encoded into a one-dimensional varying voltage is joined with timing infomraton derived from the same source as the horizontal and vertical drives controlling camera scanning, moment and rate.

There are certain conditions in which it is impossible to say which of two time frames is the system's. Normally, the system time frame is defined as that whihh comes from the master sync generator. This is normally identical to the scanning moment and rates of the line monitor. However, in cases where there are multiple vertical frequencies, or where there are two complete phase- and/or frequency-offset timing structures, it is impossible to ascertain which time frame is the system's. Effectively there are two equal systems. The reason the vertical structure is important is that it is the primary reference for monitors and sma-l-format vide tape recorders. In such conditions the distinction betw-en system and content is arrived at by chance and becomes a meaningless distinction.

15 (19

For VTRs it is determined by which vertical field the deck finds convenient to lock on; in monitors the ~~same~~ situation ~~holds~~ IS ANALOGOUS except thatlocking can be changed with the vertical hold adjustment.

We use the concept "time frame" becuase it allows us to contextualize the set of relationships which consititue the video image. As said above, the time frame comprises the set of time ~~space~~ and energy relationships ~~expr~~scomprising two consecutive fields. The time frame, becuase it is both context and content, allows us the flexibility to treat this complex set of dynamic r elationships as a static entity, indeed almost as a physical object.

But of course there is no material analog to the time frame becuase it is one of the ~~peculiar~~ singular capabilities of video that, while leaving unchanged the relational structure of the time frame, we may in various ways alter its appearance. Various image paramters may be reassigned at the convenience of the ~~user~~ user.

What this infers is that any expression of the time frame is equeivalent to any other. All scan processors implicitly recognize this, ~~for the signal is not~~ for they are designed not to act upon the sgnal directly--the relationships are not changed--but on the display through regulation of beam energy and deflection patterns. A full raster is always scanned in 1/30th sec. whether it appear as a single dot, a thin line, disjunct areas on the screen or complete blackness. Scan processors alter the spatial manifestations of the time frame, not the time frame itself.

~~Xxx~~ Now, while the nomrla video image does a fine job of repres-~~entation~~ enting the visual field (remember, it was designed ~~forx~~ to accomodate transparency), it is not much good as an analytic graph. Our impression of brightness is too ~~imprecise and~~ subjective for the energy component to be revealed with any precision. (And, of course, if the energy compbnent is indistinct, the time components will be similarly indistinct.) But since we may reassign arbitrary signals to various display paramters, we are able to concoct a pseudo-three dimensional time frame graph with the aid of the Rutt/Etra scan processor. Combining, in a way, the properties 6f oscilloscopes (variable verticaldeflection) and monitors (raster scan and beam intensity changes), we shall use the energy component to modulate vertical deflection as well as beam intensity. In this way we can produce an artificial terrain representing the time frame. A sine wave is represented thus:

(photo and three vector drawing)

The vector diagram locates the paramters of the time frame and should be imagined in three-D space with the energy vector pointing out from the picture plane.

Woody Vasulka pioneered this technique in video (independently originated, this pseudo 3-D graphing is a common analytical output from a range of scietific instruments) This is Woody before add after:

(two photos)

As his forehead is the highest energy portion of the picture, it deflects the beam the most and so receifds the highest relief. The darkness of his eyes deflects the beam the least. The plane no para) We shall be employing this graphic technique throughout this book to illustrate all processes and operations appliable to it. ~~Operations~~ Processes not applicable are those which operate between frames, such as switching or editing, or those which operate on components too high in frequency to be resolved by the scan processor, such as colorizing. Both these situations maight be said to be outside the bandwidth -f the Rutt/Etra.

~~Page 15B follows~~

It should be stated that we may speak of encoding equivalences only because a-l arbitrary signals find expression within this regular and periodic time frame structre. Electronic sound, possessing no such structure, does not permit us to view its operations this way; ~~precisely~~ because all output signals are aribtrary. While signals may be transformed, those transofrmations cannot be said to be equivalent. In sound, to be sure, there are other factors at work to make equivalence outisde its sphere, such as spectrum c hanges in wave reshaping, factors which are hidden in the video display, but ~~thatx~~ to consider these is outside our scope. Because of the nature of the phenomenon and the manner of its encoding, audio has only 1 display paramter; video has many.

There are a number of other important principles of which we should be aware here. organization ~~operative in video systems~~. One of the most important is the disctinction between fields, which gives us "the fiction of the frame."

Paradoxically, while the frame is the longest unit of video operation it is one of those entities that exist only in the eye of the beholder. Each frame consists of two interlaced fields of 262½ lines each, with each field occupying 1/60th second. Now, each field might be said to contain ½ the picture information of a frame, except that our terminology, which is derived from film practices, is imprecise to the degree of being inaccurate. While the field certainly does contain ½ the picture information of the frame, it cannot be siad to contain ½ the picture information of any particular frame or scene, and in fact contains the only picture information we are going to receive from any encoded moment.

In a movie camera the shutter is opened for a finite period during which ~~the~~ time the frame is entirely exposed in a single moment. The shutter then closes while the film is moved to the next frame where the process is repeated. Film is a sample and hold device, in which the photons interact with the full frame and are "held" there indefinitely through latency and proce-sing until the decomposition of the emulsion, the base or both. But a video camera has neither a shutter nor operates on the sample and hold principle. As the photosensitive portion of the pick-up tube is continually sensitive, ((p. 16 follows)

there is no moment of exposure. The "development" of the latent video image occurs when the scanning beam strikes a point on the photosensitive plate causing an electron flow proportional to the amount of light striking that point (the actual state of affairs is somewhat more complicated, but the dynamics are as described here). In video there is no frame sampling; only a single point is sampled at a time, with the effect that the frame is continually active, never static. Any change in the light field before the beam strikes an arbitrary point will be expressed in the resulting signal. Since the registration of images is continuous and not momentary, what in video is called a frame bears little resemblance to the momentary image of film. The frame is, rather, the expression of the formal structure of the time frame, with the purposeful discrepancy of the time at which each field begins. This discrepancy is ½ line, so that one field begins in the upper left corner of the screen and ends in the lower center while the other begins in the upper center and ends in the lower right. It is this ½ line offset that efficiently and automatically produces the interlace.

In any case, there is an interesting indefiniteness to all this: to specify that field number 3,263 and field number 3,264 are a frame is no more valid than to choose 3,262 and 3,263 or 3,264 and 3,265. The frame is, therefore, more the description of a process--the continuous process of interlace scanning--than a unitary concrete entity. Nonetheless, it has become conventional to designate that field which begins in the upper left #1 and that which begins in the center #2.

If we unravel, as it were, the time frame, we find ourselves with time divisions on a one-dimensional signal. These divisions we shall call "time marks." One point to remember is that this signal is absolutely continuous from the moment the system is actuated to the moment it is turned off. The horizontal and verticaal infomration comprising the time frame here exists as marks, sharply rising and falling voltages specifying particular instants which represent the time frame along this continuous signal. These marks then stand for and are utilized as instants in which a variety of processes begin or durations during which they continue.

The process of specifying the beginning of another process is called "triggering," and the entity which institutes it is called a "trigger." The specified signals which are triggers include horizontal drive, vertical drive, horizontal sync, vertical sync and, in color, burst flag. (- DIAGRAM TRIGGER)

Another process which, like triggering, is a regulator of processes, is "gating." Here the state of a gate permits a process to continue so long as the gate is in the specified state. It is distinct from a trigger in that a trigger fires another signal which after that initial moment is autonomous from the trigger, whereas IN GATING THE SIGNAL IS ACTIVE ONLY SO LONG AS the gate is at the specified level. ~~Both triggers and gates~~ TIME MARKS are most often pulses, which is a signal ~~xx~~ that has rise and decay times of such short durations that it can be said to have only two states and whose duration is short compared to the time-scale of interest. Pulses look like this:

(GATE DIAGRAM)

(diagram rising pulse) (diagram falling pulse)

The gating ~~ix~~ time marks of video are the horizontal and vertical blankings. These turn the beam on and off during retrace. Somep what simplified, they look like this:

(diagram)

Where they drop down the beam turns off, when they rise the beam turns on. Becasse most of their state is high (on), they are occaisonally and justifiably referred to as "unblankings."

Thus, at the beginning of each line the horizontal drive triggess the beam, sets it on its horizontal journey, while a short time later (approx 1 microsec?) the blanking rises to ~~txxnxthexbeamxon~~ enable the beam to write. Near the end of the journey, the blanking disables the beam, during which peridd it retraces so as to begin the process again. A similar situation occurs with the vertical dirve and blanking during each field.

DIAGRAM OF HD, SCAN LINE BLANKING

(here description and diagram of all timing signals)

Let's consider time frame and time mark in a different way by choosing the descriptive example of the registration of an arbitrary signal from an osc-llator or other electronic source. First, wehave our time marks

(labelled diagram)

And wehave the arbitrary signal, in this case a sine wave of approximately 31,500Hz which is free running (i.e. has no electronic relationship such as triggering to the time marks). Free run, following second paragraph, page 25

If absolute brevity were required, we could summarize video as th- practice of joining arbitrary signals to time marks. These time marks, by representing the beginnings or durations of processes, allow relationships to be determined which 1) establish the time and space rppreeentations of the frame, and 2) maintain stability of relationships within the frame. This means that the time relationships between arbitrary and specified signals are the same onthe display as they were in the encoding mechanism. In conventional utilization, this means that the electron beams of the display and the camera are at corresponding spatial coordinates on the face of the tube at corresponding temporal coordinates as measured within the time frame. Basically, it is only through specified signals that we can speak of having temporal coordinates at all. Transparency would not be possible without this enforced correspondence which is the organization of space by means of time and (in camera encoding) vice versa.

(diagram of camera-monitor scanning coordination)

The time frame, as we stated earlier, is composed of a complex interrelation of timing components. These components are as follows:

1) Horizontal drive (HD)--15,750 Hz pulse. Regulates the horizontal sweep, retrance and blanking of the beam in cameras. This is a trigger.

2) Horizontal sync--15,750 Hz pulse. Regulates the swee, and retrace of the beam in monitors. This is a trigger. Hor-

izontal and vertical sync are usually generated together as "composite sync."

3) Horizontal blanking--15,750 Hz pulse. This is a gate in all its utilizations. It is always generated with vertical blanking in the complex waveform of ~~"composite~~"blanking" or "composite blanking." Horizontal blanking does the following:

A) Blanks the beam in monitors just prior to retrace and restores the beam just afterwards.

B) In processing equipment, turns off the arbitrary signal near the end of each line and turns it on again after the beginning of the next.

C) Establishes, in its time relation to horizontal sync, the position and duration of the front and back porches.

D) Its amplitude establishes the pedestal level, which denotes the absolute blank of the system. This is not to be mistaken for black level, which is an arbitrary calibration of just noticable excitation of the phosphors (~~usually~~ conventionally at 7.5% above pedestal).

(INCLUDE EQUAL. PULSES)

(I. diagram of horizontal signal relationships)

((II. diagram, labelled, of horizontal line s-nc components)

4) Equalizing pulses--These ~~are~~ consist of two sets of 6 1/2" (i.e. 31,500 Hz) pulses that occur during the vertical blanking interval immediately preceding and following the vertical sync pulses. The purpose of this array is to maintain horizontal

synchronization throughout the vertical blanking and retrace, thus enabling the 1/2H disparity between the 1st and second fields. If the e qualizing fields were not present, loss of 2:1 interlace would result, reducing the resolution of the system (random interlace systems lack equalizing pulses.) Equalizing pulses are generated as a component of horizontal sync.

(diagram, two consecutive fields in verticalblanking)

5) Vertical Drive (VD)--60 Hz pulse. Regulates vertical sweep ~~ofxthexbeamxinxcamerax~~ , retrace and blacking of the beam in cameras. This is a trigger.

6) Vertical sync--This is a serrated pulse (i.e. a divided pulse) which occurs each 1/60th sec between the ~~equalizing~~ two sets of equalizing pulses. Its funcitoniss to regulate the sweep and retrace of the beam in monitors. This is a trigger. It will be noticed that the serrations have a duration of 1/2 H, so as to maintain horizontal sync during vertical blanking. Vertical sync is generated with horizontal sync as composite sync.

7) Vertical blanking--60Hz pulse. This is a gate which turns off the beam of monitors during vertical retrace. As a gate, vertical blanking is high for most of te field and low for 18-21 H at the end and beginning of each frame. It is the blankings, vertical and horizontal which determine the amount of active ~~timing~~ picture information of the frame. As stated, approx ~~21~~ 18 of ~~525~~ 256.5 lines are blanked, which leasv

VERTICAL BLANKING IS OF THE SAME AMPLITUDE LEVEL AS HORIZONTAL IN THE ~~encoded~~ composite video it occupies approx .28 (?) s.

(diagram, vertical timing relationships)

8) Subcarrier (also challed chroma, color subcarrier and (incorrectly) chrominance--3.58 MHz sine wave. Carreies the color portion of the signal, and exists in two components, the burst and the chrominance, both 3.58 MHz sine waves. The burst is t he reference and is located at the beginning of unblanked lines. Its amplitude, phase, frequency and position relative to each line do not change. The chrominance is the color actuating ~~sing~~ signal and occurs during active picture writing. Changes in the amplitude of chrominance control color saturation (e.g. whether it is pink or red, light blue or deep blue); changes in the phase of the chrominance relative to the stable burst control hue change (e.g. whether it is red or green).

(diagram burst and chrominance on the line, with some indication of phase referencing)

8) Burst flag--15,750 pulse. Determines the time location of the burst during each line. It functions as a trigger.

9) Burst key--15,750 Hz pulse. Determines the duration of the burst during each line. This is a gate. We shall discuss th color methods in a later section. It is necessary to mention them here to ~~point-out-to-in~~ make clear the interrelations of the timing signals.

As the maintenance of these preiese time relationships is critical to the functioning of the system, all synchromications must be derived from a single source, the "master clock." This can be either the 60 Hz of the power line frequency, a composite video signal from external sources (as in network applications

This is usually a high frequency crystal oscillator which generates square waves or pulses at an integer multiple of both vertical and horizontal frequencies. 14.1 MHz is one frequency often chosen for this application although many are possible (31,500 Hz, for instance, is the lowest possible master clock frequency for monochrome systems). The pulse is then counted down to synchronization frequencies and relative times of occurance of the various specified components. There are many methods used to derive these components, but of course the final results are the same. The reason for a master frequency is to minimize the effect of frequency drift, so that when this drift occurs in the master clock, all internal relationships are maintained. The master clock, unlike clocks we are familiar with, doesn't "tell"time, but is the time of the system.

(diagram dividing master clock)

Thdss timing structures are ajl pulses because the applied processes demand precision. The sharply falling and rising components, called "leading edges," are veru high frequency components of the waveform (tat is, they take very little time to occur). This gaiux gives them the ability to delineate very small moments on time. Think how difficult it would be to be precise with a sine wave:

(diagram)

Where (when, actually) the leading edge of the square wave gives a sharp indication of moment, the sine wave gives only a much more general sense. Indeed, it is the definition of the sinusoid that its transitions are everywhere equal with respect to slope (remembe the rotation diagram). A pulse can be viewed as a square wave with a very short of very long duty cycle.

There are other waveforms with leading edges, such as the ramps.

(diagram rising and falling ramps)

These are characterized by a linearly changing voltage until maximum/minimum where they return ~~to~~ rapidly to the initial level. To be precise, the sharp transition of the rising ramp is the "trailing dege." Either "positive going" (rising) or "negative going" (falling) edges can be used as triggers, depending on the engineering of the partiuclar device.

No leading edge is absolutely vertical, for that would indicate that the transition is literally instantaneous: obviously impossible. All ramps are, then, very sharp "sawtooth" waves, which are a subset of triangle waves.

(~~dagr~~ diagram triangle and sawteeth)

The steepness of the short slope of the sawtooth is often regulated by the response characteristics of the components it enters. It will be seen shrotly that intentional response limitations ~~mak~~ aid the scanning retrace of cameras and monitors.

These are the structures and components which allow the formation of a consistent, periodic and coherent frame. We shall examine in very general terms how this is done useing a simplified camera-display system as a model.

... a horizon

Level. To be precise, the sharp transition of therising ramp is the "trailing edge." Either "positive going" (rising) or "negative going" (falling) edges can be used as triggers, depdnding on the engineering of the particular device.

These structures and processes are the components which allow the formation of a consistent, periodic and coherent frame. Using camera encoding as a model, the following general steps are active in that formation.

1) The lens projects a round image on the transparent face of a round pick up tube. Unlike film, there is no opaque frame mask to delineate the rectangular image boundaries. Becuase the lens inverts the image, the top of the picture is really at the bottom of the tube, the scanning pattern of the camera is reversed from right to left (as looking at the target from outisde the tube) and from bottom to top. When we speak of top and bottom, it will refer to the timage, not to the physical orientation of the camera.

2 2) Our simplified tube has several charges applied to
x it to emanate
it. There is the cathode, which receives a steady voltage which allows/
steady continuous towards
a/beam of electrons toxflowxto the target. There are several focusing, acceleration and decelleration grides and coils which we have not displayed here.. The target itself is coated with a
phtosensitive
/ substance whose resistance is altered inversely to the amount of light falling on it. When there is axhighxintensity m8ch light, the ressstance is small; when little light, the resistance is high. When there is no lingt, this substance behaves as an insulator, so that when the electron beam strikes it, essentially no voltage can

Voltage of your signals

be tapped from ~~itx~~ the target. As light increases in any particular spot, the resistance declines and an electrical flow ~~isxproduced~~ ~~which-is-a--~~ of amplitude proportional to the light intensity is produced.

3) The sync generator sends horizontal and vertical drive pulses to the horizontal and vertical deflection amplifiers of the camera. These amplifiers use the drive pulses to ~~amplify the signal (increase its amplitude)~~ ~~and derive ramp singlas from the drive pulses~~. These ramps are sent to the horizontal and vertical deflection coils which move the beam up or down and side to side. For example, as the vertical ramp increases, thebeam is pulled farther and farther down until it reaches its lowest point at the peak of the ramp. When the ramp snaps suddently to its low point, a rapid vertical retrace occurs. The same situation occurs with horizontal. Thre is no blanking here--the beam is continuously on--and whatever the beam picks up during its retrace is tapped off the target along with the rest of the signal. The basic spatial dimensions of the iamge are shaped here by the location of the beam sweeps. Aspect ratio If there is, for instance, a miscalibration, it will be carried along thorughout the system. There is little one can do to ameliorate the situation without expensive a-dsophisticated digital re-timing techniques.

4) At the same time as this is happening, the sync generator is sending to the processor horizontal and vertical syncs and blankings to a module we'll call the sync and blanking adder. In most systems, horizontal and vertical sync are conveyed in a single signal called composite sync; horizontal and veritcal blanking in composite blanking (or, someitmes, called just "blanking"). The

sync and blanking adder receives the signal from the target, which, it will be remembered, was scanned according to time directions from the same master clock. The result of this is to allow sync and blankings to be added later while maintaining the proper relationships of the time frame.

in fact, is a relative condition, so that both the time marks and the arbitrary signal may be said to be free running.

(diagram of sine wave in same TB as time marks)

In the encoding process the arbitrary signal will be linked to the time mark anywhere in its period it happens to fall. The resulting signal might look variously like this:

(3 diagrams of composite video)

When displayed it will look variously like this:

(4 photos free running 31500 on monitor)

There are two elements at work. The time base determines how the signal will look on the monitor. Since this arbitrary signal goes through approximately 2 full cycles each 1/15,750 sec., each line likewise goes through four complete changes. The second element is the time frame. It is in this kind of synthetic situation where the essential abstraction of the time frame becomes most apparent and also where its usefulness is most pronounced. We are not plotting positions on a two dimensional surface; rather we are assigning time relations which determine the position of the content--~~thk arbitxaxxx~~ an periodic energy structure--in the ~~twoxdimenx sionaix~~ double time-based array manifested in the raster. Coherence, the preservation of the relationships between voltage level of the arbitrary signal and the time frame, although visually unstable, is active here: this ~~ign~~/signal is fully recordable and consistent in every playback.

27

We may, if we wish, trigger the 31,500Hz signal with the horizontal drive of the system. In that case, the oscillator is told to begin its cycle at the beginning of each line where it executes two cycles before being told to start again at the next line. Then the video signal is unchanging in appearance and looks like this:

(monitor photo and waveform drawing)

Curiously, and important to realize, is that if we point a video camera at the display of the locked signal, what emerges from the camera is a 31,500Hz signal more-or-less identical to the oscillator-generated waveform locked to the time marks. This illustrates another principle of experimental video, what we shall call the equivalence principle, which is that every light projection on the pick-up tube has a waveform encoding particular and equivalent to ~~xxx~~ it. This is obvious, and is at the heart of the mediational process. What this means is that it is, in theory, possible to duplicate by waveform generation the encoding of any camera scene. And the inverse: that any waveform generation within appropriate paramters (of frequency and amplitude) can be encoded by a camera with the same appearance it will have on a display if the camera is given the appropriate scene to scan. The reason the latter is so is because of another element in the mediational process ~~which we might call the~~ "limiting equality" which is found in nearly all technological media. This is the ereason we had to add "as it will have on a display." To preserve the visual or sonic transparency, all such media operate, in a sense, with mirrors. The camera pick-up tube is the inverse of the monitor: the decoding process may be diagrammed like this:

(DIAGRAM)

Similarly, in film exposure and projection we find this state of affairs:

(diagram)

In audio there are two moving diaphragms, the microphone's and the speaker's. In all cases the utility of the system--that which allows it to be an intermediary--has dictated that the mimetic encoding process be inverselyduplicated in the decoding process. It is this equality which preserves the transparency and allows us to accept the scene as a valid representation of human vision. (Holography seems to present one significant exception to this rule.) Thus, in a noiseless system (purely a theoretical construct) we can, if we wish, repeat the rescanning process with our locked 31,500Hz signal indefinitely and maintain the identicality and particularity of te product in each generation. The mirror of this system preserves this transparency of the processing.

The inverse of our equivalence principle is true--that any waveform generation can be encoded by a camera with the same appearance it will have on the display when the corresponding camera encoding is used is because, being "mirrors," the camera and the isplay have similar properties of light-electricity conversion. The utility of the video system has dictated to the engineers that in "normal" encoding of light the qualities the system imparts to the registered scene not grossly violate our recognition of normal perception. Nonetheless, at certain limits of the system, distortions are introduced by the camera and/or monitor. For example, if a ball falls at an appropriate speed before a video camera, it will appear

(no para following)

Instead of being in a single position for each field (as would be the case with film), it intersects a greater number of scanning passes than it would if it were at rest. Likewise, if it were rising it would appear disclike, because it intersects fewer scanning passes. The speeds involved, indidently, are not great. Now, if we encode a waveform, a series of pulses, which have the same temporal relation to the time frame as the ball has to the light projection of the pick-up tube, the appearance on the display is likewise distended, just as in the camera encoding. The reason for this is, of course, becuase the monitor's intersection of the electronic ball is identical to that of the camera's to the material ball. Remember that the waveform encoding is not identical because the material ball's encoding reflects the distension while the electronic encoding does not. Equality is preserved because of the inverse mirror.