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PROPOSAL

FOR A

MAGNETIC TAPE TO PHOTO REPRODUCER

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2. LIST OF ILLUSTRATIONS

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ABSTRACT

[redacted] proposes a Magnetic Tape to Photo Reproducer System, which will have as its input a recorded video tape. 25X1

Television pictures can be played back from a disc recorder and viewed at normal speed, in slow-motion, or in a single frame with all motion stopped. When the T.V. frame of interest is discovered, it is identified as a number in a counter. When the VTR is replayed, the counter chooses the correct frame and unblanks a high quality CRT, and the display is photographed. Thus the photograph is made from the first generation VTR reproduction rather than from a second generation disc recording. Additional aids to photo interpretation and identification are image enhancing, black and white stretch, and spot wobble.

Photographs are 3" by 4", both silver halide cut film and Polaroid fast develop film.

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3. INTRODUCTION

[redacted] proposes to design and construct a Magnetic Tape to Photo Reproducer that will fulfill the requirements of the R.F.P. specification. 25X1

Recorded video tapes from external sources are played on a VTR. When a scene of interest appears, the operator can record a 20 second segment on a disc recorder (DR). Playing the DR permits a close inspection of frozen-frames or slow-motion pictures. The frame (or field) to be photographed is chosen and its location is now stored in a counter. The original tape is now replayed on the VTR and when the particular frame is reached, a CRT unblanks to expose the photographic film. This permits a picture of maximum quality because the first generation video tape reproduction is photographed.

System objectives are:

(i) Maintenance of picture quality between the stored data of the tape and the ultimate photographic output.

(ii) Good reliability, low maintenance and easy operation.

(iii) Video enhancement to bring out picture details.

(iv) Ability to handle American and European T.V. standards.

Principal features of the proposed system are:

(i) A video tape recorder that can play 525/60, 625/50 and 405/50 tapes. A dropout compensator makes dropouts less objectionable.

(ii) Means for image enhancement, including vertical and horizontal aperture correction, black and white stretch, and spot wobble.

(iii) In addition to the normal speed picture monitor display, the video signal can be recorded on a [redacted] developed magnetic disc recorder and the picture played back at 1/5 speed on frozen- 25X1 frame for continued and detailed examination of one frame or field.

(iv) A cueing system marks a particular frame on the original video tape as a function of frame choice from the disc recorder. Having made all required adjustment to the picture in terms of brightness, contrast, stretch, and enhancement, the VTR is replayed, and then the desired video frame is displayed upon a high-resolution CRT, and photographed.

[redacted] is one of the largest users of video tape and [redacted] has years of experience designing systems similar to the one described here. Therefore, we are confident that the proposed system represents an optimum solution for the stated requirements.

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4. STATEMENT OF THE PROBLEM

The requirement is for an electro-optical system that can transfer video pictures from magnetic video tapes to a photographic record with the minimum loss of quality. This problem is not new to [redacted] and calls for a certain sophistication in design approach. We are confident that the techniques described in this proposal will fulfill the requirements of the R.F.P. 25X1

4.1 Video Tape Input

The recorded video tape is the input to the system. These tapes may have been made in conformance with any of the television standards in common use throughout the world. The principal systems with which we are concerned are listed below:

525 lines	60 fields per second
625 lines	50 fields per second
405 lines	50 fields per second
819 lines	50 fields per second

It is believed that the 819/50 standard is unlikely to be required, and for this reason it is presented as an extra cost optional feature. In any case, it is desirable that these various standards be accommodated on a single, especially-adapted video tape recorder of basically standard design.

4.2 Tapes From Non-Standard VTR

From time to time, video tapes recorded on helical or other video recorders may have to be played. This is a vexing problem because the tapes are not interchangeable and each must be played on its own type machine. Therefore, we will not attempt to engineer all these diverse video

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recorders into the system, but we will be able to accommodate a standard video signal from any source.

4.3 Picture Quality

Photographs are made for maximum interpretation and identification; aesthetics are secondary. In some cases only a small area of the photograph will be of interest so it should be favored. Various schemes are available to "doctor" the picture to bring out information:

(i) Grey scale distortion to increase the contrast of a favored portion of the picture. Black and white stretch circuits are used.

(ii) Image enhancement to sharpen edges. Vertical and horizontal aperture corrections are the usual techniques.

(iii) Photograph a single field rather than a frame on moving subject, thereby reducing motion smear. Spot wobble is used to close up the space between lines.

Despite all these techniques, there is no substitute for photographing all the resolution that the tapes can afford. Small objects, especially, will demand the best resolution for useful interpretation. One way of retaining picture quality is to photograph the first generation video directly from the VTR rather than from the DR. This is because the horizontal phase stability of the DR is considerably poorer, causing vertical edges to become serrated.

4.4 Frame Selection

In order to meet the requirement of detailed and time consuming selection of individual T.V. frames, the inclusion of a magnetic disc recorder is to be considered. A significant development at [redacted] has resulted in a device that can record some 20 seconds of video at normal speeds, and then replay this section by playing the disc in the readout mode at a slow speed, or even with the motion stopped altogether. In this way an individual frame may be examined to see if it is of interest for photographing. This requirement raises the associated problem of marking the desired frame in the video tape. Techniques for achieving this are described in this proposal. 25X1

4.5 Photographing

Once a particular frame has been selected, it remains to photograph it with the least possible degradation of quality and information content. We propose to apply the video field or frame to a high-resolution cathode ray tube and photograph the phosphor screen.

A choice of optimum phosphor, screen size, and camera type for this application, must be analyzed and resolved. The solution must also include recognition of the need for a fast film processing system so that the hard copy output may be examined quickly.

4.6 Maintenance and Operation

It is a major requirement of the system that the equipment can be operated under optimum conditions on a routine basis by a single skilled technician. Thus, the layout of controls must be designed for the convenience of a single operator, and provisions made for easy and rapid maintenance.

Equipment must be specified and designed for the application of a routine series of tests, which can be easily conducted by the operator in order to give positive verification of peak operating conditions before the start of each reproducing session.

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5. SYSTEM DESCRIPTION

Since the video tape recorder, (VTR), is incapable of presenting a frozen playback image, it is necessary to employ a video disc recorder for this purpose. Although video disc recorders, (DR), are capable of generating reasonably good pictures, their quality is not as good as the television picture from the VTR directly. Furthermore, it is axiomatic that the earlier the generation of television signal that is photographed, the better is the picture. 25X1

therefore, recommends the system shown in Figure 1, where the disc 25X1 recorder is used to pre-determine the exact field or frame to be photographed but the photograph is made from the video of the VTR.

The proposed system provides a unique frame or field selection feature utilizing the flexibility of the Slow Motion Disc Recorder with its rapid re-set and recycle times. Referring to the block diagram, Figure 1, the video playback of the tape recorder is fed to the disc recorder input via a mixer. The operator continuously monitors the tape output using the "electronics-to-electronics" feature of the disc recorder, or the VTR output directly. When he locates a section of tape that he wishes to photograph, he presses the "Record" button of the disc recorder. This action, in addition to providing twenty seconds of recording on the disc, also causes a "white level" pulse from the pulse generator to be mixed with the tape playback video during the vertical blanking interval. Thus, each field recorded on the disc has this pulse recorded immediately prior to picture information. Simultaneously, comparable pulses are recorded on the video tape cue track.

At the conclusion of the twenty seconds' recording, the video recorded on the disc and the section of tape from which it was recorded have electronic "sprocket holes" uniquely identifying the corresponding fields on both. While the information recorded on the disc is reproduced (with the tape recorder stopped) for the purpose of selecting a given field to be photographed, each previously recorded "white level" pulse is separated from the other video signals by the keyed Pulse Separator and fed to a gated four-digit pulse counter, previously re-set to zero. As the recorded fields are reproduced, the counter indicates the number of successive fields played. When the Freeze button is pressed, the count stops. The frozen field is now viewed on the high-resolution CRT with the switch in disc position. The contrast, brightness, focus and astigmatism controls may then be adjusted to produce the desired image.

When this has been accomplished, the videotape recorder is rewound to a position immediately preceding the disc-recorded section (as indicated by the numerical counter on the VTR). The pulse counter then counts in reverse as the pulse input to the counter is switched from Pulse Separator output to VTR cue track output. Thus, as the VTR is played through the sequence previously recorded on the disc, the field pulses on the cue track cause the pulse counter to reverse the indicated count, and, at the count of zero, an unblanking gate permits only the desired field (or frame if desired) to be displayed on the CRT. In this manner, a first generation photograph is taken of the selected field.

Prior to photographing, pictures from the VTR and DR are studied and the Image Enhancer and stretch circuits are adjusted for optimum images, on the picture monitor and the CRT.

The CRT is enclosed in a light-tight box through which the camera lens views the CRT faceplate. A light meter is provided to insure correct photographic exposure.

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Additional accessory components include a dropout compensator, sync generator, and test signal generator. The various subsystems and components will be described in greater detail in the following sections.

5.1 System Components

The system is capable of playing back video tapes with the following standards: 525 lines/60 field, 625 lines/50 field, 405 lines/50 field, and 819 lines/50 field. This last standard is excluded in the circuit description and is an extra cost option. Although it is not necessary to reproduce color at this time, the system should be capable of future expansion for color reproduction.

5.1.1 Video Tape Recorder

The following standards are presently available in video tape recorders: 525/60 low band, 525/60 high band, 625/50 low band, 625/50 high band, and 405/50. There are other standards, but present-day video tape recording usually uses the five standards mentioned.

With the advent of new color standards in Europe, it appears that the French 819/50 standard will soon be phased out in favor of 625/50 television. On account of the limited utility of this standard, [redacted] elects to omit it from the system being proposed, and making it available as an extra cost option. Two companies presently manufacture video tape recorders, [redacted] Machines from each of these companies are of high quality and the [redacted] has had extensive experience with both. [redacted]

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will choose the best machine for the proposed system; the choice will be made on the basis of quality, performance, availability and price. A picture and a waveform monitor are included in the VTR and should suffice for operating the system.

The VTR supplied is capable of reproducing nearly all two-inch wide, transverse recorded magnetic tapes that are presently being used for broadcasting throughout the world. Recently there have been a number of inexpensive helical scan magnetic video recorders developed here and abroad. Unfortunately, there are no world-wide standards for these narrower tapes, thus requiring the tape to be reproduced on the same type machine that recorded it. To our knowledge, there are approximately six different machines on the market with six different tape standards. System capability will be provided to accept video signals from external VTR's as long as the signal meets one of the broadcast standards previously mentioned.

A convenient way to photograph video from a helical scan machine is to first record its video on the VTR. Thereafter the VTR can be played into the system in the normal way.

5.1.2 <u>Video Disc Recorder</u>

Commencing with the 1965 football season, [redacted] introduced the stop-action video disc recorder to enable television viewers to follow the often-complex action of a play. This machine, developed jointly by [redacted] provides for

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up to 20 seconds of continuous recording with a rapid re-set (about one second) to permit quick playback. During any portion of the playback, freeze-frame viewing may be effected with a return to continuous action at the operator's option. Very recently, [redacted] completed the development of an important additional feature to this machine, continuous slow motion in the ratio of 1:5. With this new degree of freedom, the operator may play the recorded 20-second segment in any sequence of normal, slow or stop motion. Figure 2 is a photograph of the new slow-motion machine. Figure 3 is a view of the keyboard, showing operating controls. 25X1

The recording medium is a polished magnetic alloy plating on an aluminum disc. The magnetic heads ride in direct but low-pressure contact with this disc. In the illustrated unit, the disc is twelve inches in diameter and rotates at 1800 rpm, servo-locked to the video synchronizing signal. For the system being proposed, this will be replaced by a newer 14" diameter disc with attendant improvement in magnetic writing speed.

5.1.2.1 <u>Continuous Recording</u>

Continuous recording and playback are provided by a single magnetic head on the upper surface of the disc. This mechanism, takes the form of a lead screw drive to transport the head carriage assembly radially. The lead screw is driven by a worm drive directly from the disc drive shaft. This arrangement establishes a positive relationship between disc and head position,

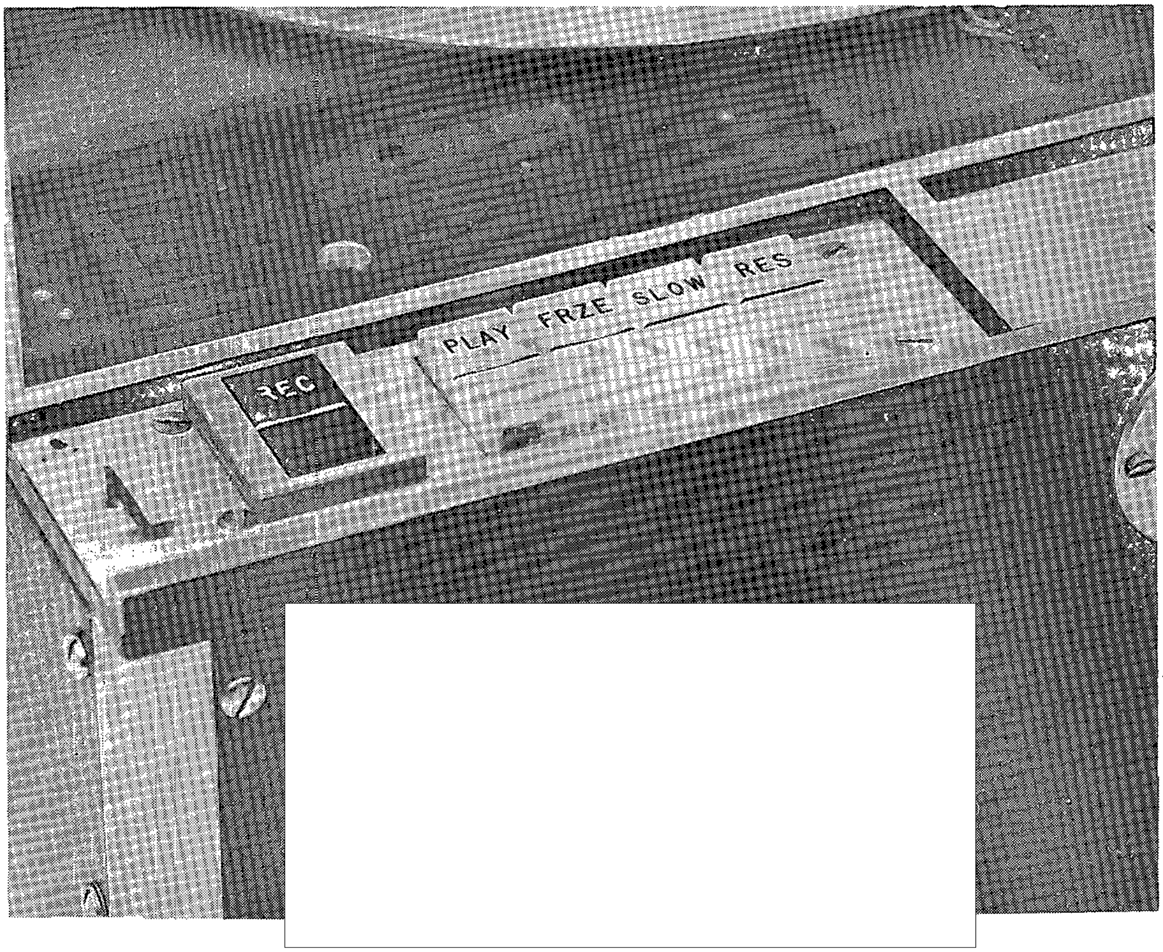

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Fig. 3

ensuring accurate tracking. There are two control features in this mechanism;

(i) a pin-type clutch for disengaging the lead screw drive, and

(ii) a method for disengaging the head carriage from the lead screw.

The worm drive ratio is 10:1, so that the lead screw rotates at 3 rps, or 10 television frames per revolution. With a track width of 0.004" and a guard band of 0.001", sufficient head travel is provided to permit a continuous recording of 20 seconds duration. This requires a total head travel of 3". These parameters result in writing speeds ranging from a maximum of approximately 1,320 inches per second at the periphery of the disc, to a minimum of 1,040 inches per second.

The head carriage disengagement feature allows the recording head to move quickly back to the starting position after a partial or full recording is made. This feature, of itself, is of considerable value in football telecasting, solving the operating problem of the time delay normally involved in recueing tape for an immediate replay. Any recording operation can be interrupted and a playback started with a delay of only one second.

Disengagement of the lead screw drive stops the motion of the head carriage assembly for stop-action frozen-frame playback. Stoppage of the head carriage permits continuous replay to be started again, with the appearance of a resumption of the program action from the point at which it was frozen by the stop-action effect.

5.1.2.2 Stop-Action Channel

To achieve the stop-action effect, an additional record/playback channel is used with a continuous circular track. This track is on the underside of the disc, located near the periphery for maximum writing speed.

For a satisfactory stop-action picture, it does not suffice merely to record and then repeatedly replay a single complete frame of the video signal. Particularly on fast-moving sports material, there can easily be sufficient displacement of portions of the image between the two fields of a complete frame to cause an objectionable degree of flicker in areas of motion. It is essential, therefore, that the video signal of one field only be used for the played-back stop-action frame. This can be accomplished by using two playback heads on the circular stop-action track, at opposite sides of the disc, and switching between them at the field rate.

The angular displacement between the heads, however, cannot be exactly 180 degrees. Since the number of lines in a frame, or the number of lines on a complete track, is an odd number, if the heads were 180 degrees apart, when one head was reading a sync pulse, the other would be reading the center of a scanning line. Thus there would be a half-line time displacement when a switch was made from one head to the other. The displacement between the heads, therefore, is made 180 degrees minus the angle corresponding to one-half of a line interval. When the displacement is set to precisely this value, it is possible to switch playback instantaneously from one head to the other with no time base discontinuity. The switching points are arranged so that both the even and odd vertical synchronizing intervals are played back by one head, while the other plays back the video interval only. This switching pattern is essential to recreate the vertical synchronizing signal properly.

The angular displacement of the two heads is quite critical to permit switching without a time base discontinuity (0.001" difference in position corresponds to approximately one micro-second in time). One of the stop-action heads, therefore, is mounted on a micrometer screw positioning assembly permitting minute adjustments in its position in the angular direction. Both heads can also be positioned in the radial direction to permit some choice in the location on the disc of the stop-action track.

Another important factor in minimizing the time base discontinuities is the consistency of angular position-

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ing of the video signal on the disc. The unit, therefore, includes a servo system to synchronize disc rotation with the video signal, and to minimize random phase errors between the video signal's vertical reference and its position on the disc.

5.1.2.3 Control System

A marriage is required of the two recording channels thus far described, into a system permitting the required operational control to alternate between continuous replay and the stop-action still frame. A series of events must take place to achieve the transition from continuous replay to stop frame, and vice versa. In going to stop frame, the actions are as follows:

(i) A transfer recording is made on the stop-action track of a frame currently being replayed.

(ii) A switch is made to play back alternately from the two heads of the stop-action channel.

(iii) The lead screw drive is disengaged.

At this point, the continuous channel's playback is halted close to the point where it played back the selected stop-action frame. To revert to continuous play, the sequence is:

(i) The lead screw drive is engaged.

(ii) After a short delay to permit mechanical tracking stabilization, playback is switched back to the continuous channel.

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5.1.2.4 Slow-Motion

The unique combination of the 4 mil record track and 1 mil guard band makes possible the particular form of slow-motion developed by [redacted] for use with the MVR Videodisc Recorder. By means of a separate clutch and gear train, the main head is moved along the lead screw at exactly one-fifth its normal speed. Under these conditions, the head will not properly traverse the original recorded track. Instead, the playback signal quality will experience a cyclical pattern which produces one "clean" T.V. field every 1/12 second. Because of the unique geometric relationship between lead screw and disc, this particular field may be indicated by a magnetic pick-up mounted to the gear-train assembly. Thus, this "clean" field is reproduced from the main head, while being simultaneously recorded on the freeze track. For the remaining 4/60 second, the same field is repeated four times from the freeze track with proper interlace. Following this is playback of the very next T.V. field from the main head, etc. In this manner, [redacted] slow-motion is provided with no loss of T.V. information since none of the T.V. fields will have been omitted. It results in a smooth continuous action at a speed designed to permit careful study of rapid action by the viewer. 25X1

5.1.2.5 Operating Characteristics

The control panel of the unit includes, as operating controls, pushbuttons designated "Record", "Play", Slow", "Freeze", and "Reset". In the "Reset" state, the record playback head is at the starting position and the electronic circuits are in the "E-E" mode (electronic-to-electronic), providing a check on the operation of the video signal path through the recorder. The "Reset" button can be operated while a recording is in progress. If a full 20-second recording is made, reset occurs automatically at the end. The "Play" button initiates playback of the continuous recording. The "Freeze" and "Slow" buttons may be operated at any time during a playback, and "Play", can, of course, be resumed while in the "Freeze" or "Slow" mode.

The control logic also permits use of the "Stop-Action" channel independently of the continuous recording channel. If the "Freeze" button is operated while in the "Reset" state, the "Stop-Action" channel will capture a frozen frame directly from the incoming signal. One useful aspect of this feature is that it permits the best possible quality of a played-back "Stop-Action" video signal, since the "Stop-Action" channel is in this mode making a first-generation recording, as against the usual second-generation resulting from "Freezing" the output of the continuous channel.

Electronic circuitry is completely solid state. The unit weighs approximately 40 pounds and measures 17" x 19" x 11". Power consumption is approximately

100 watts. Provisions are made for remote control operation.

It is noteworthy that the ability to freeze a selected field is considerably enhanced by the use of slow-motion immediately preceding the desired field. This is simply the result of operator reaction time limitations as fields change from once every 1/60 second to once every 1/12 second.

5.1.3 Dropout Compensator

A dropout compensator reduces the objectional effect of dropouts while the tape is being reproduced. A dropout is a brief reduction of rf carrier amplitude due to irregularities in the tape surface. On the television screen, the loss appears as a distracting streak. Multiple dropouts appearing in rapid succession can severely degrade the signal display. A dropout compensator prevents such effects by replacing the missing information with stored video from the previous line.

The reproduced video signal is continuously stored in the dropout compensator by a delay line having a delay time equal to one scan line. As long as there are no dropouts, the recorder output is the non-delayed video. During a dropout, the delay line supplies the video signal, substituting information from the previous scan line for the missing information. Because of the similarity between successive scan lines, the viewer will be unaware of the substituted signal.

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One could argue that photographing a T.V. picture that contains a re-inserted duplicate line offers no more information than if that substituted line was photographed as a white flash or dropout. Subjectively, however, the white dropout streak on the picture would be distracting as compared with the re-inserted line. Furthermore, during the normal viewing of the film while looking for areas of interest, a poor tape with many dropouts is distracting and uncomfortable to view. The dropout compensator makes these dropouts almost invisible.

The [redacted] manufactures these dropout compen- 25X1
sators and their International Model handles all broadcast standards.

5.1.4 Image Enhancer

The proposed system is for the purposes of identification and information rather than to entertain, as is the case in broadcasting. Image enhancing makes it easier to identify objects and pull certain objects out of the background by enhancing edges through a combination of vertical and horizontal aperture equalizing. Objects whose edges are blurred can be overemphasized to cause these edges to stand out in marked contrast to the background. Naturally, it is most desirable that enchancment be accomplished without an objectionable increase in picture noise.

[redacted] has designed and built Image Enhancers since 1957 25X1
for our [redacted] and others. Experience proves that 25X1
the most effective vertical aperture equalization employs both top and bottom line correction. Single line correction causes the

pictures to assume an unsymmetrical bas-relief characteristic that is disconcerting. Furthermore, full aperture equalization can never be realized with one line correction. Therefore, all of our work has been directed toward two line vertical aperture equalization despite it being considerably more difficult to accomplish.

Image enhancement works by analyzing the content of a picture element with respect to its surrounding elements and introducing the correction (detail) into the picture element of interest to enhance sharpness. Vertical equalizing of a given line is accomplished by comparing it to the line above and the line below. The resultant difference signals represent vertical detail that is then added to the main signal to sharpen vertical transitions.

Horizontal equalizing is accomplished in a similar manner, but on an element-to-element basis rather than a line-to-line basis. Here, a given element is compared to the preceding element and the succeeding element. The resultant difference signals represent horizontal detail that is added to the main signal to sharpen horizontal transitions.

Figure 4 is a photograph taken from the face of a picture monitor of a live color camera pickup. Notice the soft facial features of the model. Figure 5 is the same scene with the Image Enhancer switched on. Here the facial features are sharpened but not exaggerated. If the detail signal was to be increased, the girl's features would become heavily accented and skin blemishes would

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stand out. Figures 6 and 7 are another pair of normal and enhanced videoframes respectively.

Figure 8 is a test pattern taken through the same system without image enhancement. Figure 9 is the vertical detail image only; Figure 10 is the horizontal detail signal only; and Figure 11 is the combined vertical and horizontal detail. Adding this detail to the test pattern results in Figure 12. Notice that although one cannot see appreciably more of the wedge patterns than before, the contrast has increased. Since black to white contrast defines the limits of resolution, we can say that resolution has increased.

[redacted] is presently producing the Model 525 Image Enhancer. Its unique features are: 25X1

(i) Use of a phantom channel to provide drift-free operation. Continuous operation in television broadcasting makes it imperative that the equipment be highly reliable and free of drift. The phantom channel insures that the video signals applied to the difference amplifiers are derived from common circuitry so that if these circuits change or age, all the video signals vary together and the nulls of the difference amplifiers are maintained.

(ii) Circuit logic is designed to permit operation adjustments without the need for an oscilloscope. It also permits checking while the unit is actually in use and without disturbing the output signal

(iii) Noise reduction techniques to reduce the noise content of

[redacted]

the corrected signal. Normally, when the detail signal is added to the main signal it also adds noise. However, the Image Enhancer employs "crispening" that subjects the detail signal to non-linear shaping and effectively removes detail noise without impairing aperture correction.

(iv) Level Dependent Aperture Equalizing. The cameras that originally made the picture are subject to high noise levels in the black regions. Aperture equalizing of these black areas is subjectively unnecessary. Therefore, the Image Enhancer has means to remove the detail signal from black to any set shade of grey to permit maximum equalization without increasing the black noise in the picture

(v) Dynamic Black/White Peak Clippers. When the detail signal is added to the main signal it results in blacker than black and whiter than white peaks. Simple diode peak clippers are not effective because it is difficult to set them to clip peaks without intruding into the main video signal. The Image Enhancer gets around this problem by clipping the peaks of the detail signal only as a function of the instantaneous video content of the main signal. It insures that the sum of the detail and main signals can never exceed peak black or peak white. Since the Image Enhancer clips the detail signal only, it insures that the normal picture peaks of the main signal will not be harmed.

Ultra-sonic delay lines are used in the Image Enhancer to delay the video signal exactly one and two horizontal lines. As a result, the Image Enhancer can be used on a single television standard. Other standards require separate and individual Image Enhancers. [redacted] will modify two Model 525 Image Enhancers to the 625/50 and 405/50 standards.

In American T.V. broadcasting the sync generators were originally locked to a line frequency of 15750 Hz making each line 63.492us long. With the advent of color, the sync generators are now color locked to a frequency of 15734.2 Hz making each period 63.555us long. Thus, the color line period is approximately 63 nanoseconds longer than the monochrome line period. American television stations have been using color lock for the last few years so there is every likelihood that the tapes received will be made with color sync. However, tapes may be provided that are locked to monochrome sync. Playing a monochrome sync tape through the Image Enhancer designed for color sync will degrade the image enhancement because the detail signal will be incorrectly timed relative to the main signal. We recommend that the color sync Image Enhancer be used and that the Image Enhancer be switched off during the infrequent reproduction of a monochrome sync tape.

5.1.5 Black and White Stretcher

When the luminances of a television image are directly proportional to the corresponding luminances of the televised scene, the system is said to be free of luminance distortion. The basis of luminance-distortion compensation (usually called "gamma correction") is the specific non-linearity of the picture tube and CRT. The light output of a typical CRT vs. control voltage above cutoff is approximately a power function based on an exponent of 2.2. To compensate for the CRT characteristic, the amplitude of the luminance signal, as measured against black in the video signal, is arranged to vary as the 1/2.2 root of the luminance of the originally televised scene.

The non-linear circuit that performs the grey scale correction operation is called a Gamma Corrector. Its primary function is to control the over-all amplitude transfer characteristic of the television system between the camera scene and the reproduced picture. Most recorded video tapes will contain television programs that have already been gamma corrected and no further correction is necessary for regular viewing. Therefore, any additional non-linear shaping of the video signal will be for the purpose of enhancing certain luminance levels to bring out picture detail.

A black or white stretch amplifier is provided for this purpose. Note that we do not call it a gamma amplifier because that is not its main function. The amplifier is switchable to stretch blacks or to stretch whites to any reasonable degree and also to vary the point on the grey scale at which this stretch occurs. The stretch amplifier can easily be adjusted and interpreted by feeding a stair-step signal into it from the test signal generator. Ultimately, the final adjustment is performed while viewing the CRT that will be photographed. A single stretch amplifier should suffice for all standards.

5.1.6 Sync Generator

The sync generator produces the sync and drive pulses necessary for the operation of many components in the system. It is obvious that the VTR is generating signals only while the tape is being played and that at all other times some external source of pulses must be available. Separate sync generators are needed for the 525/60, 625/50, and 405/50 standards. In addition, if the 819/50 French standard is used, still a fourth sync generator is necessary.

5.1.7 Test Generator

The test signal generator is highly desirable for maintaining the system at the peak performance level. The test signals generated are:

(i) multiburst,

(ii) stair-step,

(iii) Five or ten steps with or without color subcarrier or ramp,

(iv) Sine-squared pulse and window.

These signals have been designed to examine such characteristics as amplitude-frequency, phase-frequency, amplitude-linearity, differential phase and gain of the television system. Three test signal generators are required, one for 525/60 standard, another for 405/50, the third for 625/50 standards. The 819/50 standard will require a fourth test generator if that standard is included in the system.

5.1.8 CRT, Camera Sub-system

The photographic requirements of the system demand transfer of picture to film with minimum degradation in resolution and contrast. In fact, provision is made for deliberate and controlled picture

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enhancement to increase the amount of intelligence available. Selection of the cathode ray tube, lens, and film have been made with these factors uppermost.

The selected frame is viewed on the high-resolution CRT, as well as on the picture monitor, prior to photographing. During this examination, the CRT controls are adjusted for optimum picture emphasis and the camera iris is set per the information provided by the light meter. All elements (CRT, lens, and light meter) are housed in a single light-tight unit with a viewing port. The resulting photograph is approximately 3" by 4".

Detailed descriptions of the parts of this subsystem follow:

5.1.8.1 Cathode Ray Tube

A primary consideration is the size of the display required to view and photograph a maximum of 800 horizontal line elements. This need is readily satisfied by a 3" by 4" raster using a 7" diameter CRT. With this format, edge distortions are minimal. The 800 T.V. elements per line require optical resolution of 4 line pairs per millimeter, well within the achievable performance of a Litton L.4104 high-resolution CRT with a flat face plate for uniform focussing.

The CRT phosphor must be actinic while maintaining a low ultraviolet content for convenient direct viewing. P-11 with a spectral peak at 4,600 Å represents satisfactory compromise in this respect. Phosphor decay speed is not germane to this application because of the length of time of film exposure.

The concept of photographing a small area of the display to provide an enlarged photograph of an area of interest has been considered, but discarded. It is simpler to photograph the entire display and then enlarge any part of it to the extent desired. No resolution is lost in this way, and the scan circuits are simplified.

5.1.8.2 The Camera and Lens

The type of camera selected is dictated partly by the film size required. This is stated to be 3" by 4"; and in order to accommodate this and yet leave some room for flexibility, a 5" by 4" camera is proposed, such as the Calumet CC400, equipped with a 16" rail.

The lens requirement is well met by Schneider Xenotar 135 mm., f3.5., equipped with iris control but without shutter. The optical performance and response of this lens at four line pairs per mm. will exceed 90% at all points on the field.

A blue-green filter is placed before the lens to prevent the CRT cathode glow from fogging the film.

5.1.8.3 Light Meter

Mounted beside the lens in the light-tight box is a light meter to measure the brightness of the CRT raster for correct photographic exposure.

5.1.8.4 Observation Port

A light-tight flap at the camera end of the box is provided for direct observation of the display prior to recording. If required, a telescopic sight may be affixed to this flap for more detailed examination of CRT focus and spot wobble. Since the CRT operating at 25 kV acceleration may produce slow X-rays, the observation port is provided with a lead glass window.

5.1.8.5 Film

The camera back accommodates 3 1/4" by 4 1/4" film pack and Polaroid type 52, single pack. A wide range of film types may be used, however, Tri-X has fast exposure and fine grain. Where fast processing times are important, the Polaroid single-pack film is ideal.

[illegible]

5.1.8.6 Photographic Assembly

The camera front, light meter, and the CRT face plate are enclosed in a light-tight box having the approximate dimensions 8" by 8" by 10". The film holder and observation port are positioned for easy access by the operator.

5.1.8.7 CRT Electronics

It is required that the CRT display accept 525/60, 625/50, and 405/50 T.V. standards. A single set of high quality defection coils and focus magnet can accommodate all standards.

Spot wobble is used to blend the line structure of the raster and thus improve the subjective quality of the photograph.

The CRT can be operated in two modes: in the first or frame acquisition mode, the CRT is driven by the output of the disc recorder, with the object of observing the display and achieving the optimum presentation. In the second or recording mode, the CRT is blanked off and the video tape run through, On cue, the desired single frame or field of video, is applied to the CRT and photographed by the camera.

The circuits for the CRT camera subsystem include:

(i) High voltage power supply, 25 kV, regulated ± 200 volts.

(ii) Horizontal and vertical deflection capable of being switched between the different scan standards. Scan non-linearity will not exceed 1%.

(iii) Spot wobble at a frequency high enough to prevent the individual cycles from being visible. Amplitude adjustable between zero and twice the line spacing at 405 lines.

(iv) Scan protection circuit to automatically blank the CRT in the event of loss of scan. This feature prevents the accidental burning of the CRT phosphor.

6. PHYSICAL AND OPERATIONAL CONSIDERATIONS

6.1 Size of System Components

The VTR uses a floor space 63" wide by 30" deep and is 63" high.

The disc recorder uses a table top space 17" by 19" and is 11" high.

The CRT-camera assembly, together with scan circuits and high-voltage supply uses a floor space of 40" wide by 20" deep and is 48" high.

The balance of the system is contained in a rack 20" wide by 20" deep by 71" high.

No single assembly will exceed 1,600 pounds weight.

6.2 Safety

All hazardous circuits are safety interlocked to prevent injury to personnel. Rotating mechanical parts are enclosed. The 25KV potential on the CRT can cause the generation of soft X-rays. These will be measured, and, if necessary, eliminated by lead shielding on the light tight box.

6.3 Electrical Requirements

Electrical requirements are 110 volt, 1 phase, 60 Hz, approximately 50 amperes. This is satisfactory when the system operates on 60 field standards. However, a problem of non-synchronous power mains arises where the system operates on 50 field standards.

[redacted]

Beats between the mains frequency and the field frequency of the video can give rise to 10 Hz flicker and/or flutter. Most likely the picture monitor will suffer this degradation. Then again, it may also involve other system components to a greater or lesser degree. An obvious solution is to operate the entire system or 50 Hz power thus requiring a large power converter.

[redacted] suggests that it would be in the best interest of the government to exclude the 50 Hz mains supply from this proposal. When the system is tested prior to shipment, we will ascertain where 50 Hz power is needed and recommend the smallest converter for the job, which can then be supplied to us as G.F.E. 25X1

[redacted] will assume responsibility for installing, interconnecting and testing the system at the customer's facility in Washington, D. C. 25X1

All purchased component instruction books will be furnished. [redacted] special components will also include instruction manuals and these will also be furnished. 25X1

6.4 Radio Frequency Emission

The two possible sources of RF emission are the VTR and the DR. Both components are essentially standard commercial products, modified for the subject requirement. It is unlikely that either component will produce any significant RF emission. Measures will be taken, if needed, to conform to the requirements of Federal Standard 222.

[redacted]

7. FIELD ENGINEERING

A skilled field engineer will participate during the assembly and evaluation of the system at [redacted]. This man will conduct the re-assembly of the 25X1 system following delivery, and demonstrate, operate, and maintain the equipment under the customer's direction.

It is expected that this field service will continue for a period of a year. During this time, the [redacted] field engineer will also teach your 25X1 personnel to operate and maintain the equipment.

8. SCHEDULE AND DELIVERABLE ITEMS

The work will be performed in a period of nine (9) months. It is not expected that the procurement of components will cause any serious delay in completion of the system.

The deliverable items are:-

(i) A complete Magnetic Tape to Photo Reproducer, described in the previous sections.

(ii) A listing and price quotation of spare components for (i).

(iii) An instruction manual for the operation of the complete system in addition to instruction manuals on purchased subsystems.

(iv) A maintenance manual for the complete system. This manual will include recommended test procedures, full wiring diagrams and schematics.

(v) Monthly progress reports will be submitted on the 15th day of the month following the month whose activities are reported. These reports will include an updated delivery schedule, the percentage of the work completed, planned activity in the next month, unresolved technical or contractual problems, a statement of any oral agreements reached in technical matters, a statement of any proposed change of scope of the contract, and a current financial statement.

(vi) A final report covering the entire design and development program will be submitted within 30 days of completion of the system.

 25X1

This report will present a full account of problems encountered, and the solutions achieved.

(vii) Complete Installation Engineering data will be submitted at six (6) months and again at three (3) months prior to delivery.

 25X1

[redacted]

9. PERSONNEL

The Project Manager for this program will be [redacted] working under the direction of [redacted] Vice President and Director of Engineering. 25X1 25X1

The biographies of these gentlemen together with the other senior staff who will actively engage in the design, construction and evaluation of the system, follow.

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[redacted] 25X1

10. SUPPORTING DATA

It has already been demonstrated in this proposal that [redacted] has 25X1
much experience in the design, development, application, and maintenance of all
the components used in the system. More generally, [redacted] has a 25X1
remarkable record in the development of special purpose systems and components
in the broad field of data gathering, storage, display, enhancement and
recording.

In this section, reference will be made to some of the systems designed and
built at [redacted] in which the special disciplines and technologies 25X1
relevant to the proposed program, have been employed.

10.1 Organization

[redacted] is the Research and Development Division of the 25X1
[redacted]. Directed by [redacted] 225X1
President, the majority of its business consists of research and development for the government and other industrial organizations. The areas of interest and competency of the Laboratories are grouped into six specific departments:

Electron Physics	Intelligence Systems
Acoustics and Magnetics	TV Systems
Graphic Systems	Professional Products

The primary responsibility for the work proposed herein will be assigned to the TV Systems Engineering Department.

The activities of each department are described briefly.

[redacted] 25X1

Electron Physics Department

The Electron Physics Department, directed by [redacted] 25X1 is active in the design and development of new electron tubes and devices in the areas of light sensing, light emitting, camera storage tubes, cathode ray tube displays, and electron beam recording. The efforts of this group have resulted in such unique tubes as the rotating anode cathode ray tube for phototransmission systems, the electrostatic image dissector for star tracking, a travelling image display storage tube for real time receiving systems, camera camera storage tubes, electrostatic image intensifiers, and high resolution special purpose cathode ray tubes. Applied research into specialized materials and techniques for use in electron tubes and electron devices are principal areas of interest. A total of 60 people comprise this department.

The Acoustics and Magnetics Department under the direction of [redacted] consists of 39 technical people. This department has 25X1 concentrated its efforts in the areas of acoustic transducers, psychoacoustics, disc and magnetic recording techniques, and communication systems. These efforts have resulted in the development of a unique noise cancelling microphone, an ultra-slow speed magnetic recorder, a high frequency magnetic recording system, a miniaturized voice tape recorder, and various audio broadcast equipment.

25X1 [redacted]

The Intelligence Systems Department is under the direction of [redacted] This group has developed advanced photo-transmission systems, and special photo-interpreting equipment. Consisting of 200 technical personnel, the group is active in the development of novel electronic intelligence systems. 25X1

The Graphic Systems Department is headed by [redacted] 25X1 With 30 technical personnel, this department is developing an electronic type-setting system under contract to the Air Force. New and unique electronic systems in the Graphic Arts Field have been developed and demonstrated. The heart of such systems is the Linotron, a 256 character generator tube having 400 TV lines resolution in each character and special high resolution cathode ray tube displays.

10.2 Contract Administration

An important part of management control is the contracts staff. This staff is head by [redacted] Contract Specialist, 25X1 with specialized training in technical administration. The staff includes specialists in scheduling, production control, cost control, project co-ordination, contract administration and fiscal reporting. This group is effective in scheduling the objective of the program, maintaining budgets and continuous analysis of the financial progress of the program from its inception through completion. The contract staff has three main functions, which are:

a. Project Analysis

b. Cost Control

c. Procurement

The project analysis group will be responsible for the preparation of all schedules, measuring performance against the schedule, preparing budgets and maintaining cost records. Although all levels of management are responsible for planning their own work, it is the responsibility of the Project Analysis Group in seeing that a good logical network is developed with the aid of the Project Manager and the Project Engineer immediately upon receipt of a program and kept current through completion of the project.

The total funds available for the program will be allotted to each activity. Direct labor charges will be assigned to each activity and a budget established. The budget will be monitored by the Project Analysis Group who will keep records of cost performance versus budget. If satisfactory performance is not maintained, the cognizant Project Engineer and Program Manager will be immediately notified and corrective action taken.

As the program progresses, some previously unexpected factors may be introduced which will add to the original scope of work. These added factors may affect the proposed schedule. The rework and redesign of components may result in re-evaluation of schedules. The procuring of long lead-time items and development of new techniques on a scheduled basis often presents problems of adherence

 25X1

[redacted]

to a schedule. With the above described controls, these factors become immediately evident and necessary revisions in schedules can be made quickly. Using this system, Engineering Management and Contract Administration can compare the progress of the program with the amount of effort recorded by the Accounting Department. In this way, close fiscal control will be maintained.

10.3 TV Systems Engineering

The subject program will be carried out by the personnel of the TV Department, and some of the equipments built by this department are listed.

(i) [redacted] Color Vans 25X1

Two complete color television control systems mounted in trucks have been delivered to the [redacted] TV Network, Figure 13. These vans contain all the facilities and control equipment necessary for the conduct of outside color television broadcasting. 25X1

(ii) Video-tape analysers have been developed and built. These systems measure tape frequency response, tape noise, dropouts, and the rate of wear with continued use.

(iii) A variety of high resolution flying spot scanners have been developed, one of which is shown in Figure 14.

(iv) Completely self-contained hand held wireless television chains have been built (Figure 15). A hand held color television camera has also been built (Figure 16).

(v) A number of advanced cine recorders, and color cine recorders have been built. A complete unit is shown in Figure 17, and 18, while a detailed view of a field sequential color CRT display employed is shown in Figure 19.

(vi) The design and operational concept of the television control system employed in the recently completed [redacted] [redacted] has benefited from the consultation and design services provided by [redacted] Figure 20 shows a studio control room, while Figure 21 shows the positions for the technical operator and program man. A close up of the operators control position is shown in Figure 22. Figure 23 is a photograph of a group of six (6) video tape recorders at the Broadcast Center.

NOTICE.—When Government drawings, specifications, or other data are used for any purpose other than in connection with definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

REVISIONS			
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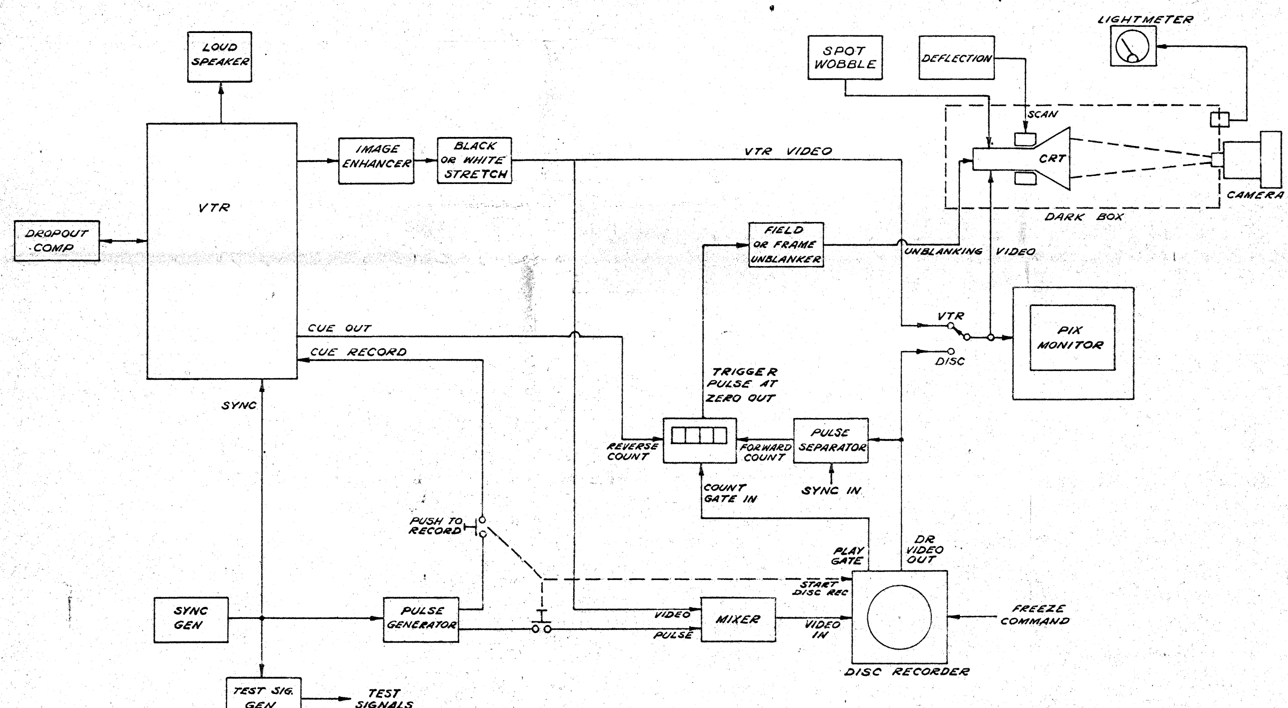

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QTY REQD						LIST OF MATERIALS			

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS DECIMALS ANGLES

MATERIAL

FINISH

CONTRACT NO.
DRAWN DATE 11-14-66
CHECKED
ENGINEER 11-14-66
RELIABILITY
REVIEW
APPROVAL (PROJECT)

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25X1

MAGNETIC TAPE TO PHOTO REPRODUCER SYSTEMS DIAGRAM PROPOSAL 66-231

SIZE C CODE IDENT NO. 16996 FIGURE 1

25X1

FIG. 13

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25X1

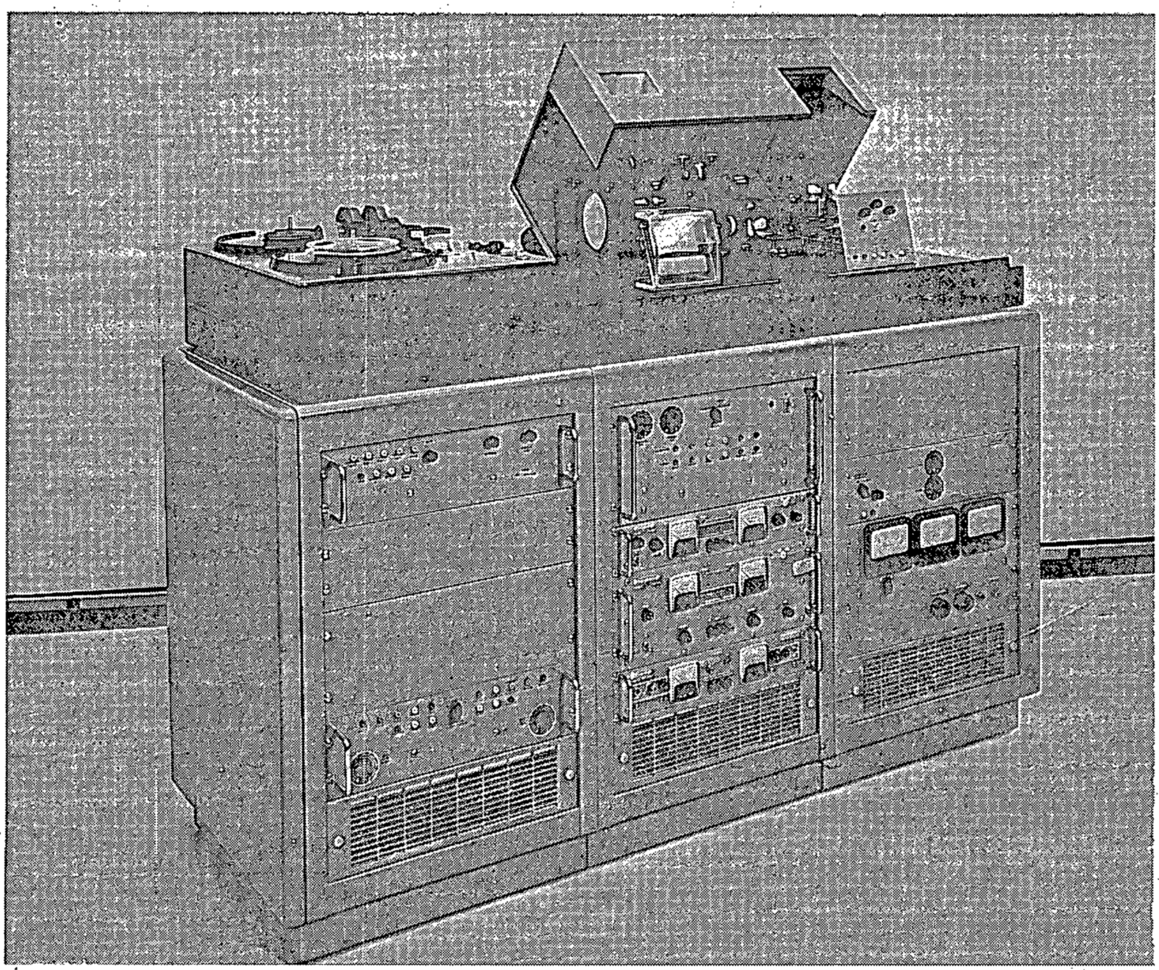


Figure 14

25X1

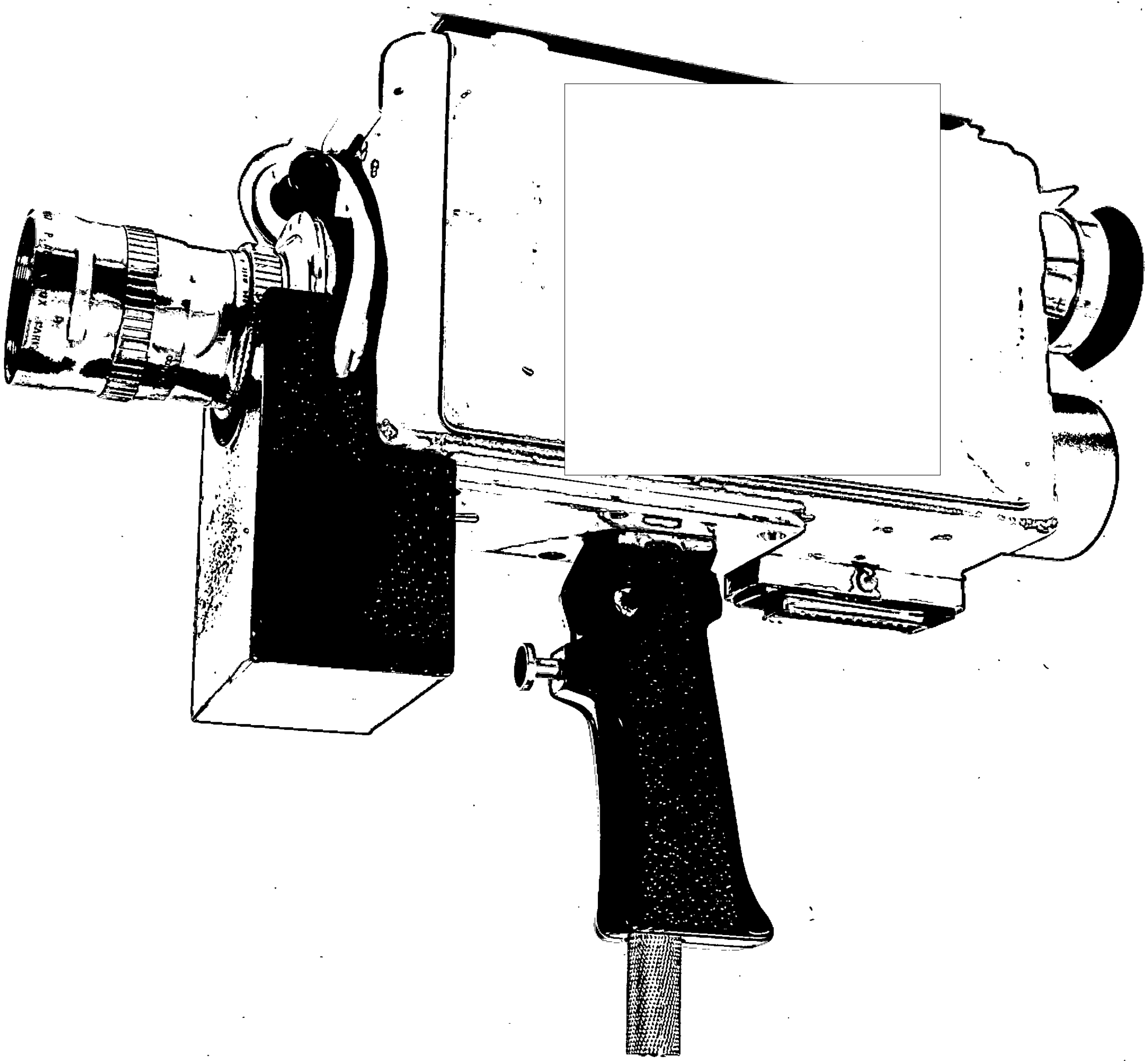
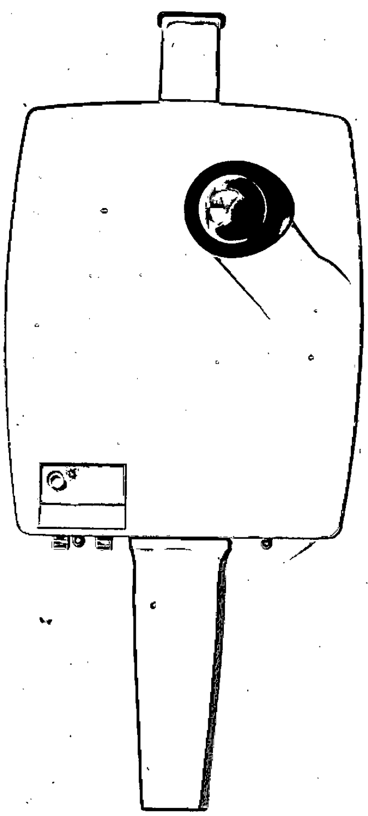
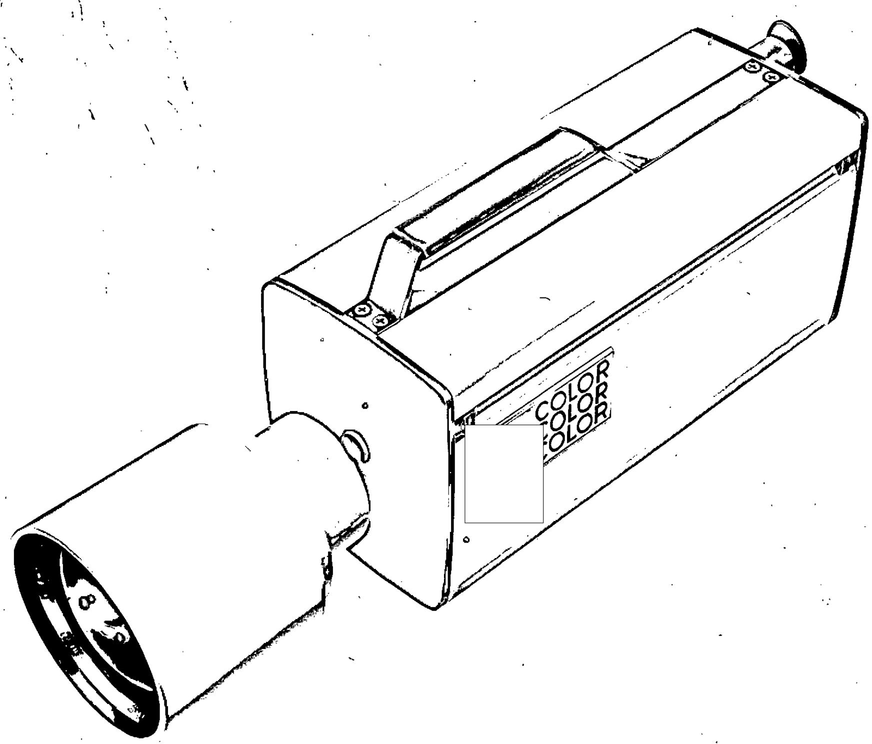


FIG. 15





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COLOR CAMERA

FIG. 16

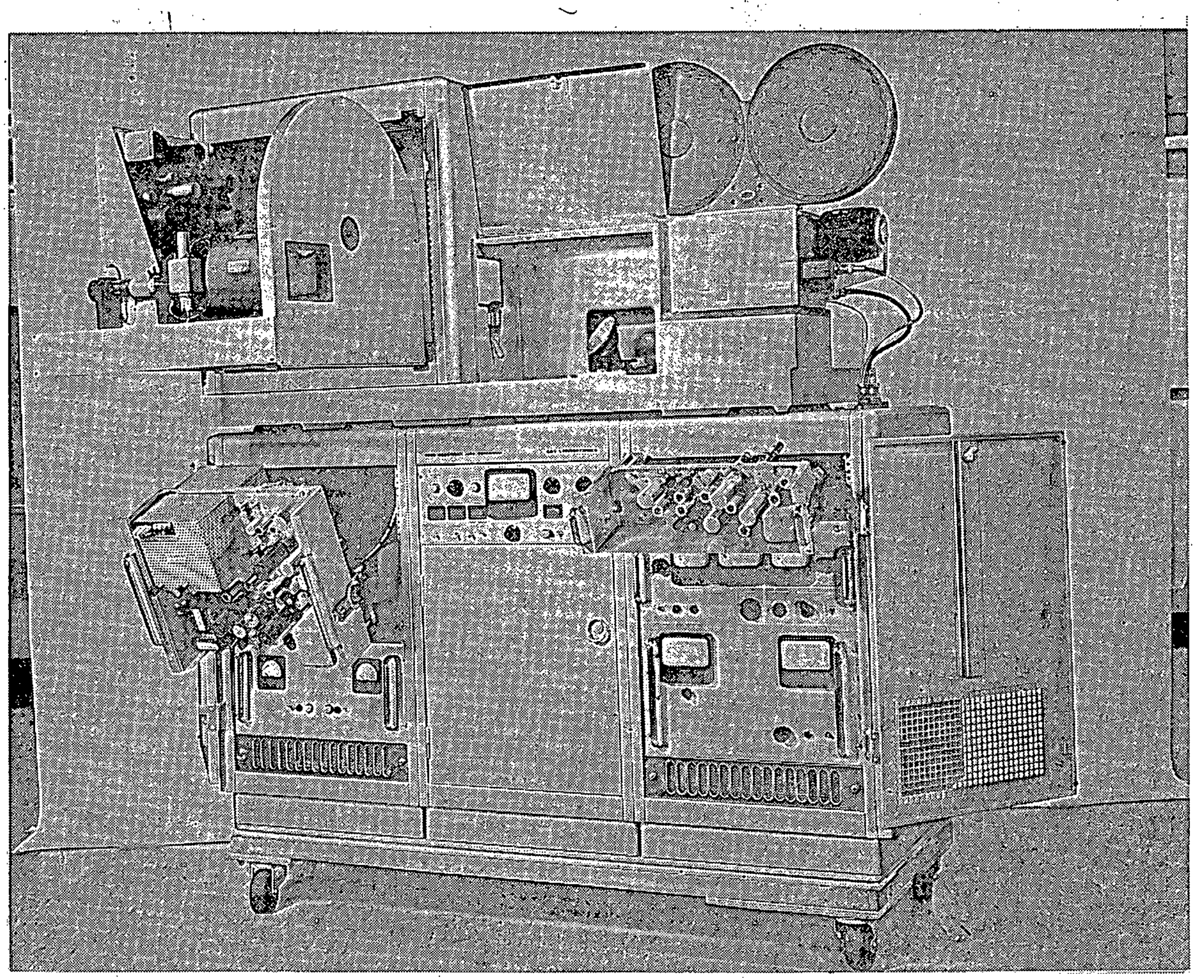

Figure 17

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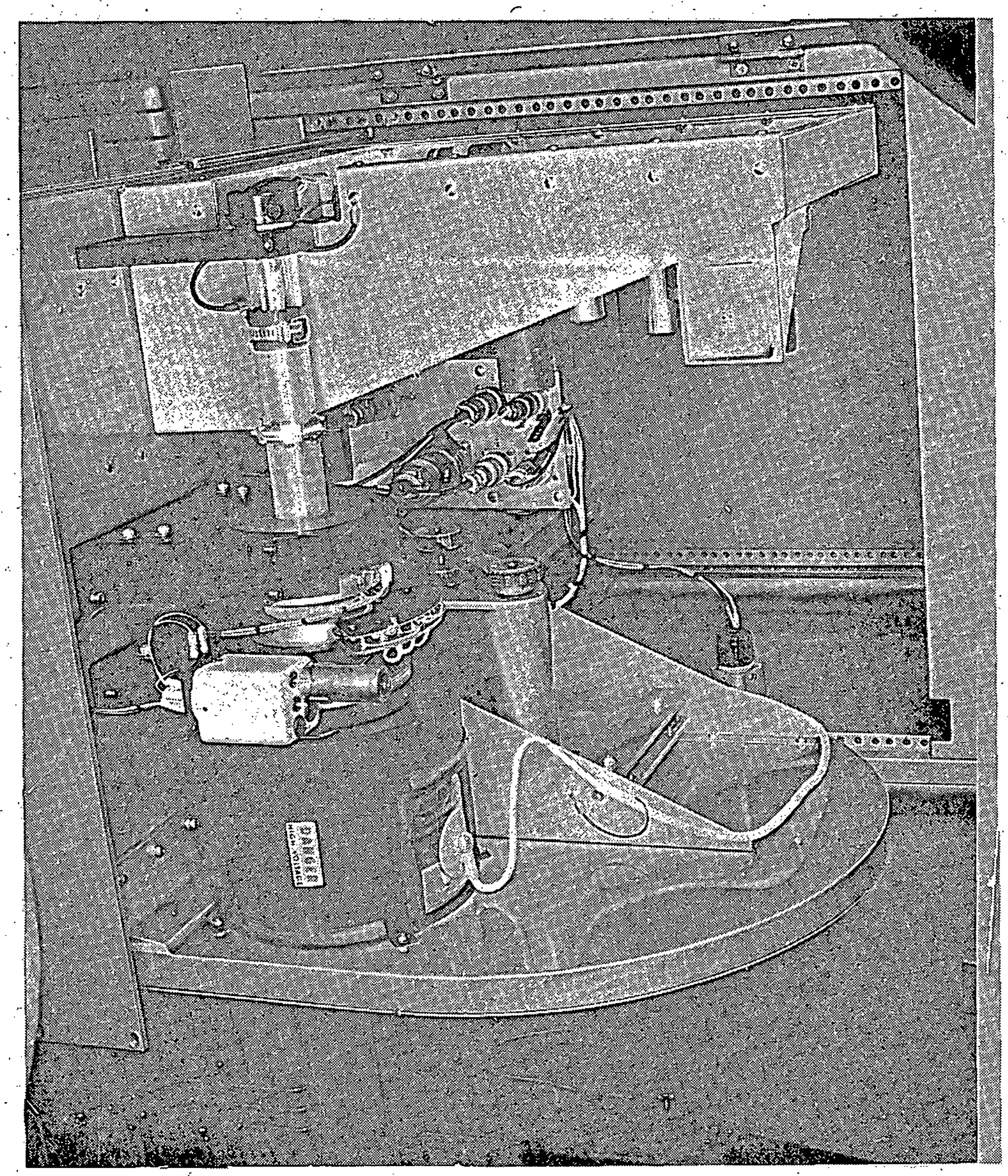

Figure 18

25X1

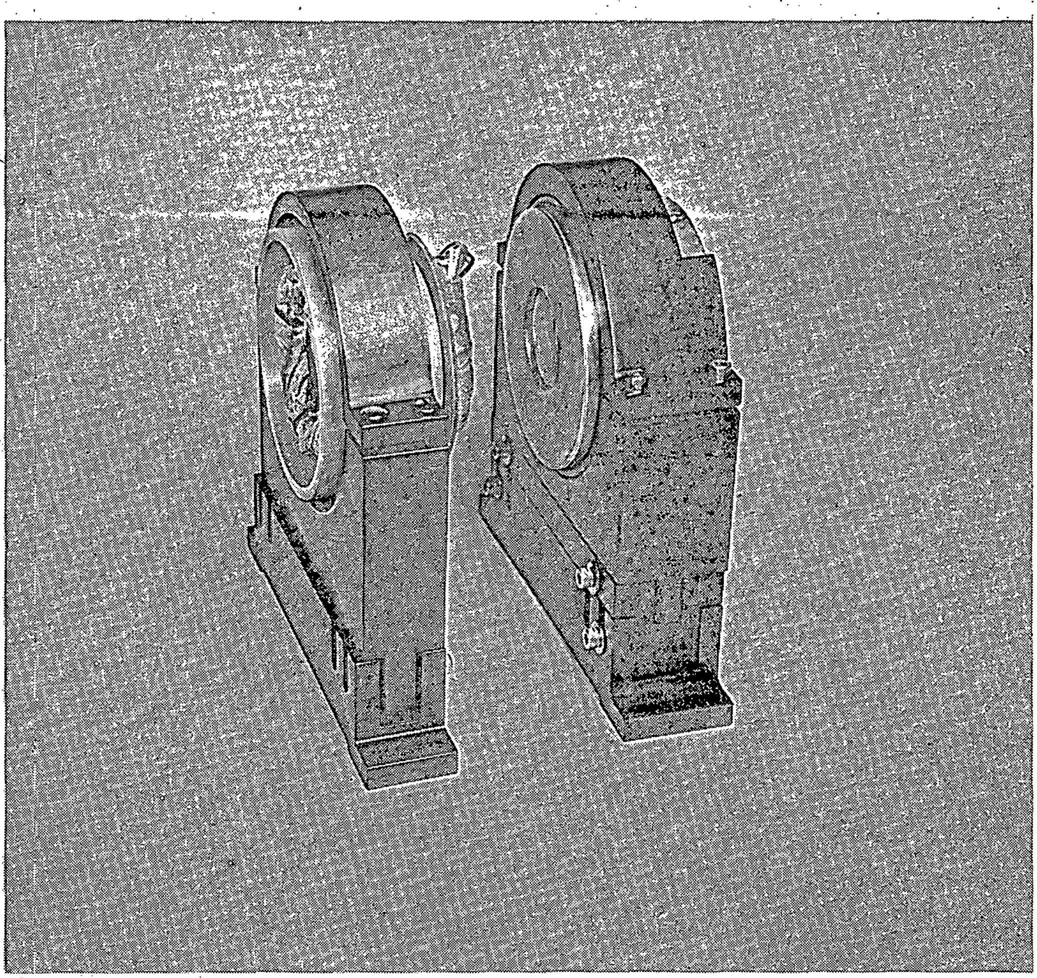

Figure 19