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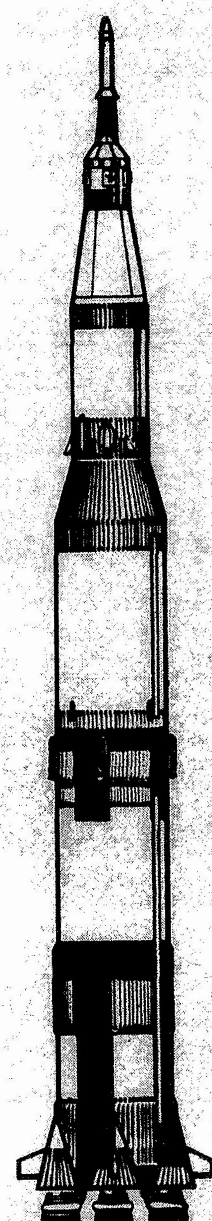

FINAL REPORT
FOR MODIFICATIONS TO THE LUNAR
ORBITER GROUND RECONSTRUCTION EQUIPMENT

MARCH 31, 1970

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ELECTRICAL/ELECTRONICS TECHNOLOGY

NASA CR 108376

# FINAL REPORT

# FOR MODIFICATIONS TO THE LUNAR ORBITER GROUND RECONSTRUCTION EQUIPMENT

Prepared Under Contract

NAS 9-9347

March 31, 1970

Approved by: ______________________

C. L. Toliver

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## TABLE OF CONTENTS
(Continued)

## LIST OF ILLUSTRATIONS

## LIST OF ILLUSTRATIONS
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# 10. INTRODUCTION

This report contains information describing the design changes to GRE's #1 and #2 and related studies accomplished under the contract. Modifications to GRE #1 consisted principally of design changes necessary to process 0.625 frame/second (1280 lines/frame) Apollo television data and 466 active lines/frame supplied at the 1280 lines/frame rate. Modifications were made to GRE #2 to enable the processing of 320 lines/frame Apollo television data including a film synchronization capacity for producing 10 frame/second film. This film may be processed further to get projector compatible film at either 20 or 30 frames/second.

Analog enhancement techniques which were investigated are presented and discussed. In addition, results are included on special studies performed under the contract for possible video processing systems.

## 2.0 MODIFICATIONS TO THE GROUND RECONSTRUCTION EQUIPMENT (GRE #1) ELECTRONICS AND THE ASSOCIATED RECORDING CAMERA

### 2.1 EQUIPMENT MODIFICATIONS

Modifications were made to GRE #1 to enable the GRE to process 0.625 frame/second (1280 lines/frame) Apollo television data and 466 active lines/frame supplied at the 1280 lines/frame rate. The design changes made were to the "sync separator" and the recording camera power supply. Eastman Kodak reference documents are:

(1) Ground Reconstruction Electronics - 1228-113

(2) Recording Camera - 1228-114

Photos of test patterns and processed video are included for equipment verification purposes.

### 2.2 EQUIPMENT VERIFICATION

Verification of the equipment was made using both test patterns and video. Figures 1 through 4 are test patterns generated by the GRE and are indicative of equipment capability. The pattern in Figure 1 is produced by a stairstep-bar signal. The stairstep grey scales can be compared to test pattern generator voltages to compare voltage versus film exposure. This will indicate any non-linearity in the entire system. The bar signal is a square wave voltage which changes the film exposure from the lightest to the darkest. This is used to check the system for ringing or overshoot and roll-off in the response.

2.2 (Continued)

Figure 2 is the pattern obtained from a multiburst sine wave signal. This signal is used to determine if any portion of the system has a gain versus frequency non-linearity. This pattern is also used to check system resolution capability.

Figures 3 and 4 are linearity patterns used to check for any sweep or timing problems which affect the linearity of the picture aspect. A slight non-linearity is noted at the bottom of Figure 3 but this was probably of a transient nature since it does not appear in Figures 1 and 2.

Figures 5, 6, and 7 are pictures obtained from test video. It is noted that the contrast in these pictures was beyond the capability of the film. Improved picture quality could probably be obtained using more compression in the GRE.

## 2.3 SYNC SEPARATOR MODIFICATION

Circuit modifications to the sync separator consist primarily of a circuit to provide interfacing between the Apollo television video and the GRE sync separator. This effectively causes the GRE sync separator to see a Lunar Orbiter format. Other functions are also provided such as pedestal blanking and video clamping to interface the video processor. A detailed schematic is given in Figure 8.

2.3 (Continued)

The video signal in is applied in parallel to transistors Q10 and Q18. The output of Q18 drives amplifier Q19. A variable gain control, R36, is provided to adjust the drive to the following sync circuits. This potentiometer is mounted on the inside of the control panel and is adjusted for best sync stability. The band-pass filter following Q19 is tuned to the frame sync frequency of 409.6 KHz to strip the sync burst from the video format.

This output is applied to amplifier Q20 which supplies sufficient gain to offset filter insertion loss. Final generation of the sync signal is accomplished by one-shot multivibrators Q22-Q23 and Q24-Q25. The first one-shot is triggered 28-30 $\mu$ sec. after beginning of the Apollo sync signal and functions as a buffer for the remainder of the 409.6 KHz sync burst. Output of the one-shot is a negative going pulse which switches the second one-shot to provide a 25 $\mu$ sec. Lunar Orbiter sync signal.

A "noise gate" signal from the GRE is conditioned and then applied between C25 and C26 to clamp this junction to ground during the video portion of a line. This prevents occasional generation of sync pulses by noise during this interval. Transistor Q21 inverts and partially clips negative spikes generated by the noise gate clamp. This buffers the one-shots from transients generated by clamping the junction of C25 and C26 to ground.

2.3 (Continued)

The video signal applied to transistor Q10 is amplified by dc amplifiers Q11 and Q12. Q13 is used to adjust the dc level of the video signal. A level control potentiometer is mounted on the control panel to select the desired level. Transistors Q14 and Q15 are connected in a Darlington configuration to provide additional amplification before input to the HP 467A amplifier.

Two other operations are performed on the video by a pedestal blanking pulse and a dc level clamp, both initiated by the horizontal drive pulse from the GRE. The pedestal blanking pulse is applied to the base of transistor Q14 and grounds the video output for 90 $\mu$ sec. This occurs during the time the video processor clamps to ground. Refer to the timing diagram (Figure 9) for time sequencing. The keyed clamp applied to the base of transistor Q11 provides a dc reference for the video voltage. This is a positive going pulse of approximately 40 $\mu$ sec. duration and the charge level of capacitor C14 is effectively set during this time interval.

2.3 (Continued)

The dc level clamp is generated by applying the horizontal pulse from the GRE to a one-shot multivibrator. The level is set by varying the bias of transistor Q4 with trimpot R8 which is mounted on the circuit board. The pedestal level pulse is generated by first inverting the horizontal drive pulse and then applying to a one-shot multivibrator. Pulse duration is controlled by trimpot R14 mounted on the circuit board. Output of the one-shot is applied to driver Q8 and then to Q9 to clamp the base of Q14 to ground. This interrupts the video and provides a ground level during the time the GRE video processor clamps to ground. A system interconnection diagram for the sync separator modification is shown in Figure 10.

## 2.4 RECORDING CAMERA FREQUENCY STANDARD

The camera drive motor power supply was modified to produce both a 30 Hz and an 82.4 Hz supply voltage. The 30 Hz supply voltage was obtained by changing the frequency of the free-running multivibrator from 60 Hz to 30 Hz and redesigning the low pass filter. Figure 11 is a schematic of the redesigned circuit. The original schematic is Figure 7-5 in reference document, Eastman Kodak Recording Camera Manual, 1228-114.

2.4 (Continued)

An 82.4 Hz frequency standard was obtained by designing a new frequency standard. Figure 12 is a schematic of this circuit. An IRIG Channel 3 VCO is used as the frequency standard. The output of the VCO is amplified by transistors Q1 and Q2 and the frequency is divided by a factor of two and four respectively by Q3-Q4 and Q5-Q6. Transistors Q7 and Q8 provide both wave shaping and amplification before signal input to the low pass filter. Output of the low pass filter is an 82.4 Hz sine wave with 0-5 volt amplitude.

The 82.4 Hz supply signal establishes the correct film speed when 466 active lines/frame video is supplied at the 0.625 frame/second rate and the 30 Hz supply signal is used for the usual 1280 lines/frame video. Selection of the frequency to be used is made by a switch mounted on the front panel.

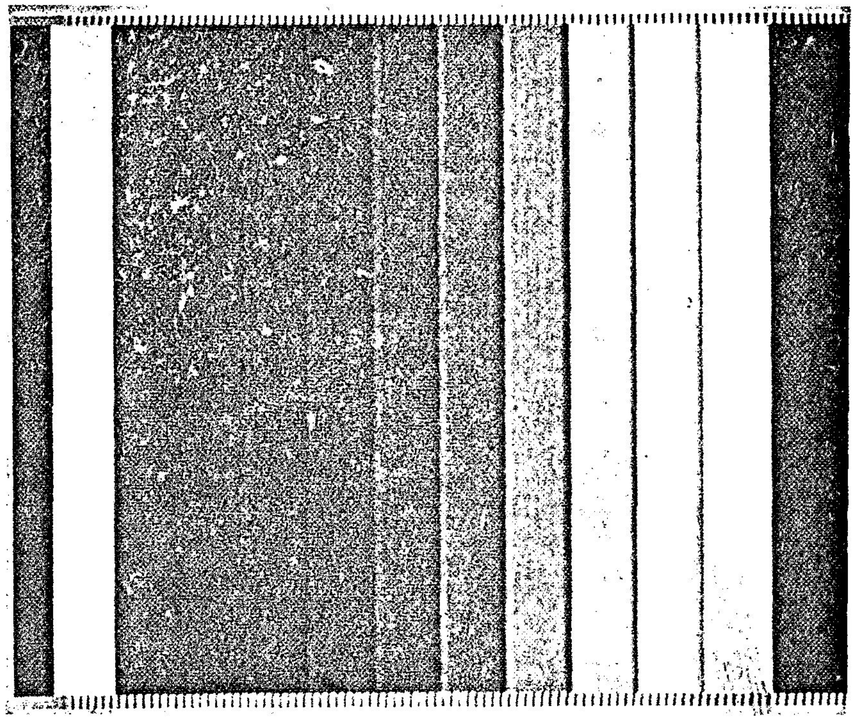


Figure 1 - STAIRSTEP-BAR TEST PATTERN

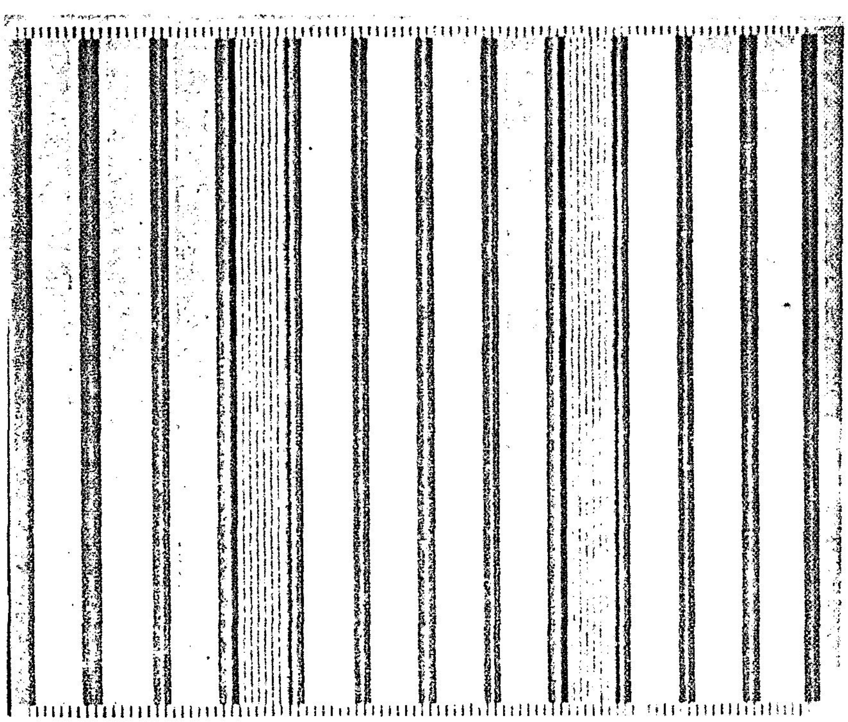


Figure 2 - MULTIBURST SINE WAVE TEST PATTERN

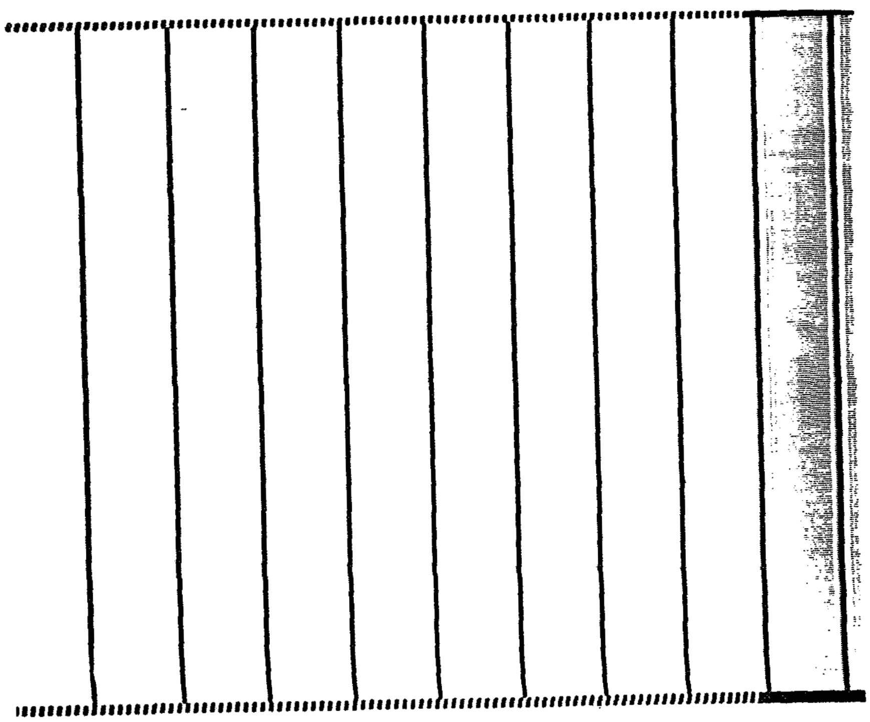


Figure 3 - VERTICAL LINEARITY PATTERN

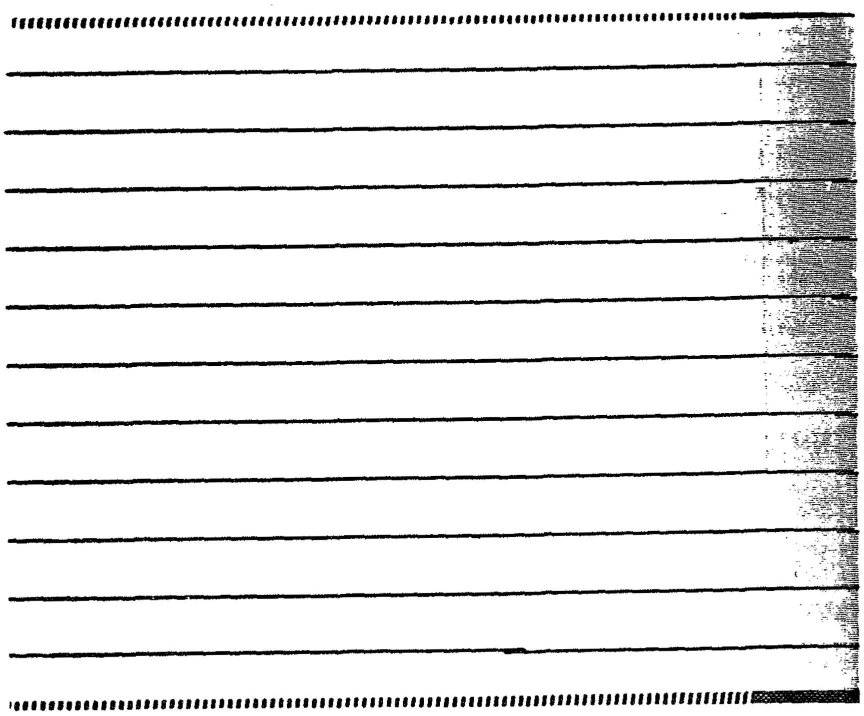


Figure 4 - HORIZONTAL LINEARITY PATTERN

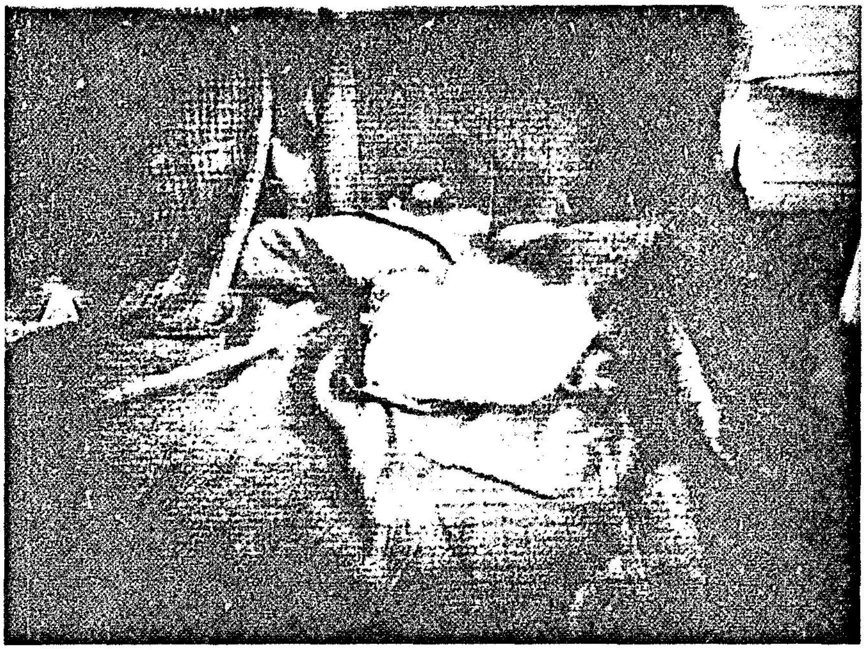


Figure 5 - TEST VIDEO - ROCK SPECIMEN

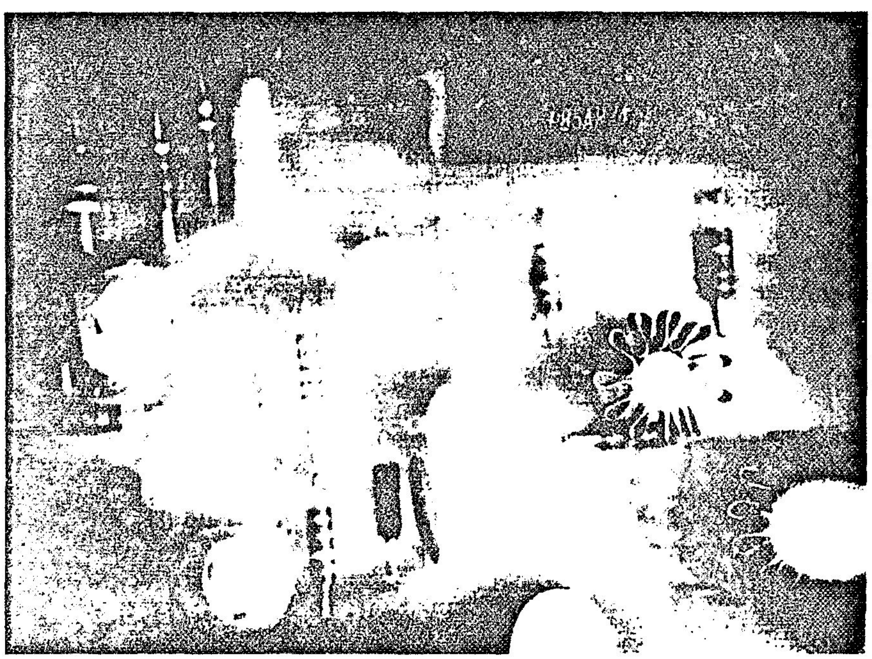
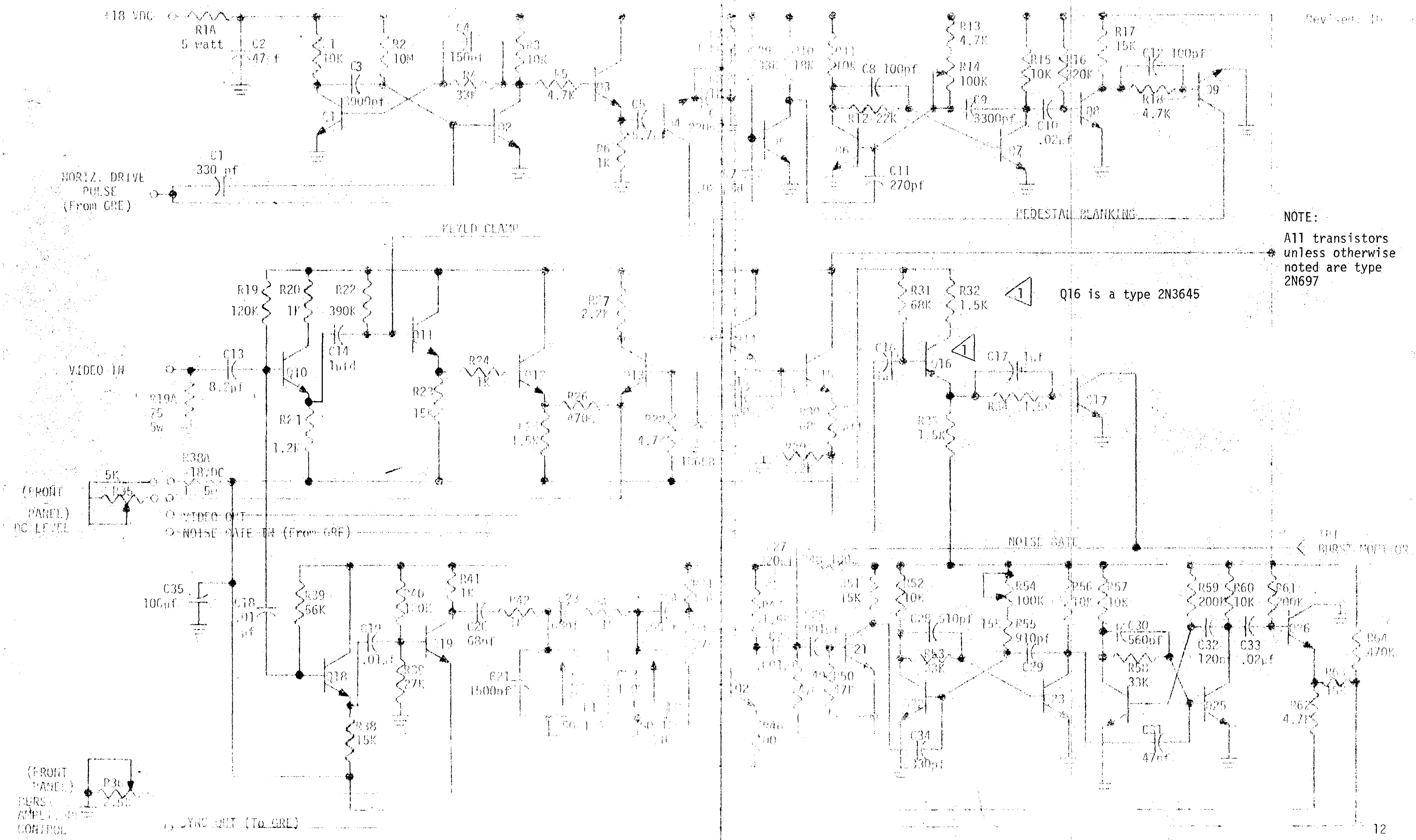


Figure 6 - TEST VIDEO - PRINTED CIRCUIT BOARD

Figure 7 - TEST VIDEO - AERIAL VIEW FROM AIRPLANE

FIGURE 8
BLOCK II 1280 LINES/FRAME
SYNC CONVERTER



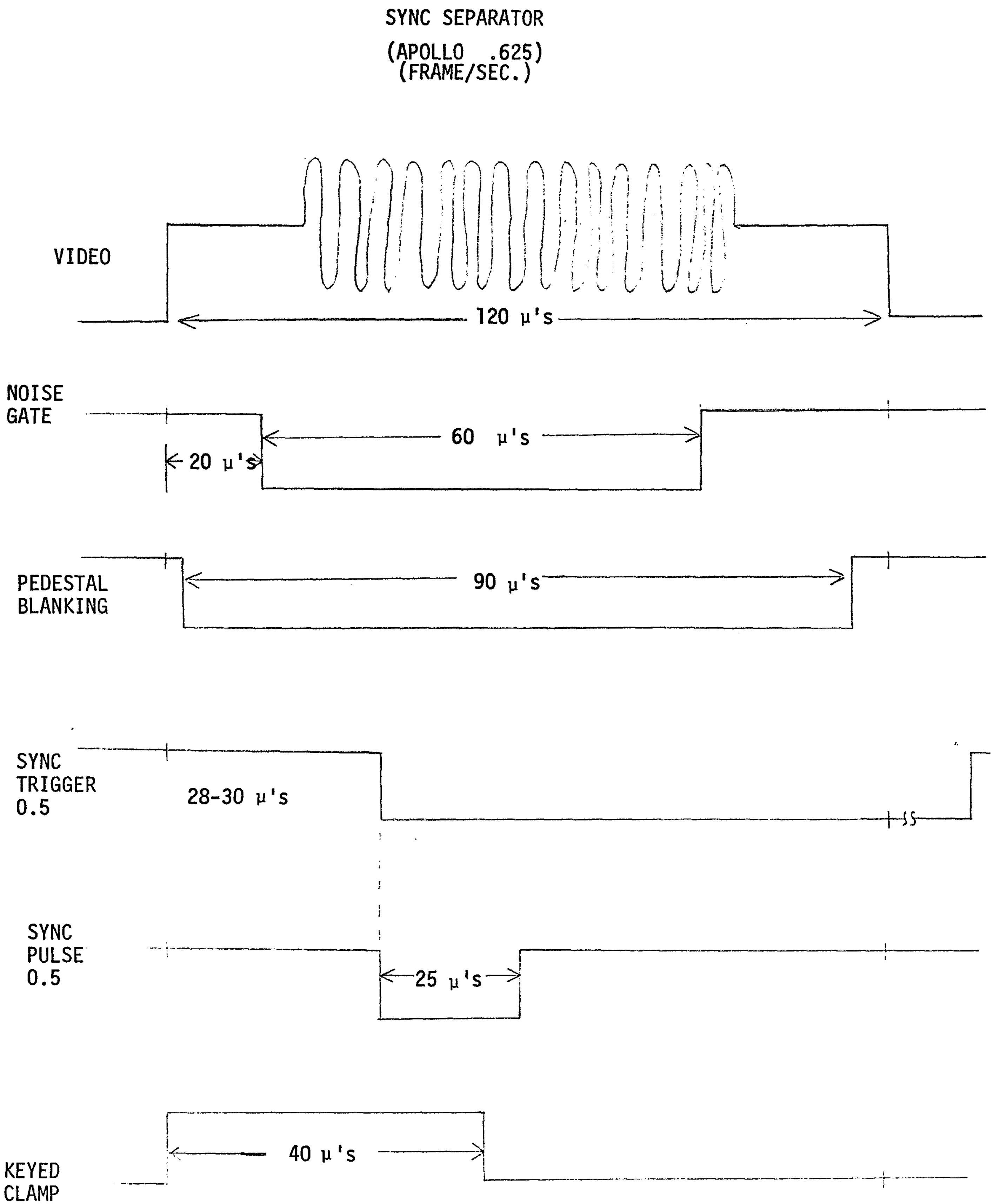



Figure 9 - Sync Separator Waveform Diagram

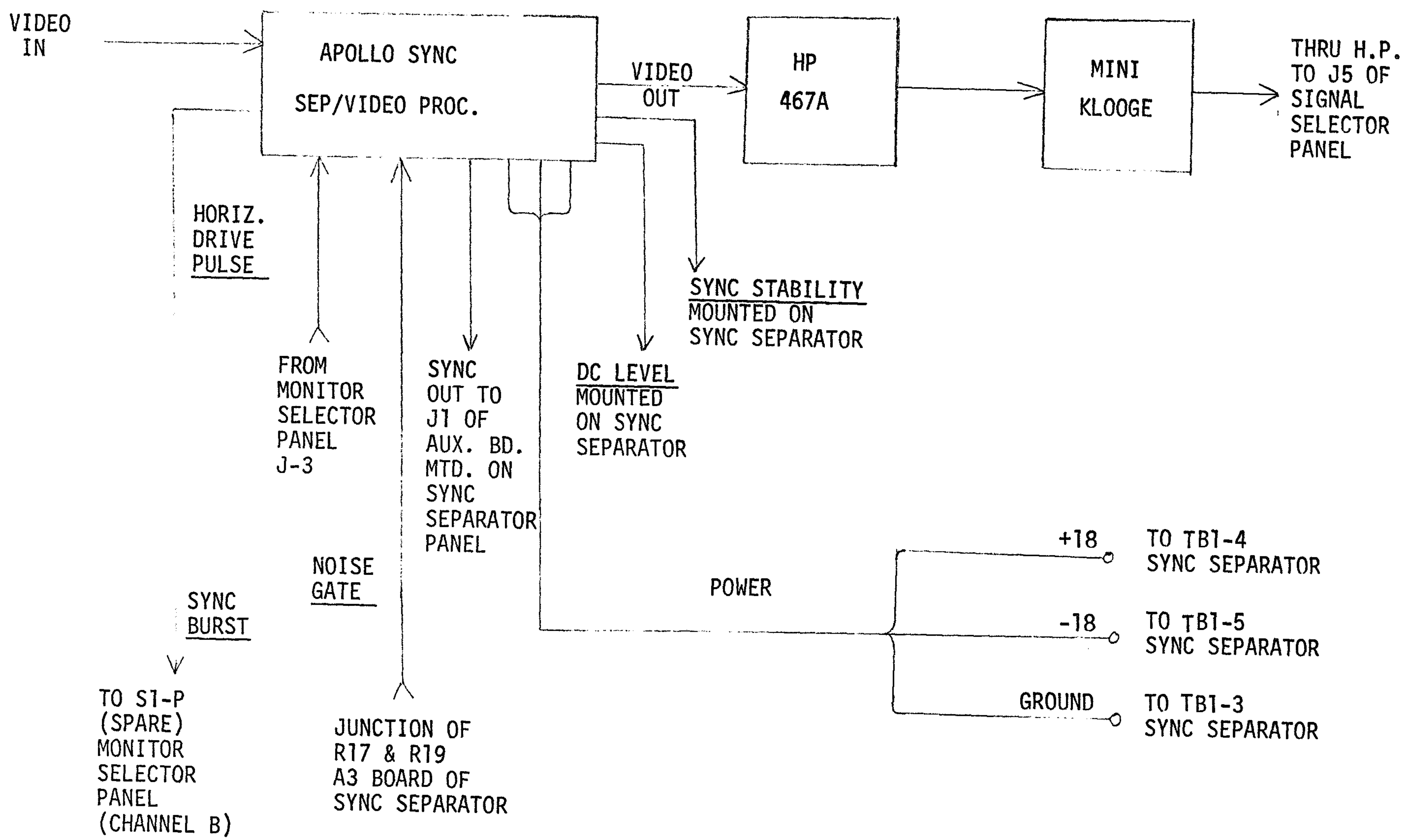



FIGURE 10 - GRE #1 INTERCONNECTION DIAGRAM

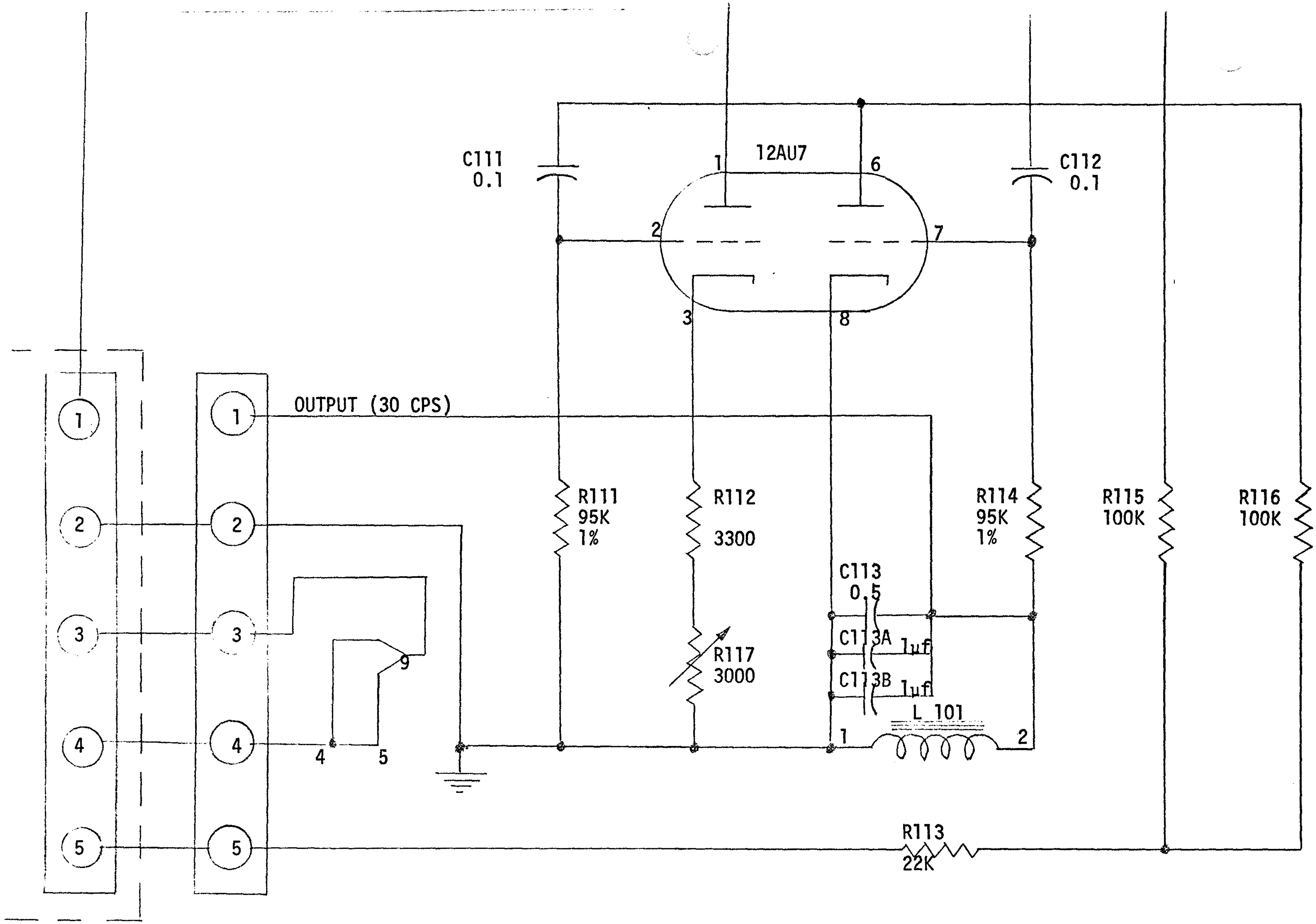



FIGURE 11- RECORDING CAMERA FREQUENCY STANDARD SCHEMATIC DIAGRAM

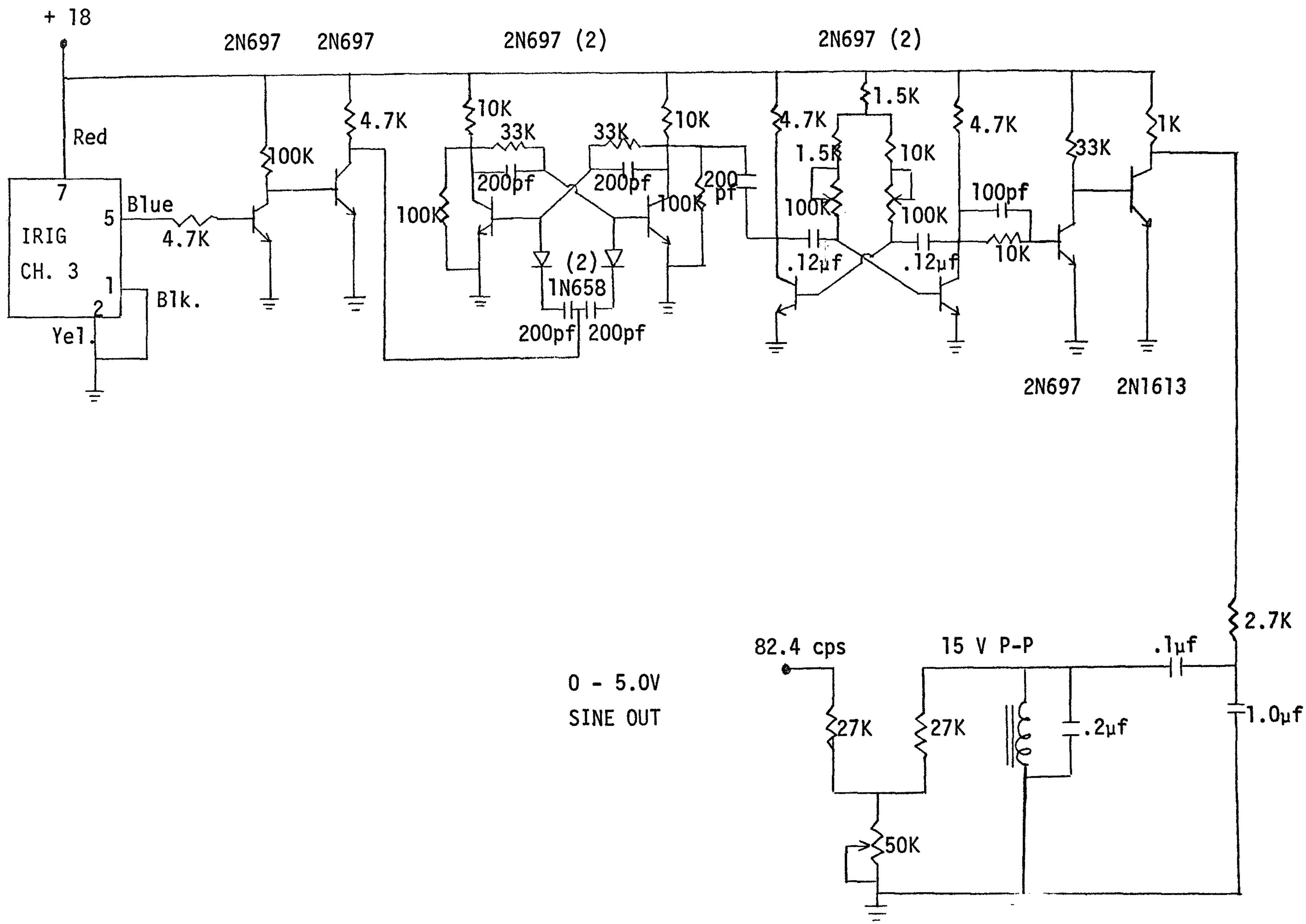



Figure 12 - Frequency Standard Circuit Diagram

## 3.0 MODIFICATIONS TO THE GROUND RECONSTRUCTION EQUIPMENT (GRE) #2 AND THE ASSOCIATED RECORDING CAMERA

### 3.1 Equipment Modifications

This section contains a description of the design changes, additions, and resulting performance of GRE #2 after modifications necessary to process 10 frame per second Apollo television data. Design changes were made to the Sync Separator, Video Signal Processor, Deflection Generator, and Camera Drive. An Apollo Sync Converter, Film Synchronization Electronics, and Power Supply for the Camera Drive were installed.

### 3.2 Sync Separator

Sync Separator circuit changes evolved from the new 3200 lines/second horizontal line frequency. Figure 13 is the corrected schematic. Master system timing is derived from the phase-locked relaxation oscillator, Q4. Capacitor C7 was changed to .02 μf to change the oscillator's natural frequency from 1600 to 6400 Hz. $C_1$ and $C_2$ in the monostable multivibrator Q1-Q2 were changed to obtain the new 5 to 10 μ sec. delay value required for the sync pulse. Total time delay required in the oscillator feedback loop is the time of one horizontal line plus the time the horizontal drive pulse must appear in advance of the sync pedestal, i.e., 5 to 10 μ sec. One horizontal line delay

## 3.2 Sync Separator (Continued)

time is furnished by Q5-Q6 and Q4-Q5. Q4-Q5 furnishes a time delay of one-half line in addition to functioning as a phase detector. A waveform diagram for the Sync Separator is shown in Figure 14.

## 3.3 Sync Converter

Figure 15 is a corrected schematic of the Apollo interface sync converter. Changes in the sync detection circuit from the circuit presently installed in GRE #1 are in multivibrators Q22-Q23 and Q24-Q25. An improvement in stability was required for the faster line rate and was implemented by extending the reset time of Q22-Q23 to a time longer than the 25 μ sec. duration pulse output of Q24-Q25. This ensures that once Q22-Q23 is triggered, successive cycles of the same sine wave synchronizing burst will not continually reset it and the Q24-Q25 output.

Reset time constants of multivibrators Q1-Q2 and Q6-Q7 were changed to provide a keyed clamp of 10 μ sec. duration and a pedestal blanking pulse of 18 μ sec. Previously these pulses were 40 and 90 μ sec., respectively, for GRE #1.

## 3.4 Video Signal Processor

Modifications to the Video Signal Processor are limited to the A2 Assembly. This assembly contains the circuits required to generate clamping, blanking, and noise gate pulses referenced in time to the horizontal drive pulse. A revised schematic is shown in Figure 16.

Modifications to this circuitry consist of by-passing delay multivibrator A2Q2-Q3 and applying the horizontal drive pulse directly to the clamp width multivibrator A2Q5-Q6. This modification was necessary to prevent the clamp time from extending into the video. The second modification consisted of changing the frequency of blanking multivibrator Q7-Q8 to correspond to the 10 frame/second sync pulse width of approximately 30 μ sec.

## 3.5 Deflection Generator

Modifications to the Deflection Generator were made to the A1 Assembly. A corrected schematic is shown in Figure 17.

Retrace gate generator, A1Q2-Q3 was modified to speed up flyback time to a period less than the blanking interval. This modification consisted of changing capacitor C3 to 200 pf. Capacitor C6 was changed to .02 μf to maintain linearity of the sawtooth pulse.

## 3.5 Deflection Generator (Continued)

Remaining changes to the deflection generator consisted of changing capacitor C10 to 550 pf. This effectively modified the Miller integrator circuit to maintain the necessary focus paraboloid waveshape. This was necessary because of the different time base of bootstrap generator A1Q4-Q5.

## 3.6 Film Synchronization Electronics

The Film Synchronization Electronics phase-locks the camera drive rotation to incoming video data to obtain exact coincidence of the video frames with film sprocket holes. Both the precision frequency source and power amplifier were removed from the 1A3 rack and replaced by the Film Synchronization Electronics in the 1A3A3 position, a blank panel in the 1A3A4 position, and a 75-300 Vdc Lambda power supply in the 1A3A5 position. A schematic of the Film Synchronization Electronics is shown in Figure 18 and the Interconnection Diagram in Figure 19.

Sheet 1 of Figure 18 contains the Frame Detection circuit. The 0.4096 MHz synchronization burst of the composite video is filtered out through a narrow band-pass filter located between Q2 and Q3. R-C time constants of the circuit between Q5 and Q6 were chosen to provide registration at Q6 only for the longer time duration frame synchronization burst. Stages Q7, Q8, and Q9

## 3.6 Film Synchronization Electronics (Continued)

provide a short duration, sharply squared pulse. Q10 provides an isolated drive for a scope trigger when desired.

Sheet 2 of Figure 18 contains the Feedback Control Circuit. The phase detector, Q11-Q12, compares the phase of the camera drive with the frame sync pulse. Any difference is used to derive an error signal which has the 10 Hz component filtered out by the low-pass filter consisting of R45, R46, C20 and C21. The filtered error signal drives Q14 which also has negative feedback applied to its emitter load. Q15, Q16, Q17 is a differential amplifier which compares the error voltage provided by Q14 with an adjustable voltage reference to obtain a zero steady-state phase error for the Camera Drive. Q18 and Q19 provide amplification and Q20 is the controlling device in series with the camera drive motor and power supply. Q21, Q22, and CR11 provide over voltage protection for Q20. Q23 is an active negative feedback stage.

Mechanical position of the Camera Drive is obtained with a light source and light sensor interrupted by a chopper. The light source is an infrared emitting diode, type TIL09, having a wave length of 0.91 μm at peak output. Q28, type LS600, is located on the opposite side of the chopper disc from the light source and is a photo transistor more sensitive to the longer wavelengths of light. The chopper disc is mechanically attached to

## 3.6 Film Synchronization Electronics (Continued)

a gear in the Camera Drive and has 12 equally divided areas opaque to infrared. Output pulses are amplified by Q29, Q30, and Q31. Q32-Q33 is a Schmitt trigger which, along with its peripheral circuit components, provides a pulse having a very steep rise-time for triggering the phase detector, Q11-Q12.

Q24, Q25, Q26, and Q27 are isolation drivers for the "VIDEO IN" and "MOTOR IN" indicator lamps. When the Camera Drive is synchronized with the video, both indicator lamps will flicker at 10 Hz with equal intensity. When there is loss of video in, the "MOTOR IN" lamp will glow brightly without any flicker and the opposite will occur with the motor stopped and only video input being present at the phase detector.

## 3.7 Mechanical Design

Appendix D contains mechanical design drawings for GRE #2. The modifications were a rearrangement of the A3 rack, including a new panel, supports for the camera drive motor, supports for the light source and sensor used in the feedback circuit, an optical chopper, and a camera drive cover.

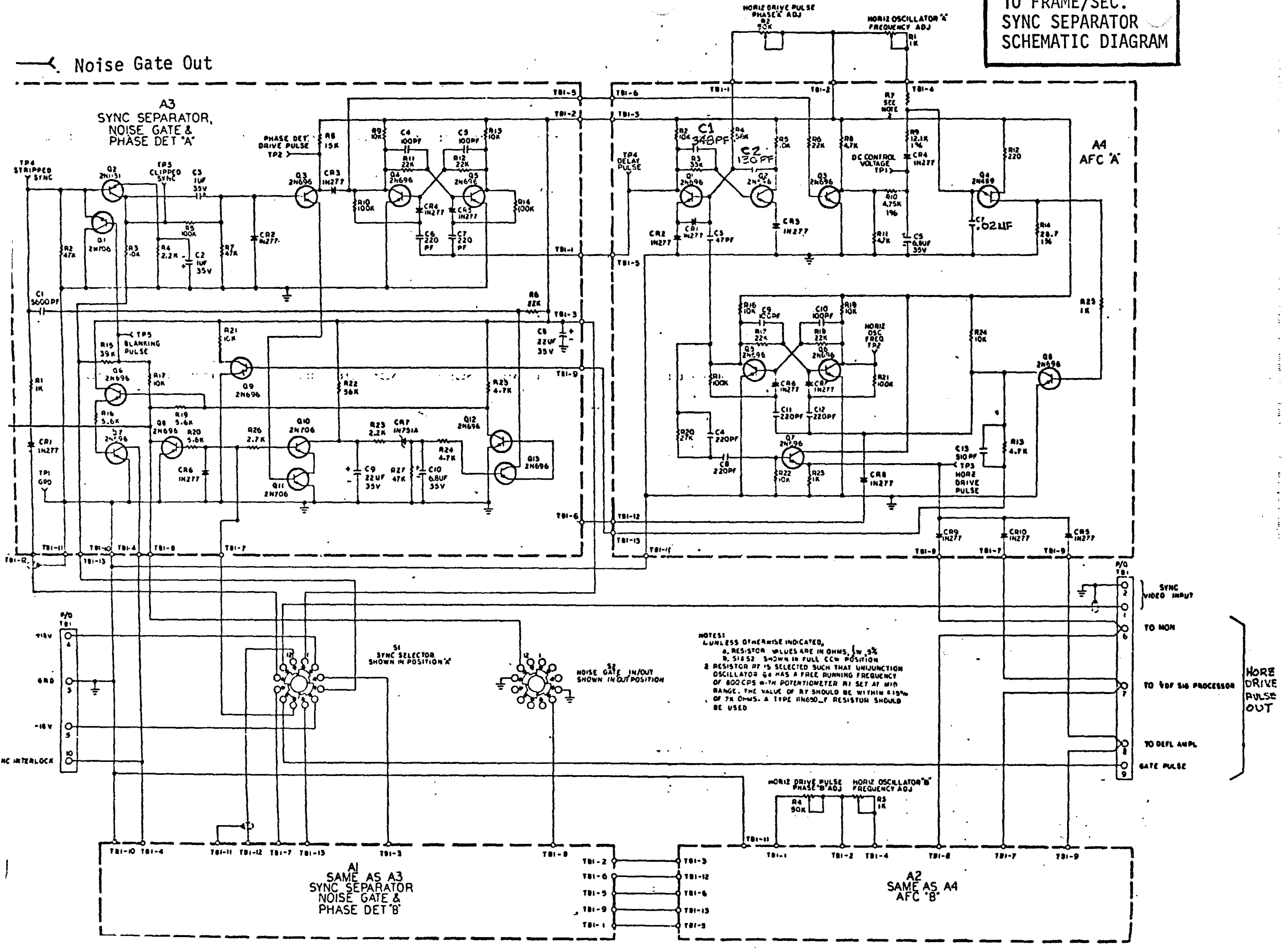



FIGURE 13
10 FRAME/SEC.
SYNC SEPARATOR
SCHEMATIC DIAGRAM

SYNC SEPARATOR WAVEFORM DIAGRAM
APOLLO 10/FRAMES/SEC.

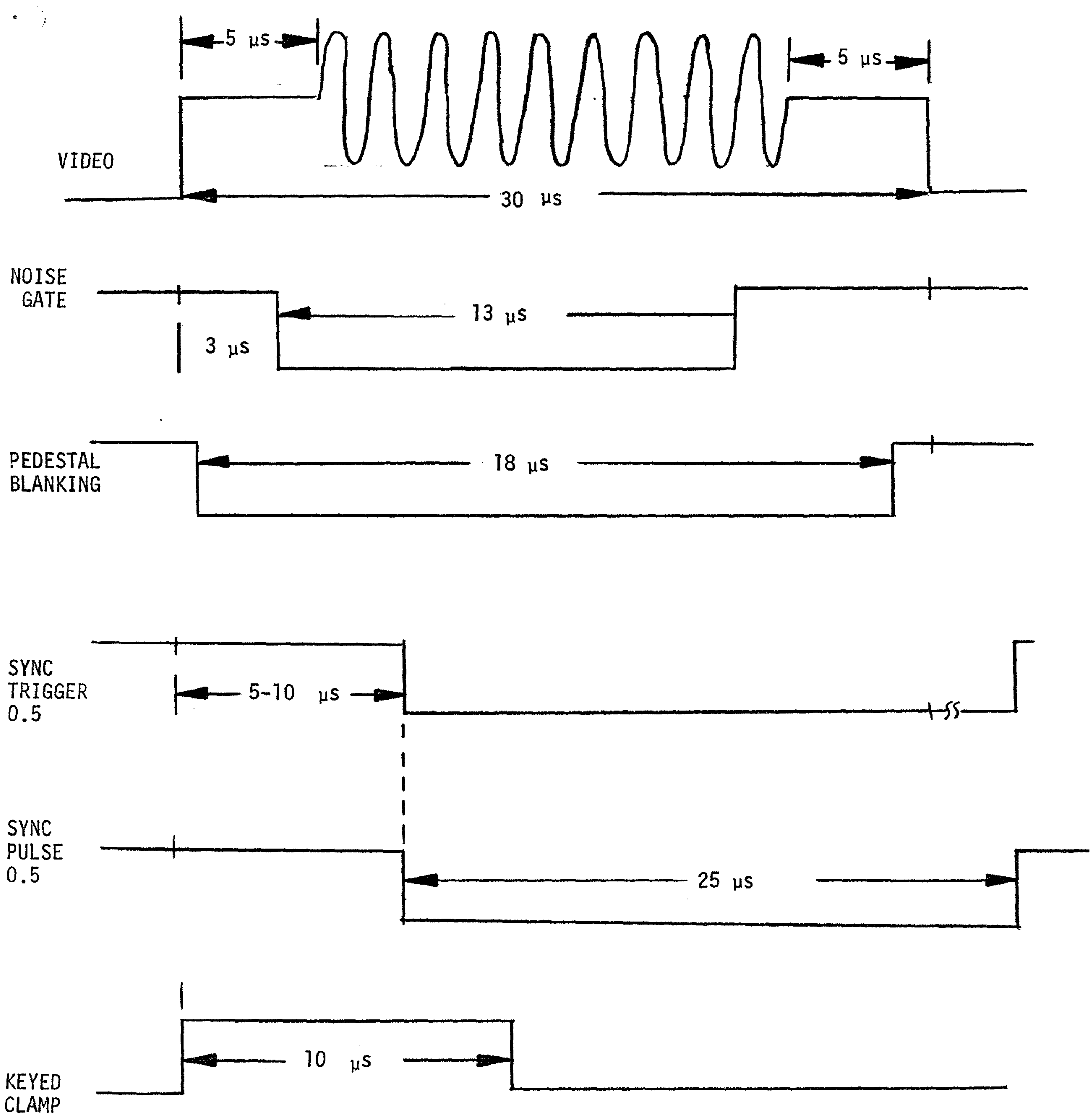
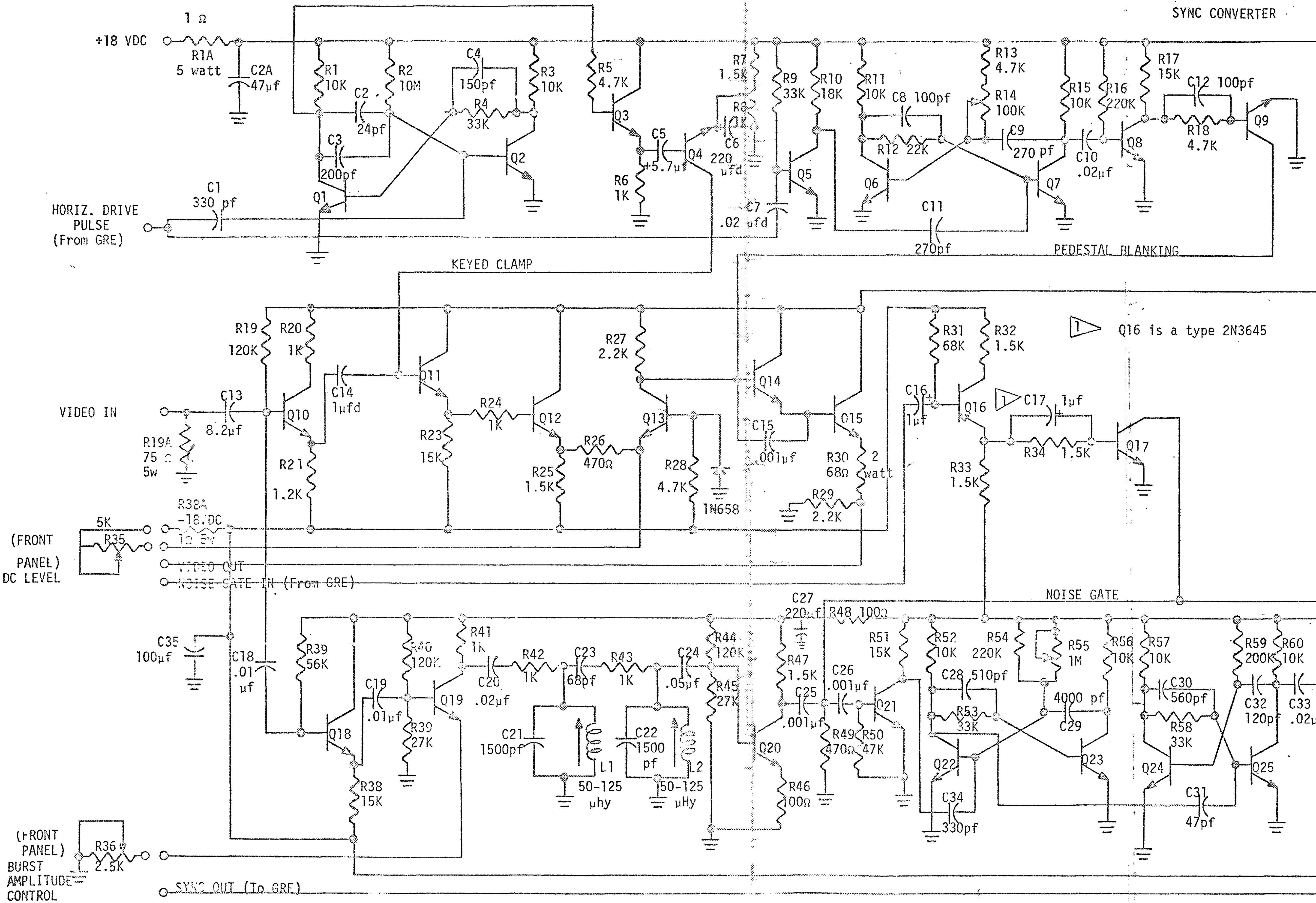



Figure 14

FIGURE 15

BLOCK II 320 LINES/FRAME, 10 FRAME/SEC.

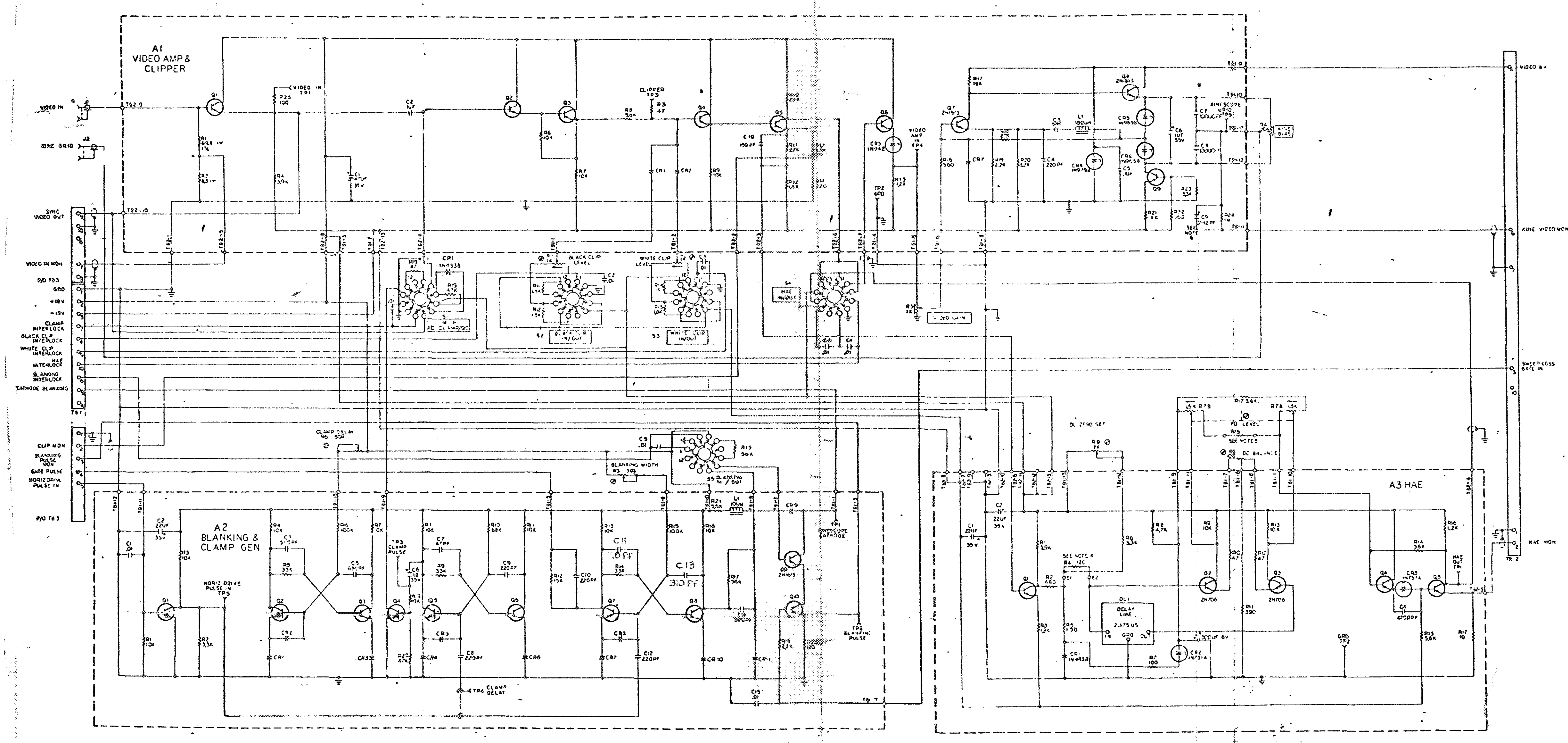
SYNC CONVERTER

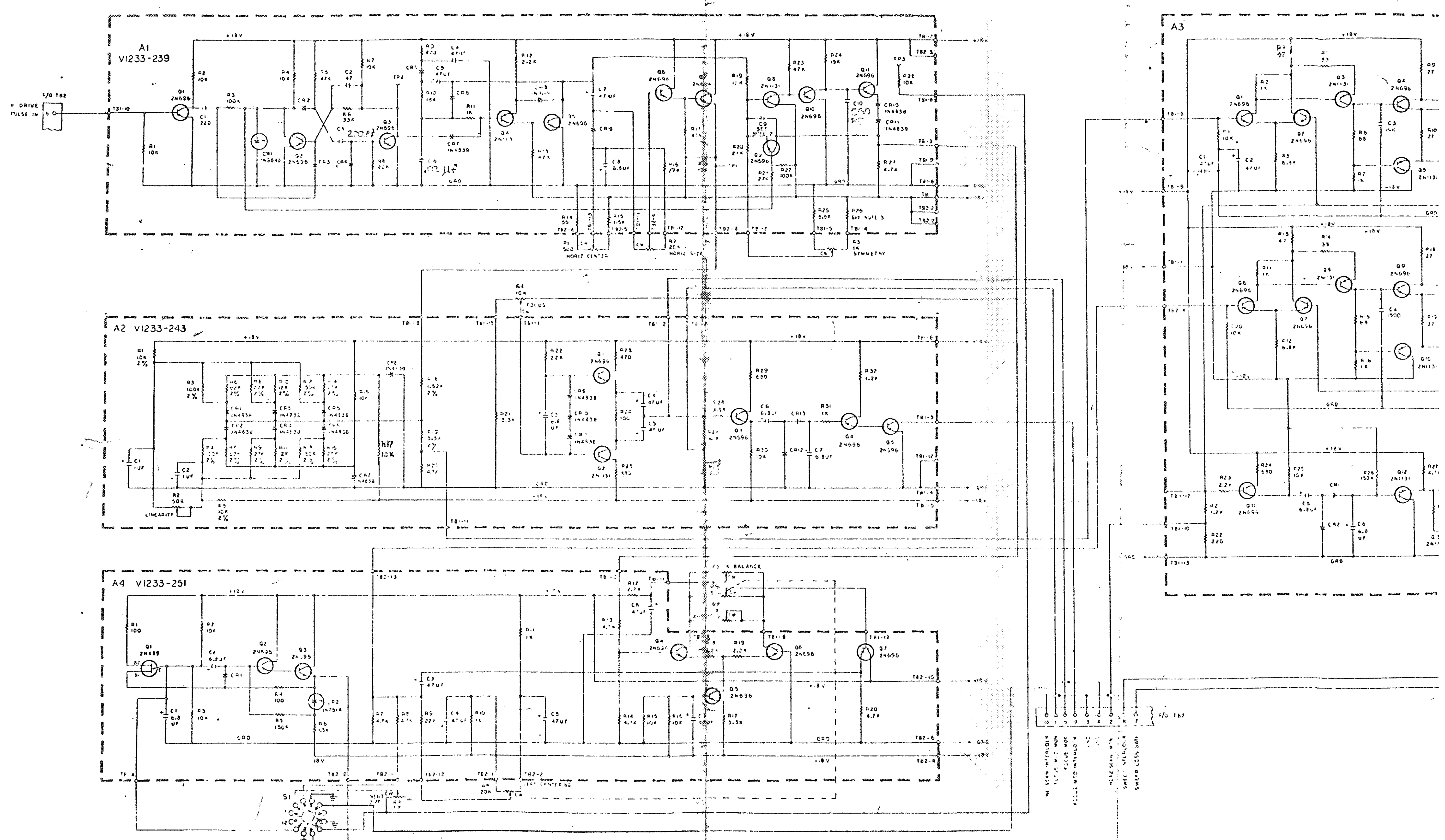



NOTE: All transistors unless otherwise noted are type 2N697.

FIGURE 16

VIDEO SIGNAL PROCESSOR SCHEMATIC




A1
V1233-239
A2 V1233-243
A3
A4 V1233-251
H DRIVE PULSE IN
HORIZ CENTER
SYMMETRY
FOCUS
LINEARITY
BALANCE

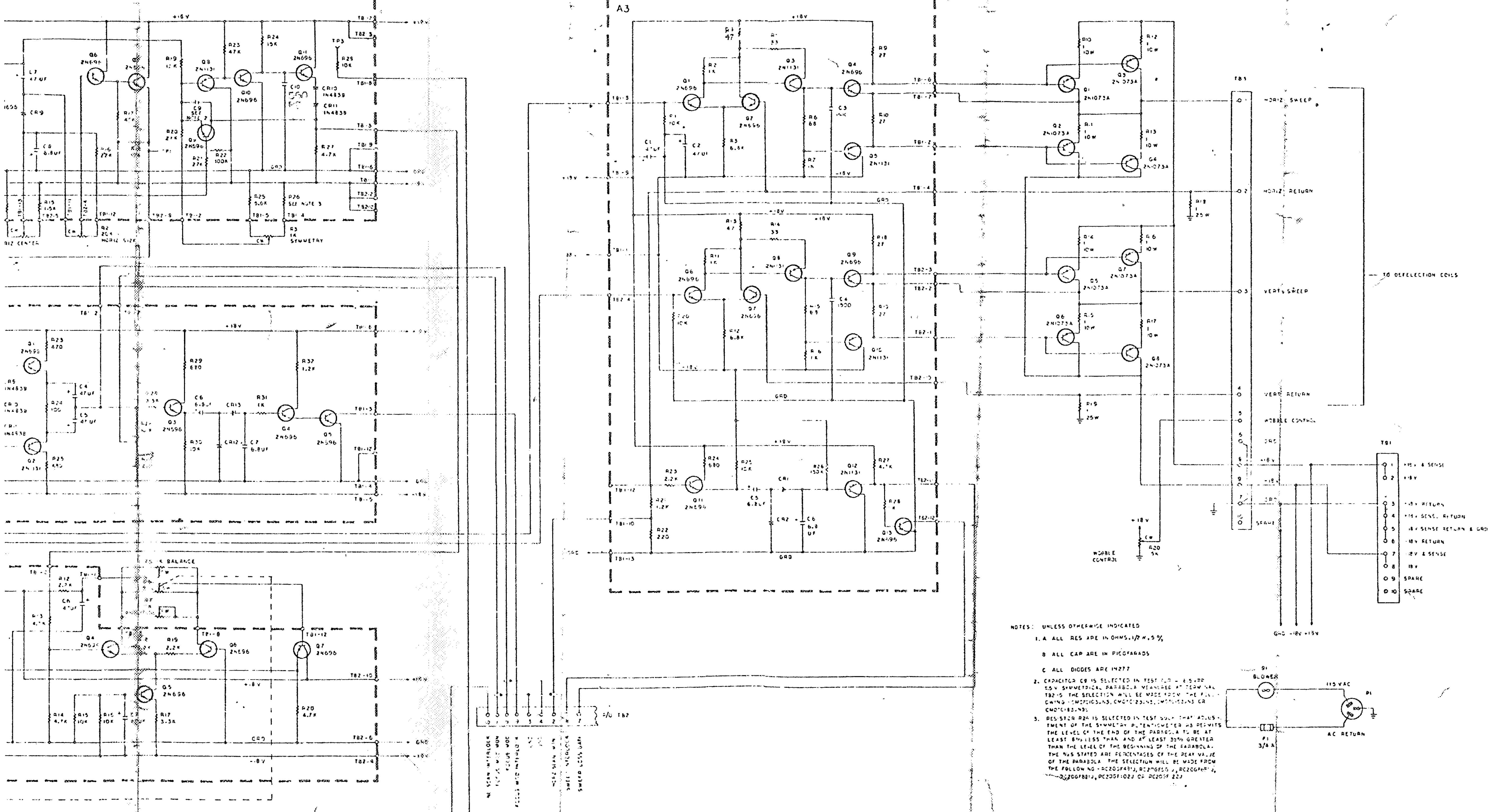
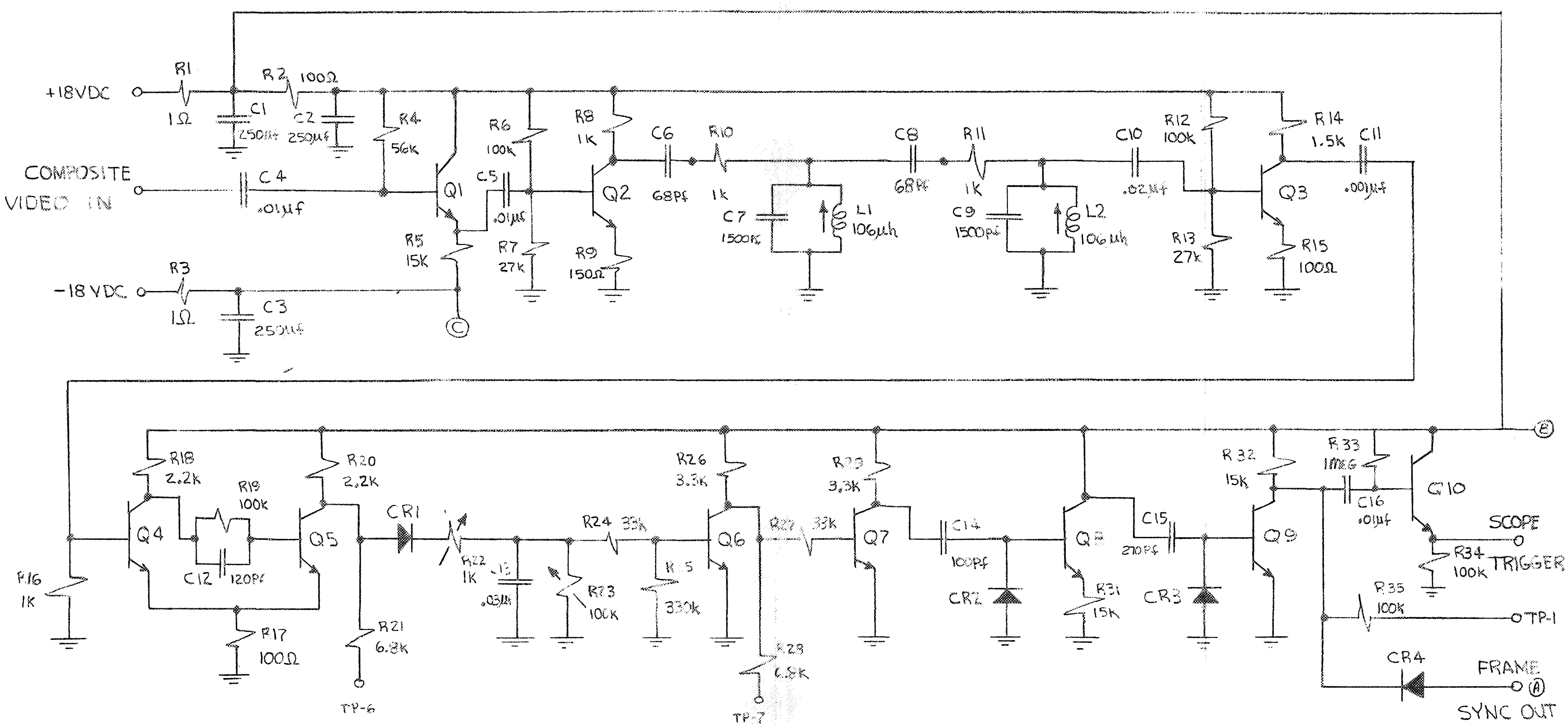



FIGURE 17

DEFLECTION GENERATOR SCHEMATIC




FRAME DETECTION CIRCUIT

NOTES:

1. ALL TRANSISTORS ARE TYPE 2N697 EXCEPT: Q19 - 2N690; Q20, Q21 - 2N174A Q28 - LS600

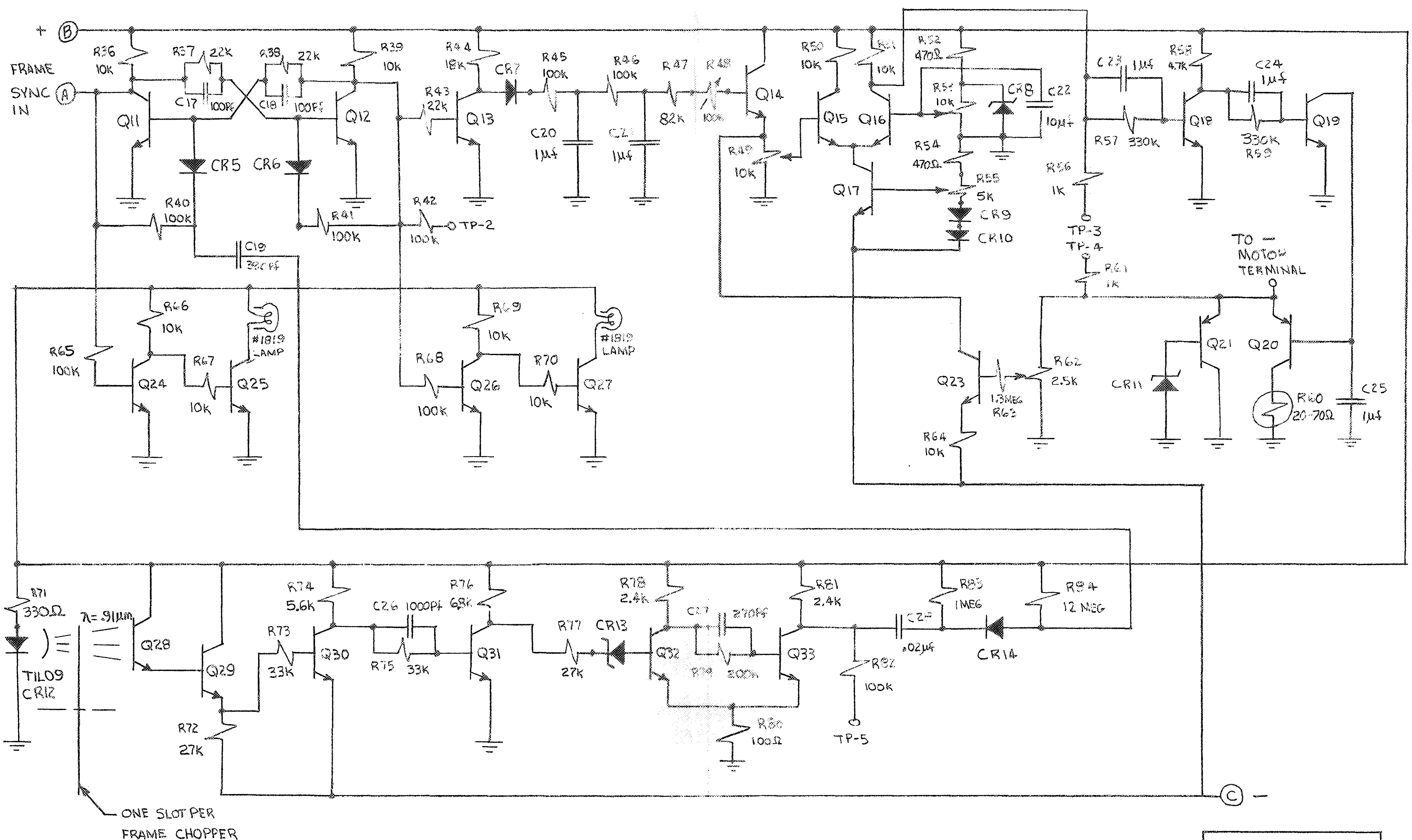
2. ALL DIODES ARE TYPE 1N914 EXCEPT: CR8 - 1N757, CR13 - 1N746A, CR11 - 1N3028

FILM SYNCHRONIZATION ELECTRONICS - GRE 2

SCHEMATIC DIAGRAM

FIGURE 18

SHEET 1 OF 2

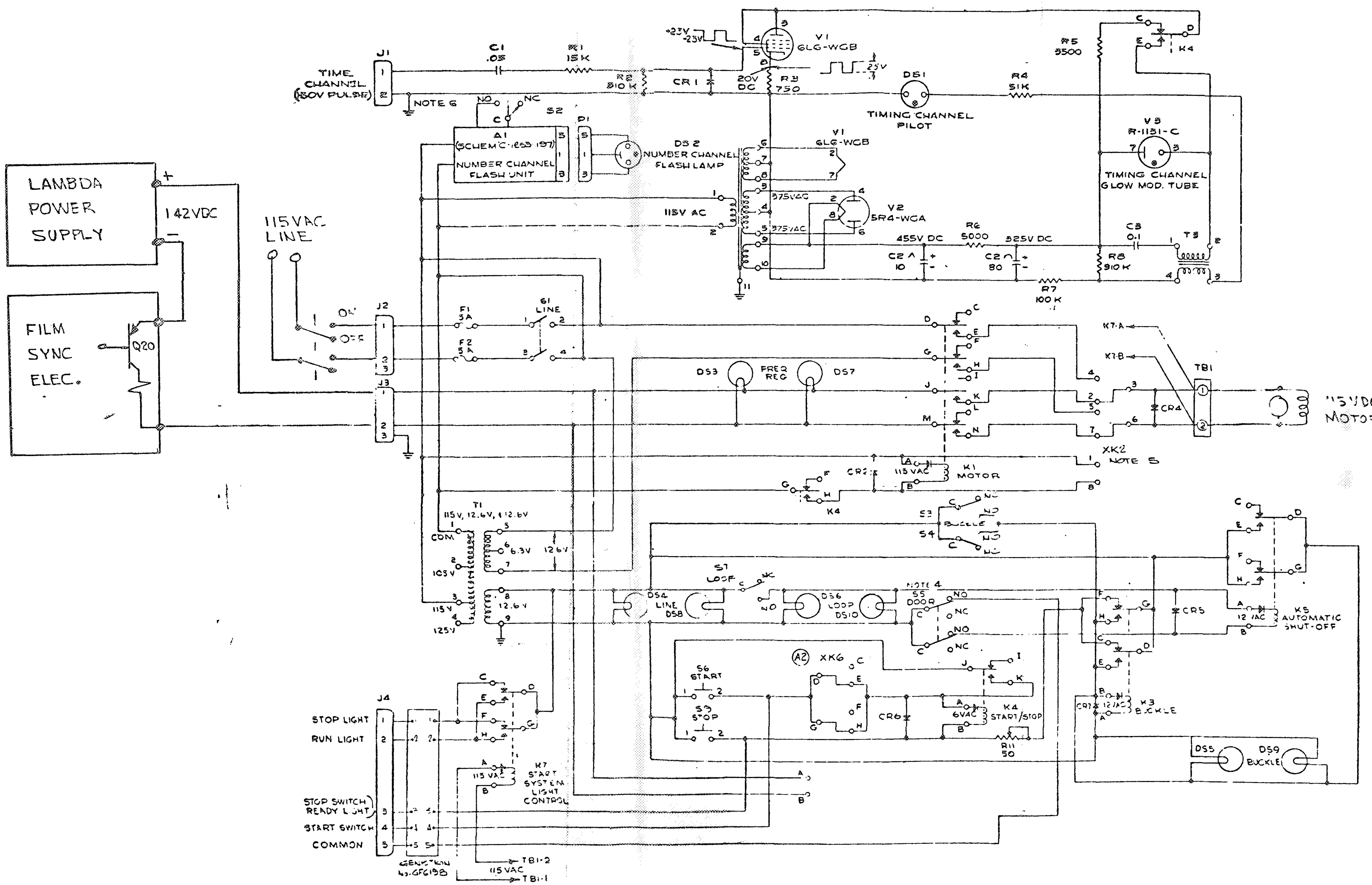



FEEDBACK CONTROL CIRCUIT

SHEET 2 OF 2

FIGURE 19

CAMERA DRIVE INTERCONNECTION DIAGRAM



# 4.0 APOLLO VIDEO ENHANCEMENT TECHNIQUES

## 4.1 ENHANCEMENT TECHNIQUES

Work accomplished on development of analog enhancement techniques are presented next and additional techniques to be developed are discussed. The principal laboratory work accomplished at present has utilized a non-linear filtering technique for emphasizing high frequencies. Details of this work with test results are presented in the next section. Additional enhancement techniques using bandwidth reduction techniques have been investigated and will be developed as part of a future program.

## 4.2 NON-LINEAR FILTER ENHANCEMENT TECHNIQUES

Circuitry has been developed and tested using non-linear filter techniques for picture enhancement. This process is based on the assumption that the video signal can be represented by the product of an illumination component and a reflectance component.

Justification for this concept is based on the fact that image formation is a multiplicative process. In a natural scene, the illumination and reflectance of objects are combined by multiplication to form observable brightness. In terms of an image, this process forms a two dimensional spatial signal expressed by:

$$(1) \quad I_{xy} = i_{xy} \cdot r_{xy}$$

If the illumination component can be assumed to be composed primarily of low frequencies, and the reflectance component high frequencies, the two components can be separated to some extent. Referring to equation 1, this operation consists of taking the logarithm of the signal. Next, linear filtering is employed to enhance the desired frequencies (high frequencies for contours). This operation is illustrated in block diagram form below and an analog circuit has been developed which produces significant improvement in test data. The test data was processed at 0.625 frames/second.

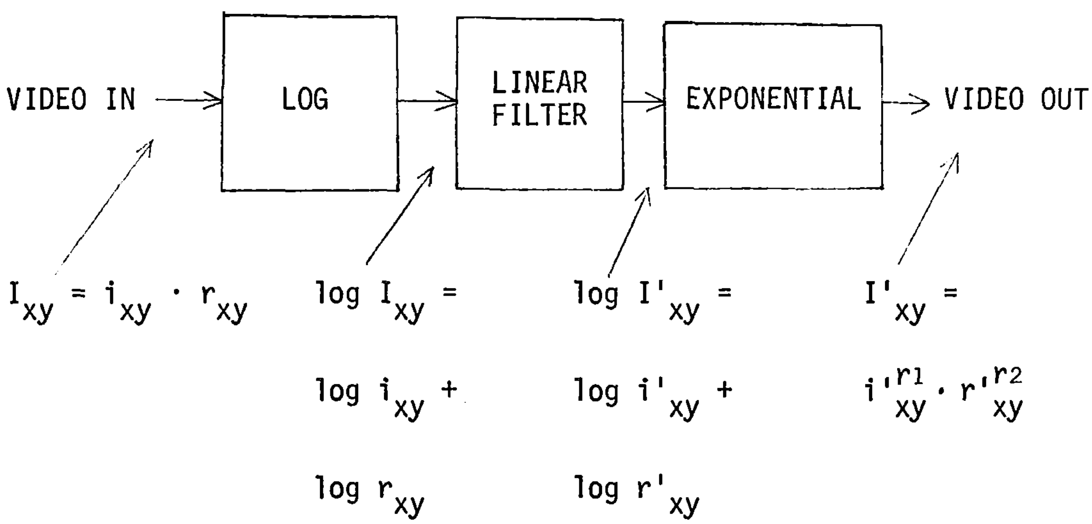



Figure 20 - Image Processor Block Diagram

## 4.3 IMAGE PROCESSOR DESIGN

A schematic of the filter is shown in Figure 21. In operation, the operational amplifier with diode feedback is used to take the logarithm of the input video signal. Selected diodes are used to provide break points and the resulting logarithmic

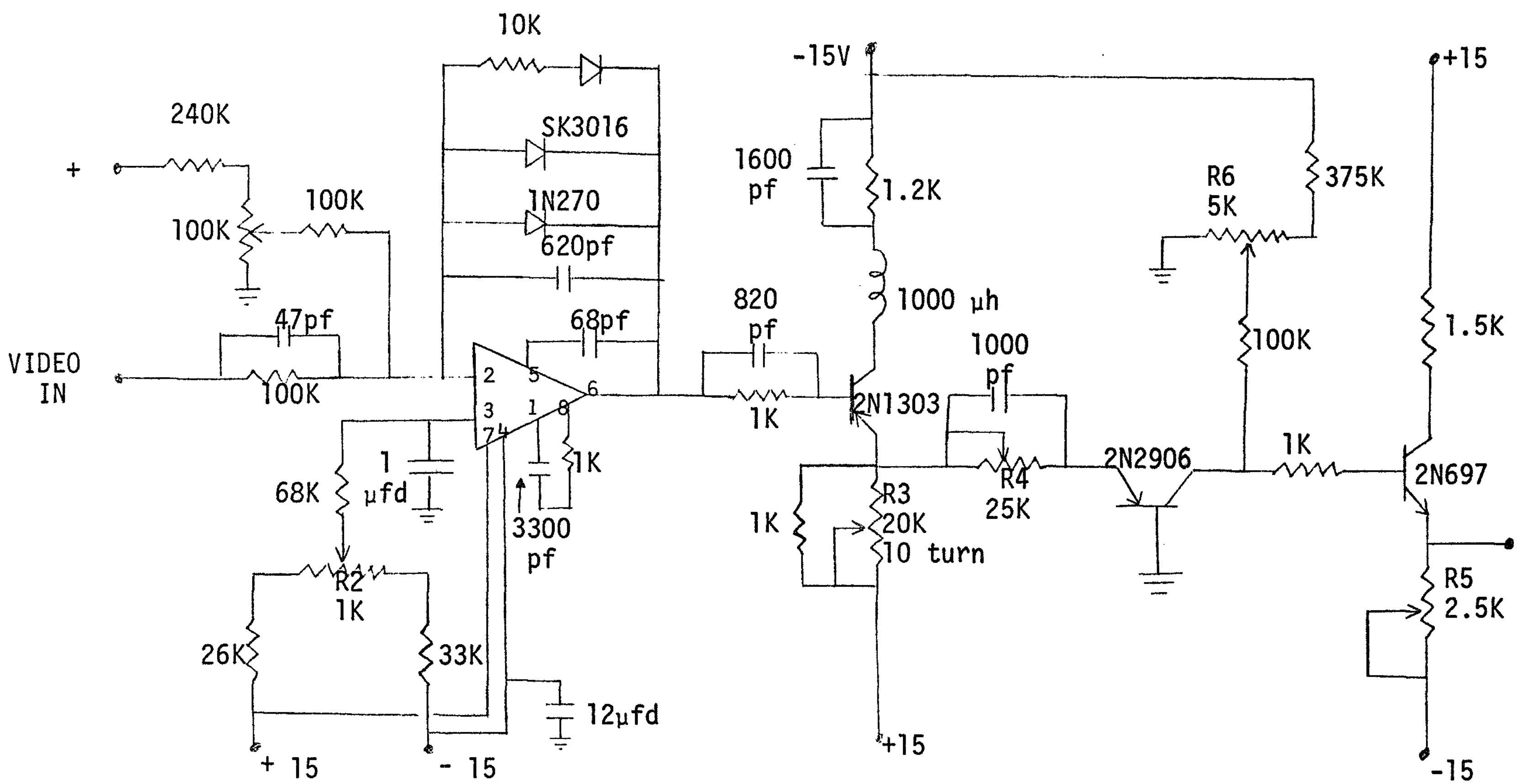



FIGURE 21 - IMAGE PROCESSOR CIRCUIT DIAGRAM #1

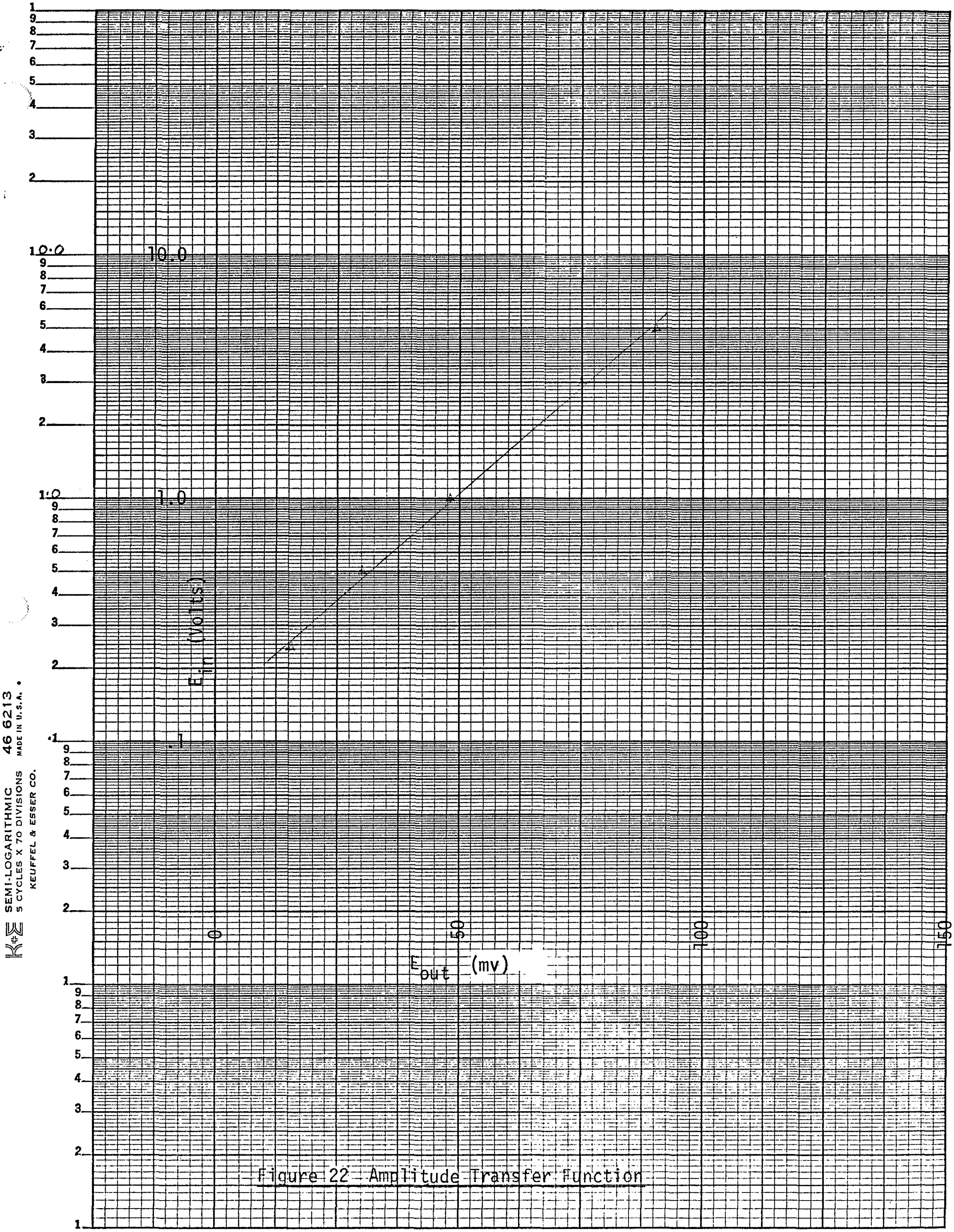



Figure 22 Amplitude Transfer Function

characteristics are plotted in Figure 22. $R_1$ is provided for bias adjustment and is adjusted for best linearity of the curve in Figure 22. D.C. off-set adjustment is provided by $R_2$

High pass filter characteristics are obtained with the 1000 $\mu$h inductor in the collector of the 2N1303 transistor. This transfer function is plotted in Figure 23 below.

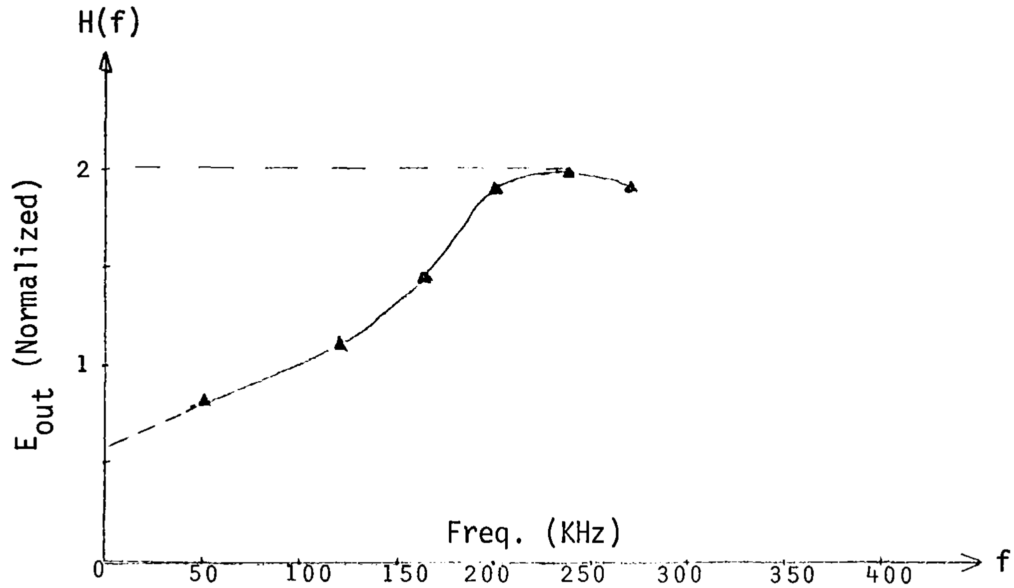



Figure 23 - HIGH PASS FILTER RESPONSE

An exponential transfer function is obtained using the emitter base characteristics of the 2N2906 transistor. The desired operating point is selected using potentiometers $R_3$, $R_4$, and $R_6$. Proper adjustment is indicated when a transfer function exactly inverse to the log operation is obtained. Using data from Figure 23, the filter output may be described by:

$$(2) \qquad \ddot{I}_{xy} = \dot{i}^{.55}_{xy} \cdot \dot{r}^{2}_{xy}$$

## 4.4 TEST RESULTS

Examples of test results are shown in Figures 24 and 25. These pictures illustrate the improvement in contrast obtained by emphasizing high frequencies. This process effectively reverses the low pass characteristics of the camera and partially eliminates the "washed out" appearance of the unenhanced pictures. Further test, with different filter response, is expected to yield a further improvement in picture quality.

The circuit in Figure 21 was also used to process 10 frames/second data. Test results indicated that the high frequency response was not adequate for 10 frames/second data and a design modification was needed. The circuit was redesigned and is shown in Figure 26. Test data runs are being made to determine the optimum frequency response.

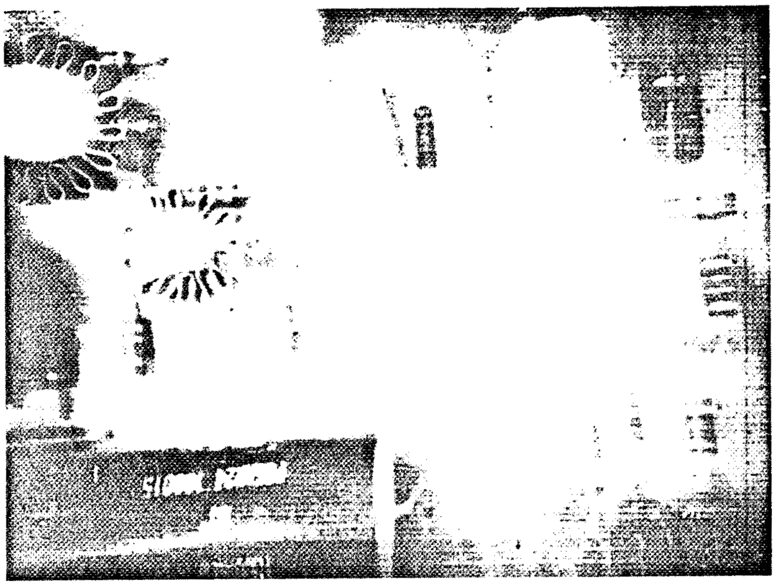


Figure 24 - Unenhanced Test Video - Printed Circuit Board

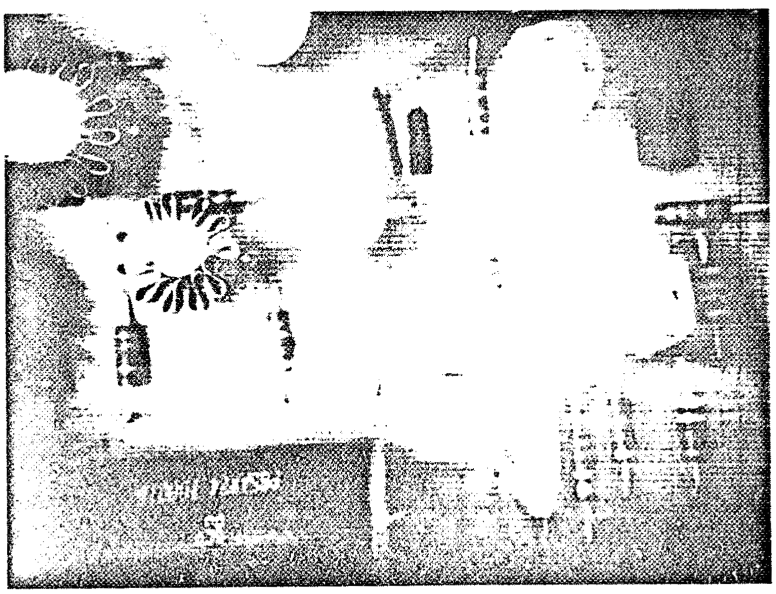


Figure 25 - Enhanced Test Video - Printed Circuit Board

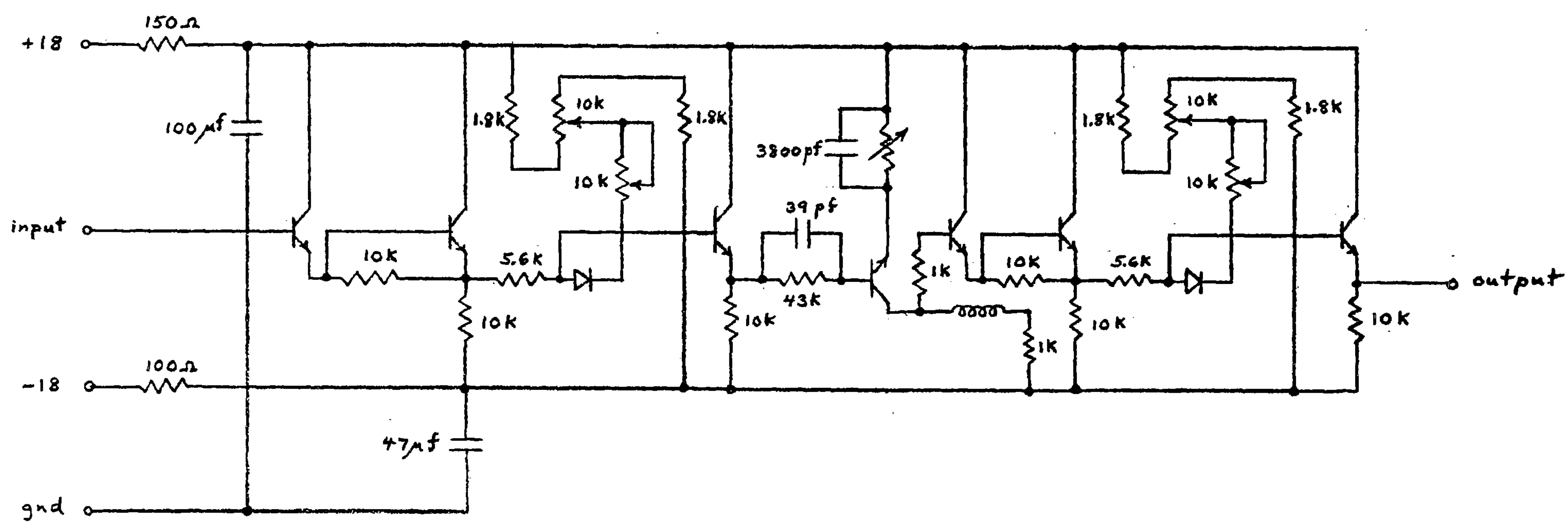



Figure 26 - IMAGE PROCESSOR CIRCUIT DIAGRAM #2

## 4.5 BANDWIDTH REDUCTION TECHNIQUES APPLIED TO VIDEO PICTURE ENHANCEMENT

In recent years, considerable effort has been expended in reducing television bandwidth while retaining picture quality. Several attempts at instrumentation have resulted in bandwidth reductions on the order of four to one. Of the various methods investigated, most have centered around detecting contours or edges in order to exploit certain characteristics of the human eye. Tests have indicated that most people prefer about 60% accentuation of the high frequency content of a television picture. This characteristic has been exploited in bandwidth reduction schemes to detect and transmit only essential information.

This work offers the possibility of picture enhancement from the standpoint of eliminating unwanted noise and also emphasizing high frequencies. A block diagram of a method for implementing the enhancement technique is shown in Figure 27 and follows after work accomplished on bandwidth reduction.

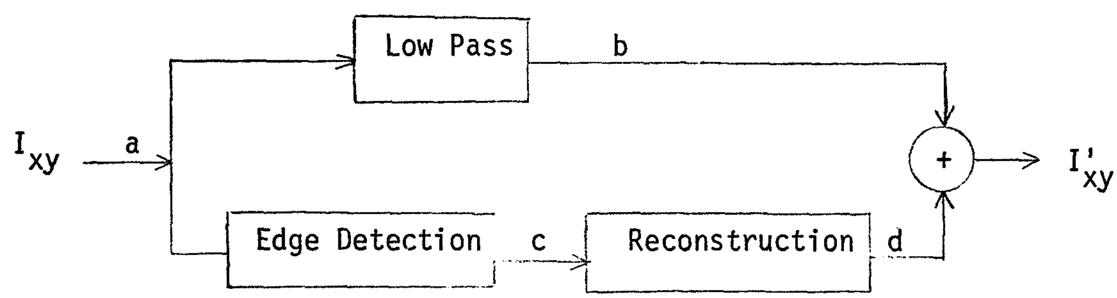



Figure 27 - Edge Detector Image Enhancer

Operation of the system may be explained by referring to Figure 28. If the input signal is a unit step function, an edge pulse consisting of a nyquist sample is detected. A synthetic high signal is then constructed for addition to the low pass signal to reconstruct the original unit step function. For noisy data, this system requires development of an edge detector which will discriminate against noise spikes so that the signal is reconstructed properly. Enhancement of the high frequencies may be achieved by overpeaking the reconstructed edge signal.

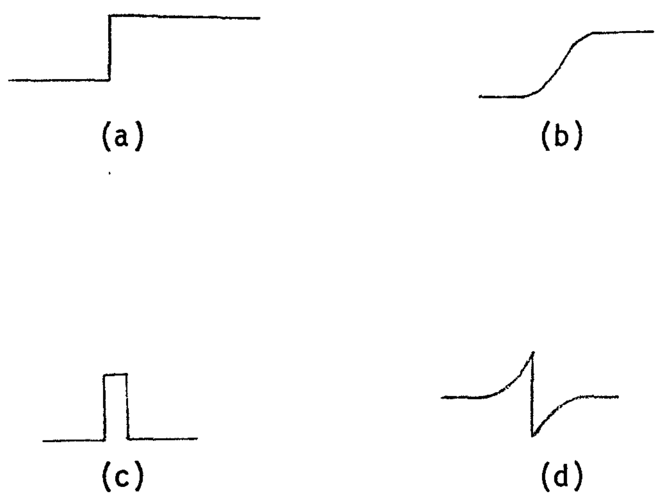



Figure 28. System Waveforms with Unit Step Input

Reconstruction of the edge signal may be achieved by using a standard time domain synthesizer. A block diagram is shown in Figure 29. The edge pulse is fed into a delay line with taps. Output of the taps is then suitably weighted before being added to form the reconstructed edge signal. Success of this technique depends on development of a detail detector capable of operating in the presence of noise. If only essential sample points are detected, the reconstructed signal and hence the resulting picture should exhibit marked improvement.

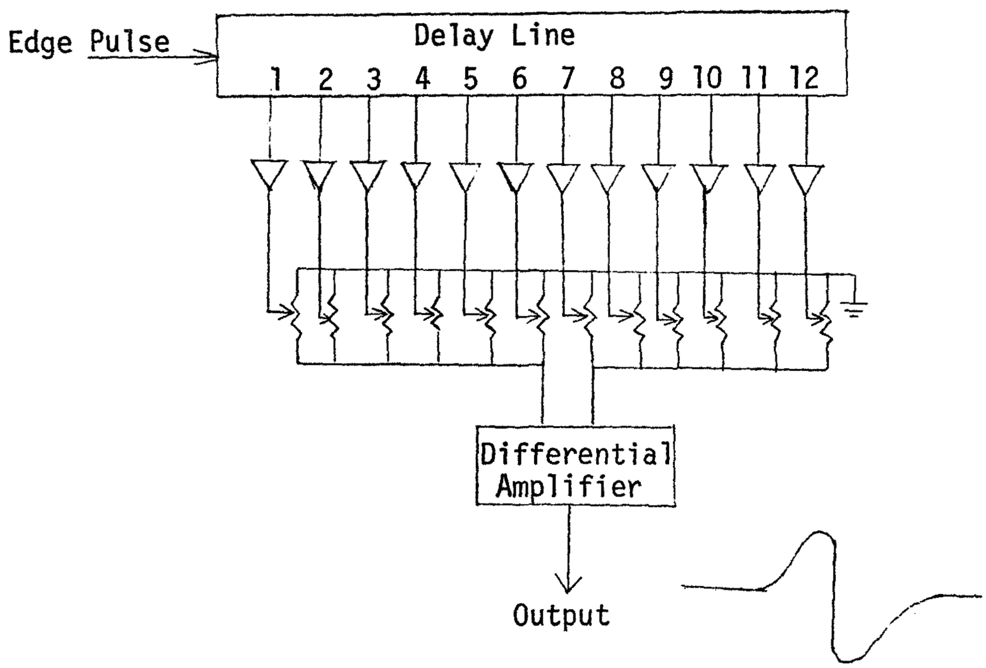



Figure 29. Time Domain Synthesizer

# APPENDIX A

APOLLO COLOR TELEVISION RECORDING AND RETRIEVAL

FROM PANCHROMATIC BLACK AND WHITE FILM

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## 1.0 APOLLO COLOR TELEVISION RECORDING AND RETRIEVAL FROM PANCHROMATIC BLACK AND WHITE FILM

### 1.1 INTRODUCTION

The following method is proposed for recording Apollo color television on black and white film and retrieving as color pictures. The system will provide a highly versatile and switchable color content in the reproduced pictures which will make the system useful for earth resources studies in addition to other already proposed applications. High resolution pictures will be obtained by using the latest technological advances and the system will be fully compatible with present computer techniques for signal enhancement.

Basically the system operates by using an electron beam recorder to optically multiplex the red, green, and blue video signals onto a single frame of black and white film. Color information is retained by assigning different spatial carriers to each field of video information. This is accomplished by using the electron beam to write each field onto the film at different azimuthal angles. The encoded color information is preserved and crosstalk is avoided with the aid of linear photographic storage. To retrieve color, the recording's fourier spectrum is first displayed in a partially coherent optical system. The spectrum is then modified by a spatial filter so that original color values are restored in the final projected image. This filter consists of a multiaperture stop containing color filters. Color film is then exposed to the projected image to obtain recorded color.

## 1.2 SYSTEM DESCRIPTION

A block diagram of the proposed system is shown in Figure 1. Before discussing the operation of the system, it is necessary to first review briefly the technique used for optical multiplexing.

### 1.2.1 OPTICAL MULTIPLEXING

Optical multiplexing is a technique for exposing a multiplicity of overlapped images on a single film frame. Considerable research and developmental work has been accomplished in this area by Technical Operations, Inc.[1] In operation, spatial carriers (analogous to the subcarriers of radio telemetry) encode each exposure so that individual images can be separated in a retrieval operation. Color images are stored as encoded red, green, and blue separation positives on black and white film. Full color retrieval is achieved by additive projection methods that are free from registration defects. To

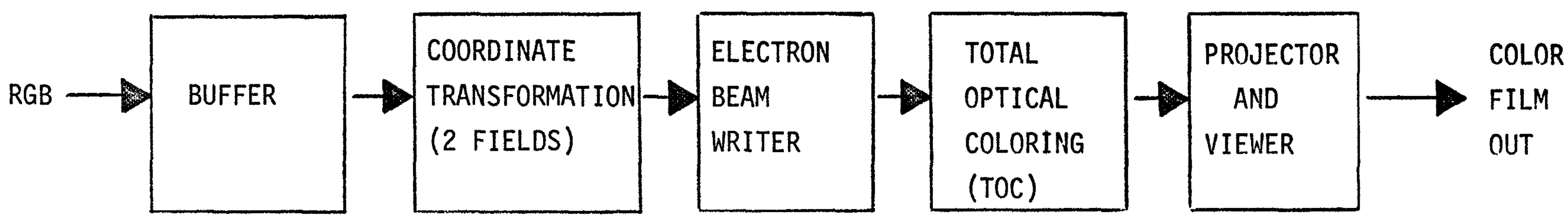



Figure 1. Apollo RGB Television Color Film Recording System

more easily understand the color capability of optical multiplexing, it is convenient to first consider the case of black and white multiple images.

## 1.2.2 MULTIPLE IMAGES

Precoding or carrier modulation is the basic principle underlying multiple imagery.[1, 2] In the optical context, a carrier is a spatially periodic function, i.e., a transmission ruling. Rulings made up of alternating clear and opaque bars of equal and constant width are common devices that have the properties of a spatial carrier. If an image is exposed through a ruling in contact with the recording emulsion, the resulting image is described as being carrier modulated.

Figure 2 illustrates how an exposure would look after being exposed through a ruling. Removal of the halftone raster can be accomplished by a spatial filtering operation in a projector as shown in Figure 3.

The projector is described as coherent only because the light source is very small compared with a conventional projector. The smaller the light source, the more spatially coherent is the light at the exit pupil of the condensing lens. The condensing lens focuses the

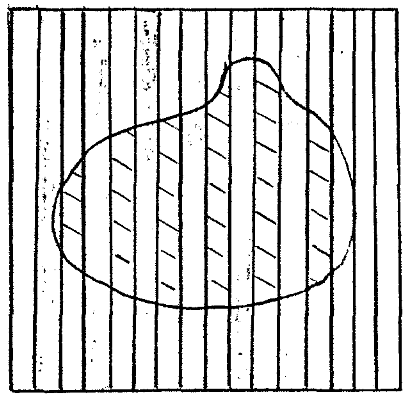


Figure 2. Illustration of Half-Tone Transparency

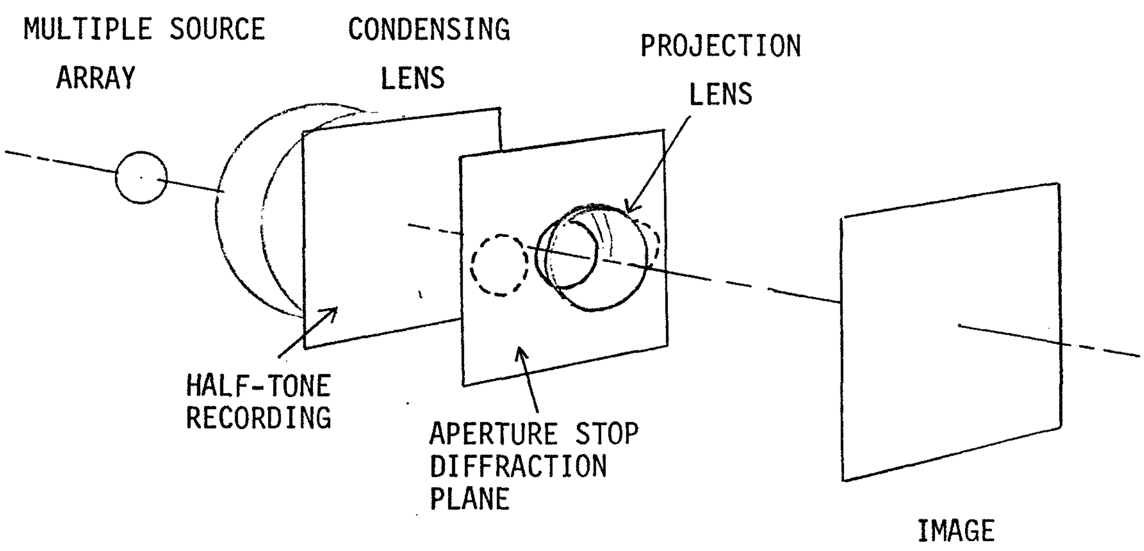



Figure 3. Coherent Projector

source into the entrance aperture of the projection lens and in that plane, the pattern of a diffraction grating will appear as in Figure 4. The central spot is a direct spectral image of the source and is referred to as the dc or zero order. The symmetric spots on either side are called the first, second, and higher harmonic orders. Because an image multiplies the ruling in the case of the half-tone target, each one of these orders contains the entire unmodulated image spectrum.

Spectra generally bear very little resemblance to the objects they represent yet they carry all the information necessary to reimage the objects. By passing just one of these orders - any one of them - through the projection lens and blocking all the others with an aperture stop, the original image is received with the half-tone removed (Figure 5). This is one of the best known examples of coherent spatial filtering.

Looking at Figure 4, it is noted that the orders are spread out only along the horizontal axis in the diffraction plane. If the half-tone is rotated, the orders will rotate about the dc axis. This azimuthal feature makes optical multiplexing possible. Exposures are

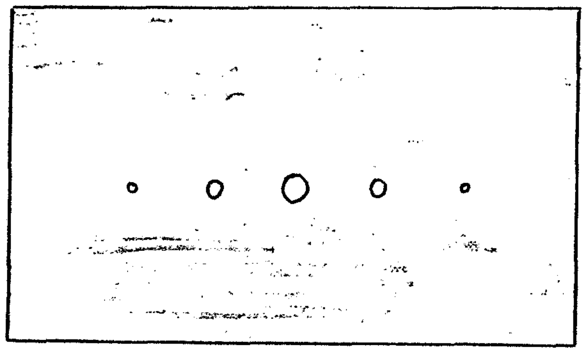


Figure 4. Half-Tone Image Diffraction Pattern

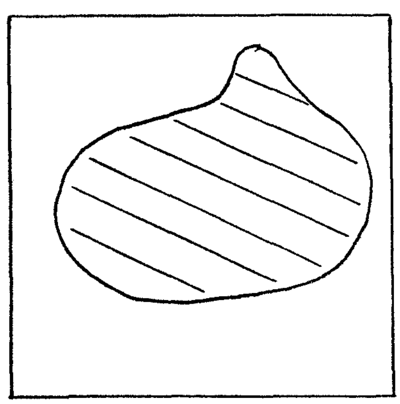


Figure 5. Half-Tone Removed from Figure 2

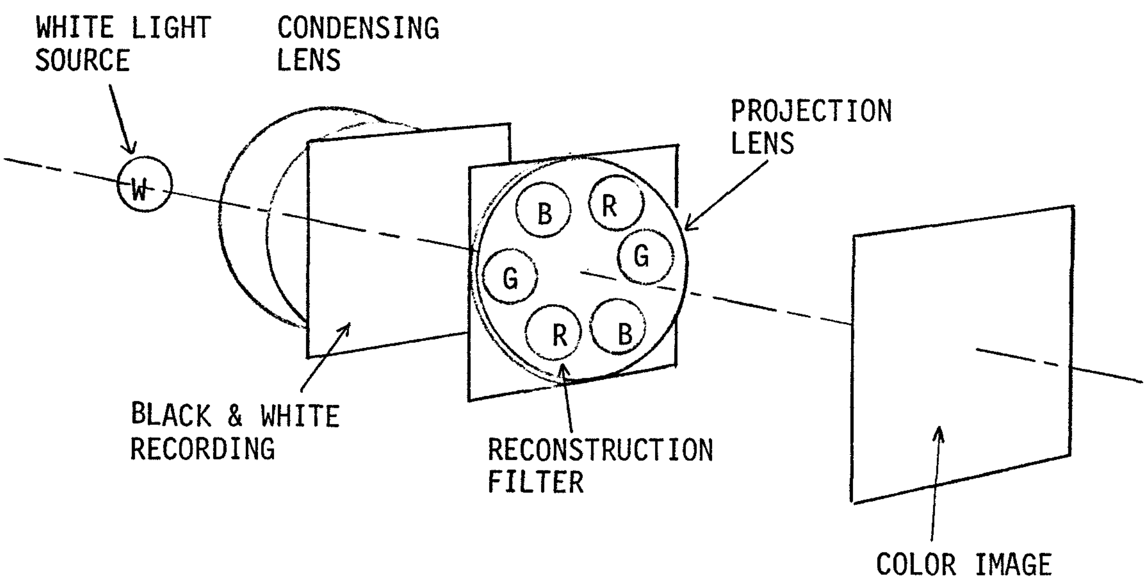
mixed by adding them on a single emulsion; photographic processing is controlled to satisfy linearity requirements, and finally separation is accomplished by spatial filtering similar to the raster removal technique just discussed.

### 1.2.3 COLOR RECORDING

By effectively modulating each separation positive with a differently rotated spatial carrier and summing the three exposures on a single frame in registration, multiplex color recording is achieved. Reconstruction of the color image proceeds in the same way as multiple imagery except that white light illumination, together with an array of colored filters in the diffraction plane, is used. This is shown in Figure 6.

### 1.2.4 RGB RECORDING SYSTEM

With this background, operation of the system in Figure 1 may be more easily understood. It is evident from the preceeding discussion that a single field of television information recorded on film is already frequency modulated. Therefore, only the even or odd fields alone are needed to reproduce the image when the fourier transforms are taken. Of the six fields




NOTE: W = WHITE SOURCE
B = BLUE FILTERS
B = GREEN FILTERS
R = RED FILTERS

Figure 6. Color Viewer Schematic

available, only three need be recorded and processed. However, upon considering the operation of the Apollo TV camera, it is evident that all fields have the same spatial frequency modulation. To achieve optical multiplexing, the scan coordinates of two out of three fields of information must be rotated so that each has a unique spatial frequency modulation.

### 1.2.5 COORDINATE TRANSFORMATION

To effect coordinate rotations for two fields of the data, it is anticipated that the easiest approach will be to digitize the data and store it for retrieval in the desired coordinate frame with digital to analog conversion. Several possibilities for accomplishing this are listed below:

1. Interface with a computer for storage and read out. Present Lockheed design will be investigated to see if this capability already exists.

2. Digitize and store data in a core memory matrix. This matrix will be scanned in the desired coordinate frame during readout.

3. Digitize and store data on a memory drum. Read data out via an address matrix. This offers the attractive possibility of large storage at low cost.

Of the three methods proposed, the last is the most attractive from a cost viewpoint. However, the read out circuitry from the drum will be more complex than that for core storage. Real time processing is feasible if the word length is limited to five bits (32 levels) using method two. In this case the buffer will consist simply of a field selector.

### 1.2.6 ELECTRON BEAM WRITER

An electron beam writer will be used to record the television data on black and white film. Considerable development work has been accomplished in this area by Minnesota Mining and Manufacturing Company. A commercially available recorder will be modified to permit optical multiplexing. Modification of the electron beam writer will center around a deflection system to permit writing television information on the film at different azimuthal angles. Azimuthal angles will be $0^o$, $45^o$, and $90^o$.

The image on the film is formed by the electron beam from the electron gun. Deflection of the beam corresponds to the incoming horizontal and vertical sync signals. This permits an intermittent drive system. The almost instantaneous response of the electron beam permits the obtaining of the high contrast necessary for good picture quality. Spot size of the electron beam is approximately 0.0003 inches which presents a resolution capability in excess of the incoming data requirements.

### 1.2.7 TOTAL OPTICAL COLORING

This unit is used to chemically process the film before display in the projector.

### 1.2.8 PROJECTOR AND VIEWER

A projector similar to that shown in Figure 6 will be used to retrieve a color display which will be used to expose color film. The filter wheel will be rotatable so that the filters may be matched to the sequence of incoming red, green, and blue data. An external viewer will be provided to determine when the desired color is being projected.

# REFERENCES


1. Mueller, Peter F., "Standard Microfilms for Recording Color and Multiple Images," Proceedings of the 1969 NMA Convention.

2. T. Suzuki, M. Mino, and G. Shinoda, "Image of the Optical Grating Modulated by the Signal and its Application to the Measurement of Strain Distribution," Appl., Opt. 3, 825 (1964)

3. State of the Art Discussions with Dr. Peter F. Mueller and Dr. James Harvey, Technical Operations, Inc., Burlington, Mass.

4. Company Literature, Minnesota Mining and Manufacturing Company.

# APPENDIX B

BLACK AND WHITE RECORDING

FROM APOLLO TELEVISION

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## 1.0 TECHNICAL RECOMMENDATION

1.1 The Advanced Manned Spacecraft Technology Division of The Boeing Company recommends a system for recording on 35 millimeter film, black and white television information from the Apollo RGB scan color television. The approach that will be taken is to make extensive use of the present GRE in such a way as to minimize the cost to the Government consistant with the time constraint of supporting Apollo missions.

### 1.2 Definitions

#### 1.2.1 Frame

One complete television 2:1 interlaced picture. Consists of 525 lines occupying 33.3 milliseconds in time.

#### 1.2.2 Field

One-half of a complete 2:1 interlaced television picture, consisting of 262½ lines occupying 16.67 milliseconds in time.

#### 1.2.3 Field Rate

60 fields per second.

#### 1.2.4 Frame Rate

10 frames per second generated from 6 successive fields consisting of 3 odd and 3 even fields in the following sequence: $R_o$, $B_e$, $G_o$, $R_e$, $B_o$, $G_e$.

#### 1.2.5 Black and White or Monochrome Signal (Y)

A black and white signal is generated from the color signal according to the following relation:

$$Y(\text{even field}) = K_r R_e + K_b B_e + K_g G_e$$

$$Y(\text{odd field}) = K_r R_o + K_b B_o + K_g G_o$$

where $K_r$, $K_b$, and $K_g$ are the weighting functions to obtain black and white for the human eye.

## 1.3 System Description

### 1.3.1 General Description

The system, shown in Figure 1, consists of an RGB scan converter, kinescope display, and a 35 millimeter camera. Appropriate circuitry is provided for black white control and television picture enhancement. The RGB scan converter consists of a Fixed-Head Parallel Video disc buffer unit, a servo control option, 16 read-write heads and electronics, 1 period modulator (PM), 6 PM demodulators, 6 1 x 2 PM switches, 16 Write Gate Logic Units, 16 1 x 2 Write Gate Switches, 6 2 x 1 video switches, and sync control logic.

The black white control circuitry preceding the kinescope will consist of a summing amplifier preceded by potentiometers to control the percentages of Red, Blue, and Green signal which is summed. The position of the enhancement circuitry (before or after summer) will be determined experimentally and will consist of amplifiers with non linear response to enhance weak signals. The 12 position switch is manually operated to insure that the proper color is recorded on its respective track on the recorder.

In operation, a full frame will be recorded before processing begins. The first six fields will be recorded on the first six tracks. At this time, both the even and odd fields will be read out, digitized and placed in core storage.

### 11.3.1 General Description (continued)

The address matrix will select the necessary word groups to provide a line interlaced output to the digital-to-analog converter which outputs to the kinescope.

Simultaneously with readout from the disc recorder, the input video will be switched to the next six channels for recording the next six fields. Switches are provided at the recorder output to switch inputs to the demodulators. Operation of the switches will occur at the beginning of the horizontal sync period with a switching period of less than one microsecond.

### 1.3.2 FPV Disc Recorder and Servo

The Video Disc Recorder is similar to the unit presently used in the NASA color television ground station and is manufactured by DATA DISC, INC. Twelve channels are used for video recording with the television horizontal sync recorded on the 13th channel for servo loop control. Erasure is accomplished 100 u sec prior to record with a special erase head to increase the output signal to noise ratio. The horizontal sync signal may also be recorded by manual control as needed. Tracks 14, 15 and 16 are spares. Company literature on the recorder is attached.

1.3.3 PM Modulator

The PM Modulator accepts as input a 4 MHz video signal. The video is then pre-emphasized, driving a voltage controlled oscillator. The oscillator provides a frequency output proportional to video voltage level input. This PM waveform is connected to the disc recorder, each zero crossing of the PM waveform being transformed into a reversal of saturation on the magnetic disc.

1.3.4 PM Demodulator

The recorded signal is read back through an amplifier and then converted to video by a PM demodulator which has an output voltage proportional to the input frequency. The modem has a flat frequency response no more than 6 db down at 4.25 MHz.

1.3.5 2 x 1 PM Switch

The two by one PM switch has two PM inputs, only one of which is provided to the output as selected by the logic line input. This allows either the three odd or three even fields to be read out in parallel.

1.3.6 1 x 2 PM Switch

The 1 x 2 PM switch allows the switching of the input PM signal to one of two heads, allowing writing on one channel while reading another. This allows two fields of video to be recorded on two tracks of the recorder.

1.3.7 Write Gate Logic

The write gate logic provides a single frame write gate after initiation by the record command line. This write gate will be coincident with the vertical sync signal and will be phase adjusted to cause no transients in the resulting recorded signal.

1.3.8 Sync Control Logic

This logic will provide the H and V signals necessary to the servo drive. It will operate from $H_d$ (horizontal drive) and $V_d$ (vertical drive) or from composite sync at EIA levels. The unit will also allow operation of the disc when sync information is lost.

1.3.9 Erase

Purpose: This is to provide additional flexibility in the external control of the record and select signals of the Video Disc Recorder System. With this additional control the Video Disc Recorder track(s) can be pre-erased prior to the recording of the video image(s). Use of this dc erase provides better signal and eliminates the ghosting pattern caused by the carrier signal of a previously-recorded video image.

1.3.10 Kinescope and Camera

A kinescope and camera similar to the present GRE design will be used. An investigation will be conducted to see if present units can be modified for use.

1.3.11 Core Storage and Address Matrix

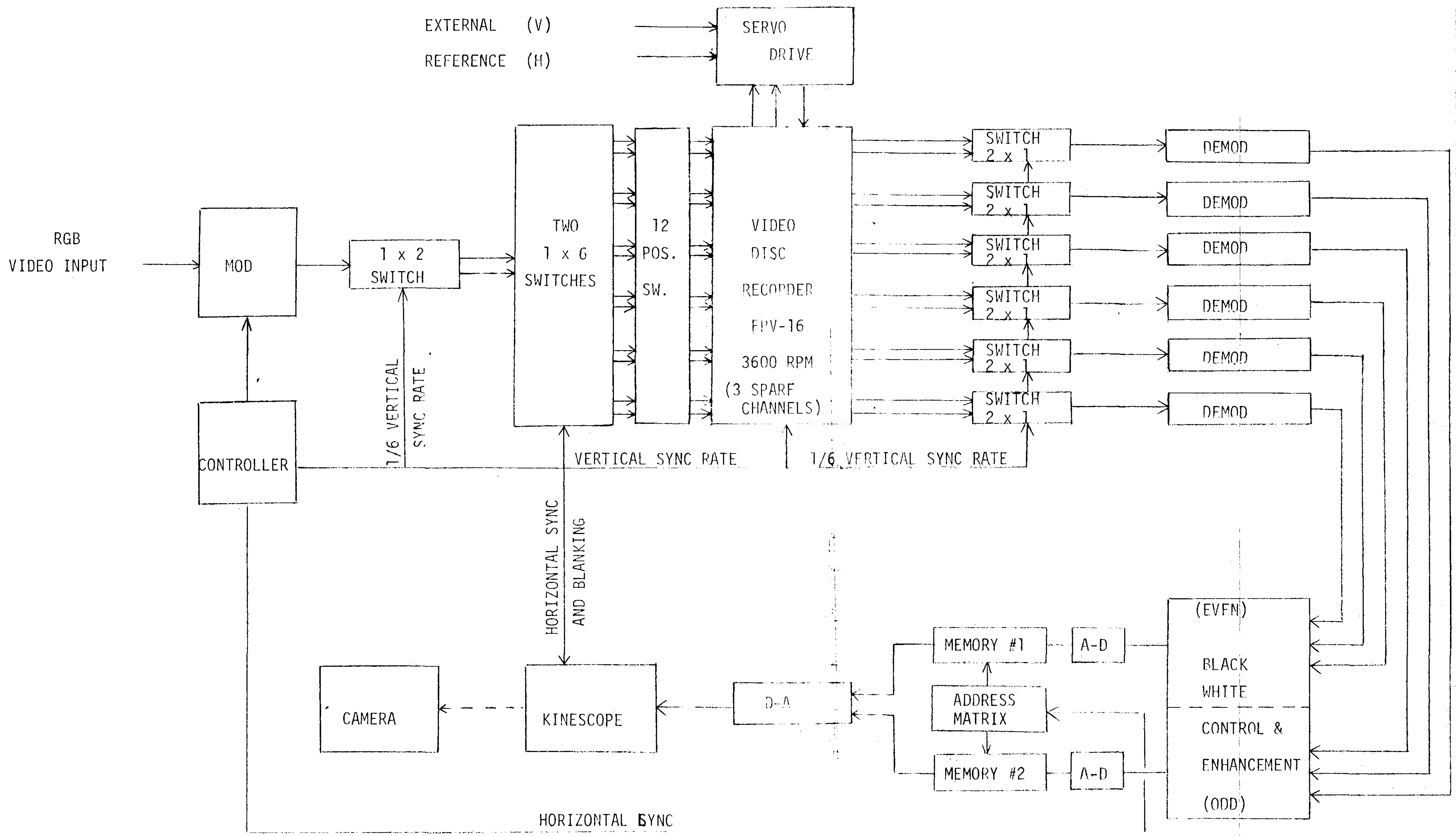
Preliminary investigation indicates that the present Lockheed design can be modified for use.

## REFERENCES

1. RGB Scan Converter, Data Disc Inc., Display Division, Palo Alto, California, 94304

2. Period Modem System, Data Disc Inc., Display Division, Palo Alto, California, 94304

3. Poole, Harry H., Fundamentals of Display Systems, McMillan and Company, Ltd., 1966.


EXTERNAL (V)
REFERENCE (H)
SERVO DRIVE
RGB VIDEO INPUT
MOD
1 x 2 SWITCH
TWO 1 x 6 SWITCHES
12 POS. SW.
VIDEO DISC RECORDER FPV-16 3600 RPM (3 SPARE CHANNELS)
SWITCH 2 x 1
SWITCH 2 x 1
SWITCH 2 x 1
SWITCH 2 x 1
SWITCH 2 x 1
SWITCH 2 x 1
DEMOD
DEMOD
DEMOD
DEMOD
DEMOD
DEMOD
1/6 VERTICAL SYNC RATE
CONTROLLER
VERTICAL SYNC RATE
1/6 VERTICAL SYNC RATE
HORIZONTAL SYNC AND BLANKING
(EVEN) BLACK WHITE
CONTROL & ENHANCEMENT (ODD)
MEMORY #1
A-D
ADDRESS MATRIX
MEMORY #2
A-D
D-A
CAMERA
KINESCOPE
HORIZONTAL SYNC

FI # 1

# APPENDIX C

# GRE #1

# BASIC EQUIPMENT PROCEDURES

The Boeing Company

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# GRE #1 EQUIPMENT BASIC PROCEDURES

## INTRODUCTION

These simplified procedures have been prepared to assist in familiarizing personnel with the photo data equipment. The procedures should prevent the user of the equipment from making serious errors in operation. It is estimated that from four to twelve weeks of operation on the equipment is required before good data can be made on a reasonably repetitive basis.

## DESCRIPTION OF EQUIPMENT

The photo data equipment consists of the following major items:

1 - Ground Reconstruction Electronics (GRE)

2 - Video Tape Recorders (FR-900)

In addition, there are a number of items of supporting equipment, which are mentioned, as required, in the following procedures.

## INITIAL TURN ON PROCEDURES

CAUTION: PRIOR TO TURNING ON CIRCUIT BREAKERS, SET SWITCHES ON EQUIPMENT AS LISTED BELOW:

GRE:

| Switch | Location | Position |
|---|---|---|
| Main circuit breaker in power distribution panel | Lower left front on GRE | OFF |
| ON-OFF switch on anode supply | Lower center front on GRE | OFF |
| Power switches on both QB12-8 power supplies | Below anode supply | ON |
| Signal selector | Middle left front on GRE | TEST SIGNAL IN |
| Monitor Selection | Below oscilloscopes | |
| Channel A | | PM VIDEO |
| Channel B | | VIDEO INPUT |

INITIAL TURN ON PROCEDURES (Continued)

GRE: (Continued)

| Switch | Location | Position |
|---|---|---|
| Composit signal generator | Above power distribution panel | EXT. VIDEO/ SYNC |
| AC regulator | Lower left front | ON |

FR-900

| Switch | Location | Position |
|---|---|---|
| Main circuit breaker | Bottom right front | ON |
| Upper row of push buttons | | STOP |
| Lower row of push buttons | | OFF |

MAIN CIRCUIT BREAKERS

Turn on all of the Main Circuit Breakers.

For equipment at other locations, the corresponding power panel circuit breakers should be turned ON.

## INITIAL TURN ON PROCEDURES (Continued)

### GRE:

At each GRE turn on switches and circuit breakers in the following sequence:

> CAUTION: FAILURE TO FOLLOW THIS SEQUENCE WILL DAMAGE KINESCOPES

1. Main circuit breaker in power distribution panel (lower front of GRE) (See Note).
2. If not on, turn on both switches in precision power source (above anode supply).
3. Wait for HV light (right hand light) on precision power source to come on.
4. While waiting, turn on, or check that the following switches are on:
   - A. Frequency regulator (below camera), line
   - B. Camera, line
   - C. Oscilloscope, power
   - D. 3400A RMS voltmeter, power
   - E. Mini-Kluge (to right of RMS voltmeter), ON
   - F. Power amplifier (to right of Mini-Kluge), ON
5. After HV light on precision power source comes on, turn on anode supply.

Note: If main circuit breaker will not stay on, depress adjacent "INTERLOCK OVER-RIDE" button and try again. If unsuccessful, verify that interlock switches at back of cabinets are in maintenance mode with plungers pulled fully out. Interlocks are no longer door-activated.

## INITIAL TURN ON PROCEDURES (Continued)

### OTHER EQUIPMENT

An oscilloscope is required for operation of each FR-900. It should be plugged into the receptacles at the bottom front of the FR-900 and turned on when the FR-900 is turned on.

A Densitometer is required to evaluate film processing. It should be turned on at least 20 minutes prior to use.

A Quality Evaluation Viewer (QEV) is required for film viewing and exact film measurements. It may be left off until actually needed.

## SHUTDOWN AT THE END OF DAILY OPERATION

If the photo data equipment will be used again the next day, a limited shutdown is recommended in order to avoid long warm up times and extensive set up procedures. This limited shutdown is as follows:

GRE:

1. Turn off anode supply.

2. Turn off HV on precision power supply.

3. Reduce intensity of scope to provide a very dim line.

4. Set signal selector to test signal in.

5. Set monitor selector to PM video (Channel A) and video input (Channel B).

All other portions of GRE should be on.

FR-900:

Leave on.

Other Equipment:

Turn off all other equipment.

## TURN ON PROCEDURES FOR DAILY OPERATION

These procedures are to be followed if limited shutdown only was accomplished at the end of last use of the photo data equipment.

GRE:

1. Turn on HV on precision power supply and wait until light above switch comes on.
2. Turn up intensity on scope to desired level.
3. Turn on anode supply. GRE should now be fully on, as instructed in initial turn on procedures.

FR-900:

Should be on

Other Equipment:

Turn on oscilloscopes used with FR-900's. Turn on other equipment as indicated in initial turn on procedures.

SHUTDOWN FOR WEEKEND OR EXTENDED INTERVALS

If the photo data equipment will not be used the next day, a complete shutdown is recommended. This complete shutdown is as follows:

GRE:

1. Turn off anode supply.
2. Turn off HV on precision power supply.
3. Turn off main circuit breaker in power distribution panel.

FR-900:

1. Push STOP button in upper row of buttons.
2. Push OFF button in lower row of buttons.

Other Equipment:

Turn off all other equipment.

GRE DAILY CHECKOUT

This procedure is to be followed daily to insure the operable condition of the GRE's prior to the generation of any film.

Reference document for this procedure is Eastman Kodak - 1228-113, Operation and Service Instructions, Ground Reconstruction Electronics P/N V1233-901.

1. Preliminary checks:

   A. If GRE has been turned off allow 1 hour warm-up prior to proceeding with alignment.

   B. Insure that all power switches are in the ON position.

   C. Measure + and - 18 volt power supplies, with a Fluke 803 voltmeter or equivalent, at jacks on the front of the supplies. Set supplies using voltage adjust pots on the front of the supplies for ± .05 VDC.

   D. Set sync frequency switch on the front panel of the composite signal generator to the 800 cps position.

2. Composite Signal Generator alignment:

   A. Depress TEST SIGNAL IN P/B on signal selector panel.

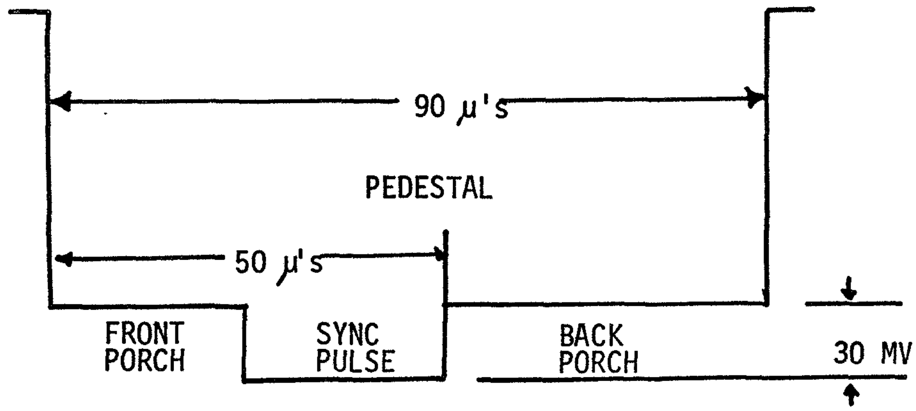
   B. Depress TEST SIGNAL P/B on monitor selector panel.

   C. Place composite signal generator function switch in the EXTERNAL VIDEO/SYNC position.

   D. Observe test signal on scope 'B' trace. Set scope time base to 10 $\mu$'s per CM and vertical deflection to 50 MV per CM.

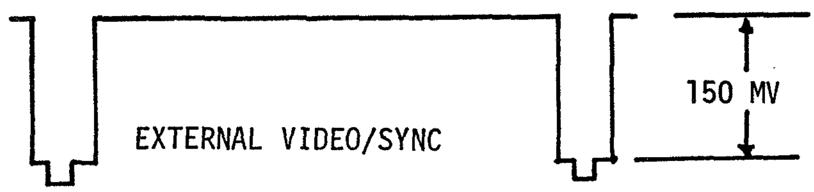
   E. Open composite signal generator front panel door.

   F. Adjust pedestal (Ref. 1228-113 Para. 1-19 and Figure 1-3) for 50 $\mu$'s from pedestal leading edge to sync pulse trailing edge, using sync delay pot in composite signal generator. Adjust overall pedestal width for 90 $\mu$'s from pedestal leading edge to trailing edge, measured at the 50% voltage point, using pedestal width pot in composite signal generator. Adjust sync pulse amplitude for 30 MV below pedestal level, using sync pulse amplitude pot in composite signal generator, (Note: scope settings may be changed for more accurate adjustment).



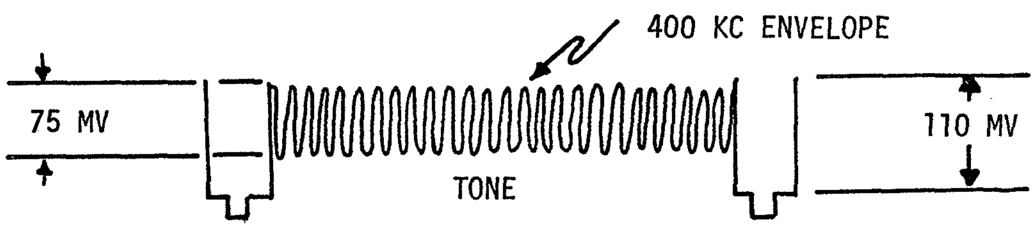

G. Set scope timebase to .2 MS/CM and vertical deflection to 50 MV/CM.

H. Adjust external video/sync for 150 MV from pedestal to peak, using average external video level pot on the front of the composite signal generator.




I. Place composite signal generator function switch in the TONE position.

J. Adjust tone 400 KC envelope for 75 MV P to P using tone amplitude pot in composite signal generator. Adjust overall amplitude for 110 MV pedestal to peak using average tone level pot in composite signal generator.




K. Place composite signal generator function switch in the STAIRSTEP position.

L. Adjust stairstep for 150 MV pedestal to peak using stairstep amplitude pot in composite signal generator. Adjust stairstep first step amplitude in the following manner:

(1) Place scope vertical in 10 MV/CM position.

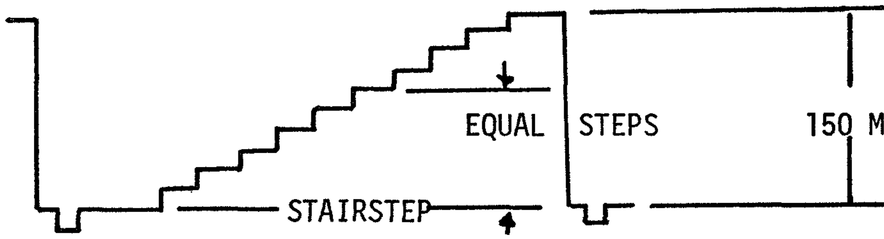
(2) Adjust scope vertical variable pot until the first 6 steps of stairsteps equal 6 CM's pedestal to sixth step.

(3) Adjust first step to 1 CM using stairstep first step pot in composite signal generator.

(4) Repeat (2) and (3) above as necessary until conditions of both (2) and (3) are met concurrently.

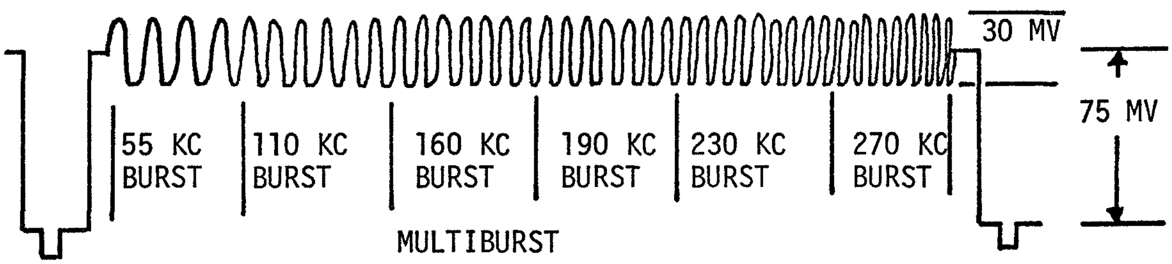
(5) Return scope vertical variable pot to calibrate position and place scope vertical in 50 MV per CM position.

Readjust stairstep for 150 MV pedestal to peak using stairstep amplitude pot in composite signal generator.



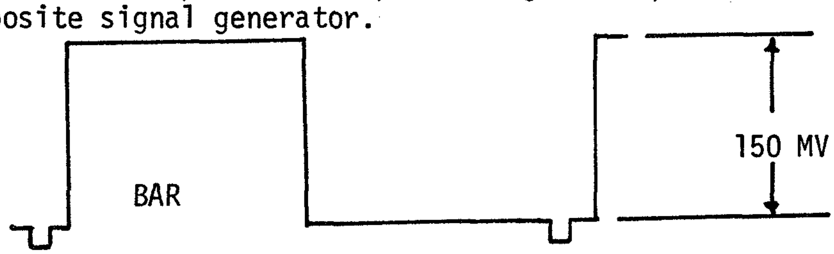

M. Place composite signal generator function switch in the MULTIBURST position.

N. Adjust multiburst average level for 75 MV pedestal to level using multiburst level pot in composite signal generator. Adjust burst levels to 30 MV P to P using appropriate burst level pots in the composite signal generator.




O. Place composite signal generator function switch in the BAR position.

P. Adjust bar for 150 MV pedestal to peak using bar amplitude pot in composite signal generator.




Q. Place composite signal generator function switch in the MULTIBURST position.

R. Close front door on composite signal generator.

3. Sync Separator Alignment:

A. Place sync separator selector switch in position 'A'. Selector switch is located on the front of the sync separator panel.

B. Open the front door of the sync separator panel.

C. Depress SPARE 2 P/B on signal selector panel.

D. Adjust horizontal oscillator 'A' frequency pot to sync the separator for minimum horizontal frequency drift, as seen on oscilloscope 'B' trace.

E. Depress TEST SIGNAL IN P/B on signal selector panel.

F. Adjust horizontal oscillator 'A' phase pot in the sync separator until start of pedestal is coincident with oscilloscope start of sweep.

G. Connect A X10 probe to the oscilloscope 'A' input. Plug X10 probe into A3TP5 in the sync separator.

H. Set scope 'A' trace vertical deflection for .5V/CM, scope mode switch to alternate and timebase switch to 5 $\mu$'s/CM.

I. Set noise gate switch in the sync separator to the IN position.

J. Adjust noise gate 'A' ADJ. in the sync separator for 5 $\mu$'s from start of noisegate pulse ('A' Trace) to start of sync pulse ('B' Trace).

K. Repeat steps F. and J. until both conditions are met simultaneously.

L. Set scope time base to .2 MS/CM.

M. Set sync frequency switch on composite signal generator front panel to +0.1% position. Observe scope traces for drift or jitter - none should be present.

N. Set sync frequency switch on composite signal generator front panel to -0.1% position. Observe scope traces for drift or jitter - none should be present.

O. Set sync frequency switch on composite signal generator front panel to 800 cps position.

P. Remove X10 probe from A3TP5 and close sync separator front door.

4. Video Signal Processor alignment:

   A. Place the composite signal generator function switch in the BAR position.

   B. Depress the CLIP OUT P/B on the monitor selector front panel.

   C. Place the black clip and white clip mode switches on the video signal processor front panel in the IN position.

   D. Open the front panel door on the video signal processor.

   E. Adjust the black clip level pot in the video signal processor until the bar signal minimum level (OV), as seen on scope 'B' Trace, is left unattenuated. Adjust to the exact point where attenuation ceases.
   NOTE: Disregard sync pulse attenuation.

   F. Adjust the white clip level pot in the video signal processor until the bar signal maximum level (150 MV), as seen on scope 'B' trace, is left unattenuated. Adjust to exact point where attenuation ceases.

   G. Alternately switch the black and white clip mode switches, on the video signal processor front panel, to the IN and OUT positions. Monitor the scope 'B' Trace and insure that no overall signal attenuation occurs. If attenuation occurs, repeat steps E., F., and G. until proper results are attained.

   H. Place black and white clip mode switches in the IN position.

   I. Place the composite signal generator function switch in the MULTIBURST position.

   J. Depress the TEST SIGNAL P/B on the monitor selector front panel.

   K. Set scope time base to 10 $\mu$'s/CM and 'A' Trace vertical deflection to 2V/CM.

   L. Plug X10 probe into A2TP4 in the video signal processor.

   M. Adjust clamp delay pot in the video signal processor for 10 $\mu$'s from end of sync pulse ('B' Trace) to end of clamp delay pulse ('A' Trace).

   N. Remove X10 probe from A2TP4 and plug into A2TP2 of the video signal processor.

   O. Set scope 'A' Trace vertical deflection to 20MV/CM.

P. Adjust blanking width pot in the video signal processor for 90 $\mu$'s from start of sweep to end of blanking pulse ('A' Trace), measured at the half voltage point of positive going transition.

Q. Remove X10 probe from A2TP2 and plug into A1TP4 of the video signal processor.

R. Set scope 'A' trace vertical deflection to DC mode and 50MV/CM.

S. Temporarily remove X10 probe from scope 'A' input and adjust 'A' Trace position for exact center gridline of the scope. Reconnect X10 probe to scope 'A' input.

T. Rotate F.O. level pot in the video signal processor fully counterclockwise (CCW).

U. Adjust DC zero set pot in the video signal processor until the pedestal (inverted) back porch is coincident with the center gridline of the scope.

V. Rotate F.O. level pot in the video signal processor clockwise (CW) one-half of fully CW.

W. Adjust DC balance pot in the video signal processor until the pedestal (inverted) back porch is coincident with the center gridline of the scope.

X. Repeat steps T. through W. until requirements of steps V. and W. can be met with <u>no</u> pot adjustment.

Y. Rotate F.O. level pot in the video signal processor fully CCW.

Z. Set scope timebase to .2MS/CM. Set scope 'A' Trace vertical deflection so that the 55 KC burst of multiburst equals 2 CM.

AA. Adjust F.O. level pot in the video signal processor for 6 CM on the 230 KC burst of multibirst, as seen on scope 'A' Trace.

BB. Remove X10 probe from A1TB4 of the video signal processor. Disconnect X10 probe from scope and reconnect existing cabling.

CC. Close video signal processor front door.

5. Deflection Generator alignment:

A. Insure that scope 'A' trace vertical deflection is in calibrate and mode switch is in AC.

B. Place composite signal generator function switch in the EXTERNAL VIDEO/SYNC position.

C. Adjust vertical center control on deflection generator front panel for the flattest signal at the lowest amplitude, as observed on the scope 'A' Trace. Lock vertical center control.
NOTE: Flattest signal at lowest amplitude will occur within plus or minus one-half turn of vertical center control.

D. Remove microscope door cover and insert microscope into hood. Lock down outer microscope stop.

E. Move the microscope through its full travel in and out and observe scan line position with respect to the horizontal crosshair. Scan line should be straight within one-third of full scanline width.
NOTE: If scanline is not straight within one-third of full width, adjust pincushion balance and pincushion amplitude pots, in the deflection generator, until line is within tolerance.

F. Move the microscope to its fully inward position.

G. Adjust horizontal position control on the deflection generator front panel until the end of the scanline meets the vertical and horizontal crosshair intersect points.

H. Move the microscope to the outward stop position.

I. Adjust horizontal size control on the deflection generator front panel until the end of the scanline meets the vertical and horizontal crosshair intersect point.

J. Repeat steps F. through I. until conditions of G. and I. are met.

K. Place composite signal generator function switch in the TONE position.

L. Move the microscope to the approximate center of its travel between the inner and outer stops.

M. Adjust the focus power supply voltage, Ref. 1228-113, Page 1-4, Figure 1-2, Item 1A2A6, until the most symmetrical dot pattern is observed in the microscope.

N. Move the microscope to its fully inward position.

O. Adjust the focus pot, on the deflection generator front panel, until the most symmetrical dot pattern is observed in the microscope.

P. Release microscope outer stop and slide the microscope out of the hood. Replace the microscope door on the hood.

Q. Place the composite signal generator function switch in the EXTERNAL VIDEO/SYNC position.

6. GRE Density Calibration:

A. Place the composite signal generator function switch in the OFF position.

B. Adjust the kine bias pot on the video signal processor front panel until the proper AC voltage value (value posted on the front of the GRE) is obtained on HP RMS voltmeter.

C. Place the composite signal generator function switch in the EXTERNAL VIDEO/SYNC position.

D. Adjust the video gain pot on the video signal processor front panel until the proper AC voltage value (value posted on the front of the GRE) is obtained on the HP RMS voltmeter.

E. Repeat steps A. through D. until conditions of both B. and D. are met.

F. GRE is now ready for film generation.

## LINE BURN-IN PROCEDURE

### I. SELECTION OF NEW PHOSPHOR

A. System Configuration

1. GRE System on
2. Kinescope on (Hv. and Anode)
3. Kine Bias and Video Gain set to approximately the same settings required for film exposure.
4. Monitor P.M. output on A channel of oscilloscope.
5. Use Ext. Video/Sync mode for all the following conditions.

B. Phosphor Search

1. Observing P.M. output on oscilloscope, use Vert Center knob of the deflection generator to search for new phosphor. Unused phosphor can be noted by an increase in P.M. output amplitude as the line is moved from the last used line.
2. The "New Phosphor Area" should have (a) a straight line "grassy" area display on the oscilloscope indicating an area with consistant light output, and (b) the absence of high peaks of short duration swinging upward or downward from the average "grassy" display; these indicate "hot spots" or voids which will produce streaks on film outputs.

### II. SETTING THE LINE CORRECTIONS

1. Using the microscope and the Kine Vertical Position control on the Kine Control Panel, locate the line on the horizontal crosshairs of the microscope.

II. (Continued)

2. Using the microscope and its associated stops set the ends of the line to intersect the vertical crosshairs; use the Horiz Center and Horiz Size controls as needed to set the ends of the line on the crosshairs.

3. Using the horizontal crosshair of the microscope check several places across the line to see that it is level and has no bow or tilt.

   (a) To correct for tilt, (one end of the line is higher than the other)

   Remove the blank panel above the Kine Control Panel, observing the high voltage warning sign; tilt the cradle using the knob at the top of the Kine cradle. Adjust this in conjunction with the "Kine Vertical Position" control on the Kine Control Panel to obtain simultaneous conditions of both ends of the line on the Kinescope intersecting the crosshairs of the microscope.

   (b) To correct for line bow (the center of the line higher or lower than both ends)

   Adjust the Pin Cushion Amplitude and Pin Cushion Balance controls inside the deflection generator in conjunction with the Kine Vertical Position on the Kine Control Panel to flatten the line until the line can be seen to intersect the horizontal crosshair across the entire line.

4. Once it has been determined that the line is free from tilt or bow, use the Horiz Center and Horiz Size controls to set the ends of the line beyond the end of visibility when the microscope is placed at either stop. (Note: This is a long line which is used to burn in phosphor outside the area of interest)

## III. BURN-IN PROCESS

1. Once the previous conditions have been met, adjust the focus power supply (High Voltage) to 200 volts above or below the in-focus setting.
2. Adjust the Kine Bias and/or Video Gain controls on the Video Signal Processor to give a reading of between 7.5 to 12.5 micro-amps (Meter is on the Kine Control Panel).
3. Assure that all lockable controls are locked in place and that the Composite Signal Generator has an output of Ext. Video/Sync.
4. Remove the light cover from the microscope mount assy., and cover the photomultiplier with a soft opaque material to eliminate light.
5. Leave the GRE under these conditions for at least 24 hours.

## IV. RESETTING THE GRE FOR USE

### A. The Kinescope Line

1. Reverse the process in step III (4) above.
2. Using the old line Kine Bias and Video Gain settings, set the Video Gain and Kine Bias for those settings.
3. Using the microscope, set the line for the same conditions as in Section II above (i.e., line length, position and straightness). Reset as required.
4. Using the 400 kc tone from the Comp Sig Gen, look at the center of the Kinescope line with the microscope.

IV. (Continued)

5. Using the Focus Power Supply (high voltage) adjust for best focus, (roundest and best defined dots on Kinescope line).
6. Using the Focus and Symmetry controls (located on and in respectively, the Kine Control Panel) focus the ends of the Kinescope line so that they have the best focus (best defined, and roundest appearing).

B. Density Run

1. Assuming the above steps have been completed, use the old Kine Bias and Video Gain settings as a basis for the following:
   (a) Make a list of five settings at two/tenths millivolt (.2 mv) intervals each side of and using as a reference the Kine Bias setting for the previous line, i.e., if the old Kine Bias setting was 5.0 mv the 10 settings would be from 4.2 mv to 6.0 mv. At the same time decrease the Video Gain as you decrease the Kine Bias or increase Video Gain as you increase Kine Bias as required in the following paragraph.
   (b) Make a list of five settings at 5 mv intervals each side of and using as a reference the Video Gain setting used on the previous line, i.e., if the old Video Gain setting was fifty millivolts (50 mv) you would have 10 settings from thirty millivolts (30 mv) to seventy five millivolts (75 mv).

IV. (Continued)

2. Using the settings determined in steps (a) and (b) above, set the GRE for Density using the settings of Kine Bias and Video Gain as recorded during step number 1 above. From the above first example the setting would be 4.2 mv of bias and 30 mv of gain. After the GRE is set up, load the film magazine and run 6 feet of film.
3. Pick a number sequence to identify each of the 10 runs, the ID number will be placed in the number channel thumb wheels in the camera base. This number is recorded on each strip of processed film for future correlation.

   After the above is accomplished, set the Output Video switch on the Composite Video Generator to the Bar position and run 2 or 3 feet of film.
4. Repeat steps B2 and B3 above for each of the 10 steps in the list.
5. After the above film has been developed, use a densitometer (such as the macbeth TD-100) to determine the density of the Bar signal for each run. Correlate the density with the Kine Bias and Video Gain settings used and determine the new settings of Kine Bias and Video Gain which will provide optimum film output.

   For the light portion of the Bar signal on the film a density of 0.3 to 0.5 should provide optimum film output and for the dark portion of the Bar signal a density of 1.60 to 1.80 should provide the optimum film output. (Note: This information was obtained from the MSC photo lab.)

IV. (Continued)

A setting of Kine Bias and Video Gain nearest to density readings of 0.4 and 1.7 should be near optimum. If additional quality is desired the procedure listed in IV B can be repeated using the new Kine Bias and Video Gain as the reference settings and use smaller (but proportional) increments of difference in the Kine Bias and Video Gain settings.

C. <u>Focus Tests</u>

1. Assuming the above has been completed, place the film magazine on the GRE and run 6 feet of film.
2. Run normal daily checks on GRE system.
3. Record on film 2 or 3 feet of each test signal of the Composite Signal Generator (Bar, Multiburst, etc.) and develop the film.
4. Analyze the film on the Quality Evaluation Viewer to determine the following:
   (a) That the video trace is approximately .756 inch wide ± .008 inch
   (b) That all six multiburst tones can be resolved
   (c) That the tone output will produce longitudinal lines or checkerboard dots over the width of the film.
   (d) That all ten grey shades of the stairstep can be defined.
5. If any or all of the conditions in step 4 above cannot be met, refer to the Eastman Kodak Manual No. 1228-113 for further procedure.

GRE OPERATION

1. GRE OPERATION

Attach film magazine to GRE camera and thread film as shown in Eastman Kodak Recording Camera Manual 1228-114, Figure 1-4. Set Camera Footage indicator to 000. Run approximately 5 feet of film, as shown on footage indicator and stop camera drive.

2. SIGNATURE RUN PRIOR TO DATA

A. Depress TEST SIGNAL IN P/B on the signal selector panel.

B. Depress VIDEO IN P/B on the monitor selector panel.

C. Place the composite signal generator function switch in the BAR position.

D. Start the GRE camera. Allow camera to run for 20 seconds and place:

The composite signal generator function switch in the MULTIBURST position.

After 10 sec. in the MULTIBURST position, place the comp. sig. gen. function switch in the STAIRSTEP position.

After 10 sec. in the STAIRSTEP position, place the comp. sig. gen. function switch in the TONE position.

After 10 sec. in the TONE position, place the comp. sig. gen. function switch in the EXT. VIDEO/SYNC position.

After 10 sec. in the EXT. VIDEO/SYNC position, stop the GRE camera.

3. FILM GENERATION

A. Sync Separator adjustment

1) Depress COMP. VIDEO IN button on sig. selector panel. Insure that SYNC SEPARATOR SELECTOR switch is in the 'A' position.

2) Assure that .625 frame per second video to be recorded is being received at the GRE.

IV. (Continued)

If the above steps are all accomplished, the GRE is now ready for use.

3. FILM GENERATION (Continued)

3) Depress the BURST button on the monitor selector panel. Adjust the scope trace amplitude and position for a presentation of the sync burst. Set the scope sweep to the 5 $\mu$'s per centimeter position.

4) Adjust the SYNC STABILITY and HORIZ OSC A FREQ inside the sync separator panel for the best possible stability of the burst presentation.

5) Set or check the following switch conditions:

   a) VIDEO INPUT button depressed on monitor selector panel.

   b) M-K BYPASS IN switch to bypass.

   c) Scope channel 'B' to 50 MV/CM.

   d) Scope sweep to .2M Sec/Div.

6) Check video presentation on scope channel 'B' the video envelope should be 150 MV. p-p occurring from "O"V. D.C. or blanking level, to 150 MV. Adjust the gain of the HP-467A power amp and the D.C. LEVEL control in the sync separator until these conditions are satisfied.

   NOTE: Care must be taken not to clip part of the video in a negative direction.

There are two common types of film generated on the GRE

A. Uncorrected video

B. Video plus Mini Kluge

NOTE: Any time the M-K is used DC level must be set for each video input to set the DC level.

3. FILM GENERATION (Continued)

A. Uncorrected Video

1) Place switches in appropriate positions for Film Type A, as shown in Table 1.

2) With video from the detection equipment coming in, adjust the GRE H/P amplifier for 150 MV from pedestal to peak, as seen on Scope 'B' trace.

3) Search the tape, on the FR900, to its starting position for the film run. Start FR900 & GRE camera.

4) Place the Ready/Fault Switch, on the signal interlock panel, in the READY position.

B. Video plus Mini-Kluge

1) Video plus M-K in XI Mode

a) Place switches in appropriate positions for Film Type B-1, as shown in Table 1.

b) Place the composite signal generator function switch in the STAIRSTEP position.

c) Place the M-K in/bypass switch in the BYPASS position.'

d) Adjust the GRE H/P Amplifier for stairstep amplitude of 150 MV from pedestal to peak, as seen on scope 'B' trace.

e) Place the M-K in/bypass switch in the IN position.

f) Gain may be added at this time by adjusting XI gain pot, until proper gain is attained; i.e., first 5 steps (75 MV normally) can be adjusted to equal 150 MV thereby giving 2 times gain.*

g. Adjust positive or negative clip No. 1 pots so that overall signal equals 150 MV. Positive clip is used when low level data gain is desired. Negative clip is used when high level data gain is desired.

h) With video, from the detection equipment, coming in, adjust the GRE H/P amplifier for 150 MV from pedestal to peak as seen on scope 'B' trace.

i) Search the tape, on the FR900, to its starting position for the film run. Start FR900 & GRE camera.

j) Place the ready/fault switch, on the signal interlock panel, in the READY position.

* NOTE: Up to 5 times gain may be attained in this mode.

TABLE 1

| FILM TYPE | SIGNAL SELECTOR | MK IN/BYPASS SWITCH | MK FUNCTION SWITCH |
|---|---|---|---|
| A | COMP VIDEO IN | BYPASS | N.A. |
| B | COMP VIDEO IN | IN | 1 XI |
| | | | 2 INT. |

3. FILM GENERATION (Continued)

2) Video plus M-K in INT. Mode

a) Place switches in appropriate positions for film type B-2, as shown in Table 1.

b) Perform steps b thru f of procedure for film type C-1.

c) Insure that positive and negative Clip No. 1 pots are turned fully counter clockwise.

d) For M-K-1, MK-2 and MK-5 settings, as shown in Figure 1, turn negative Clip No. 2 pot fully counter clockwise. Adjust Int. gain pot for 150 MV from pedestal to peak. Adjust positive Clip No. 23 pot until all steps of stairstep except the first two are attenuated.

NOTE: Scope 'B' trace vertical deflection may be changed for easier viewing of clipping action

e) Adjust Int. gain pot for value desired, as shown in Figure 1, for the first two steps of stairstep.

f) Set scope 'B' trace vertical deflection to .05v/CM.

g) Slide M-K out of its holding case and adjust right hand pot on the A2 card for 150 MV from pedestal to peak.

h) For MK-3, MK-4, as shown in Figure 1, turn positive clip No. 2 pot fully counter clockwise. Adjust Int. gain pot for 150 MV pedestal to peak. Adjust negative Clip No. 2 pot until all steps of stairstep except the last two are attenuated.

NOTE: Scope 'B' trace vertical deflection may be changed for easier viewing of clipping action.

i) Adjust Int. gain pot until the last two steps of stairstep are 60 MV overall, as shown in Figure 1.

j) Set scope 'B' trace vertical deflection to .05V/CM.

k) Slide M-K out of its holding case. Adjust left hand pot on the A2 card for stairstep total amplitude shown in Figure 1.

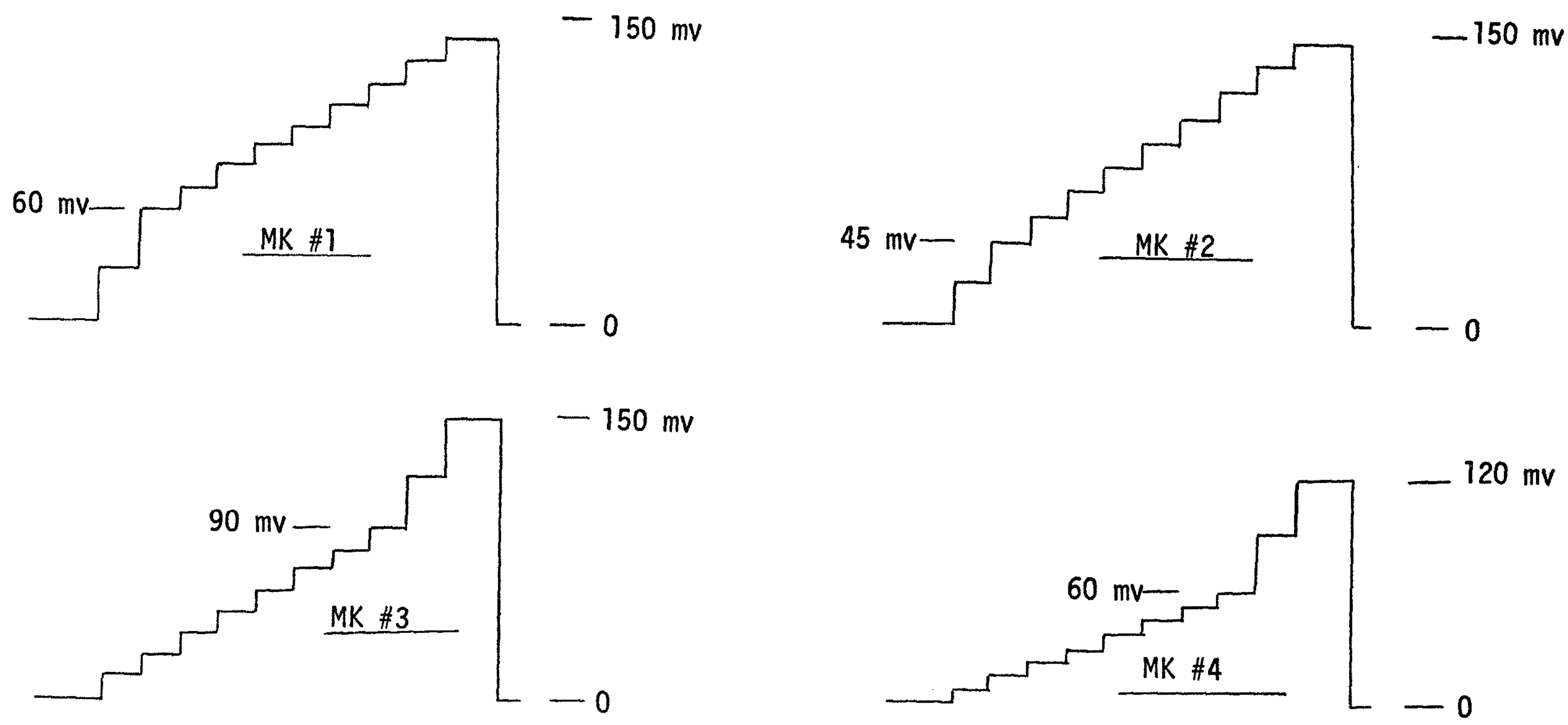



Figure C-1 - MINI-KLUGE SETTINGS

3. FILM GENERATION (Continued)

l) With video, from the detection equipment, coming in, adjust the GRE H/P amplifier for 150 MV (120 MV in the case of MK-4) from pedestal to peak, as seen on Scope 'B' trace.

m) Search the tape, on the FR900, to its starting position for the film run. Start FR900 and GRE camera.

n) Place the ready/fault switch, on the signal interlock panel, in the READY position.

C. Negative or Inverted Video

1) Insure that M-K power is on.

2) Place M-K BYPASS IN switch to IN position.

3) Place POLARITY POS-NEG switch on M-K to NEG.

4) Operate DC LEVEL ADJUST on M-K to obtain a pedestal level of 150 MV.

5) Operate M-K gain to obtain "0" V D.C. on peaks of video.

4. SIGNATURE RUN AFTER DATA

At the end of a data run leave the GRE running and perform the following steps:

A. Place the Ready/Fault switch, on the signal interlock panel, in the FAULT position.

B. Depress the TEST SIGNAL IN pushbutton on the signal interlock panel.

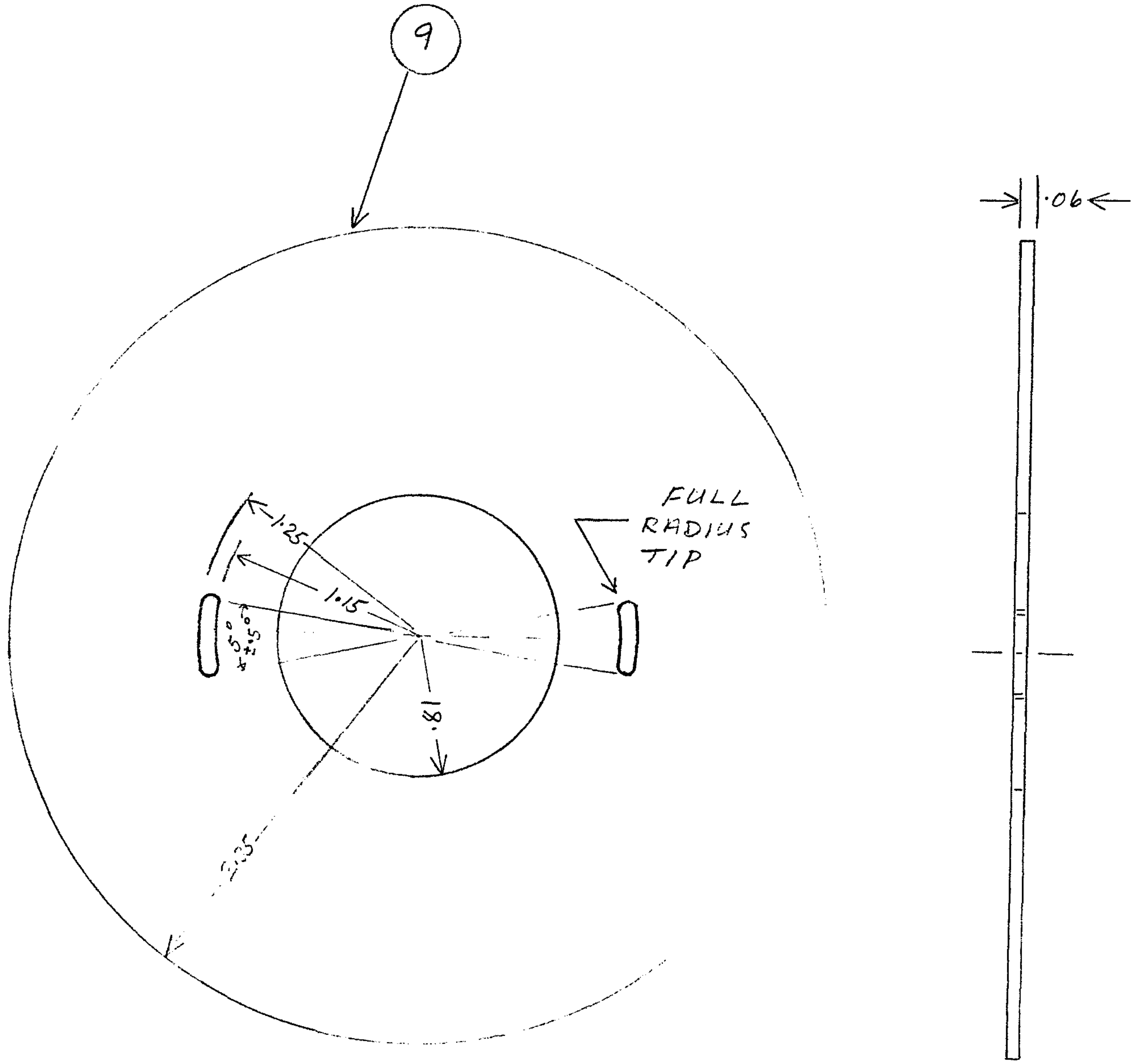
C. Place the composite signal generator function switch in the EXT VIDEO/SYNC position. After 10 sec. in the EXT VIDEO/SYNC position, place the comp. sig. gen. function switch in the TONE position. After 10 sec. in the TONE position place the comp. sig. gen. function switch in the STAIRSTEP position. After 10 sec. in the STAIRSTEP position place the comp. sig. gen. in the MULTIBURST position. After 10 sec. in the MULTIBURST position, place the comp. sig. gen. in the BAR position. After 20 sec. in the BAR position, place the comp. sig. gen. in the EXT. VIDEO/SYNC position and stop the GRE camera.

5. MAGAZINE REMOVAL

When magazine is to be removed for film processing, start GRE camera and run approximately 5 feet of film, as seen on camera footage indicator. Remove magazine, opposite of method in Item 1 of this procedure. Mark footage used on magazine and return footage counter to 000.

# APPENDIX D

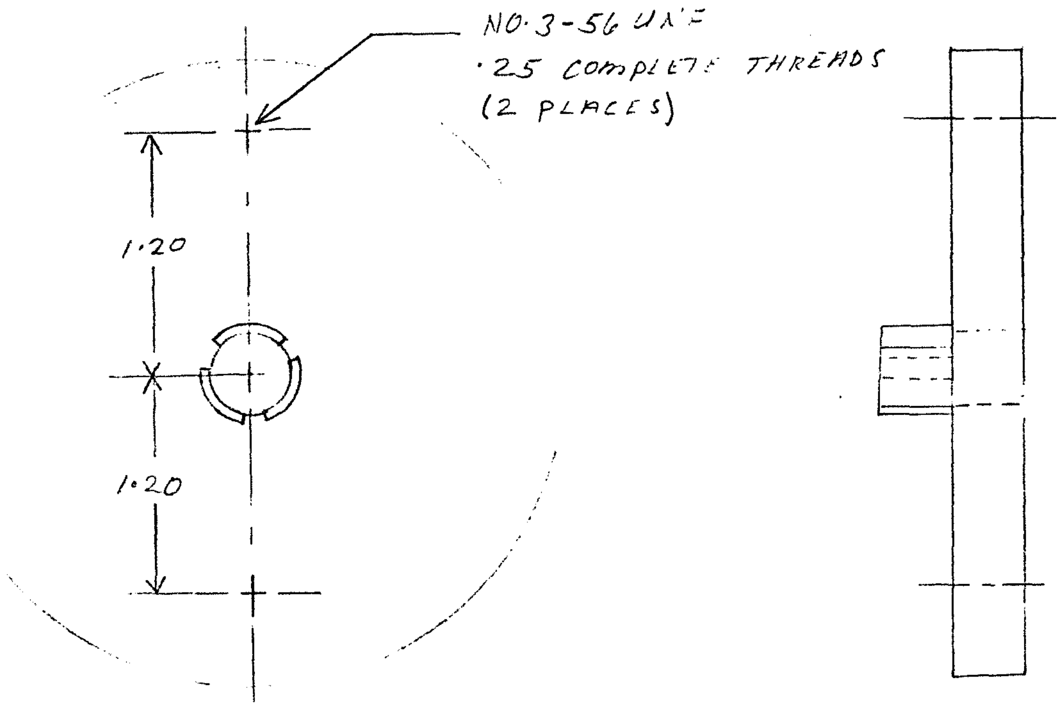
MECHANICAL DESIGN DRAWINGS FOR GRE #2




MAT'L: PLEXIGLASS

| TOLERANCE |
| --- |
| .X - .030 |
| .XX - .010 |
| .XXX - .005 |

| | |
| --- | --- |
| [illegible] | [illegible] |
| DISC TIME [illegible] MOUNT | |
| PART NO. [illegible] 0 | |

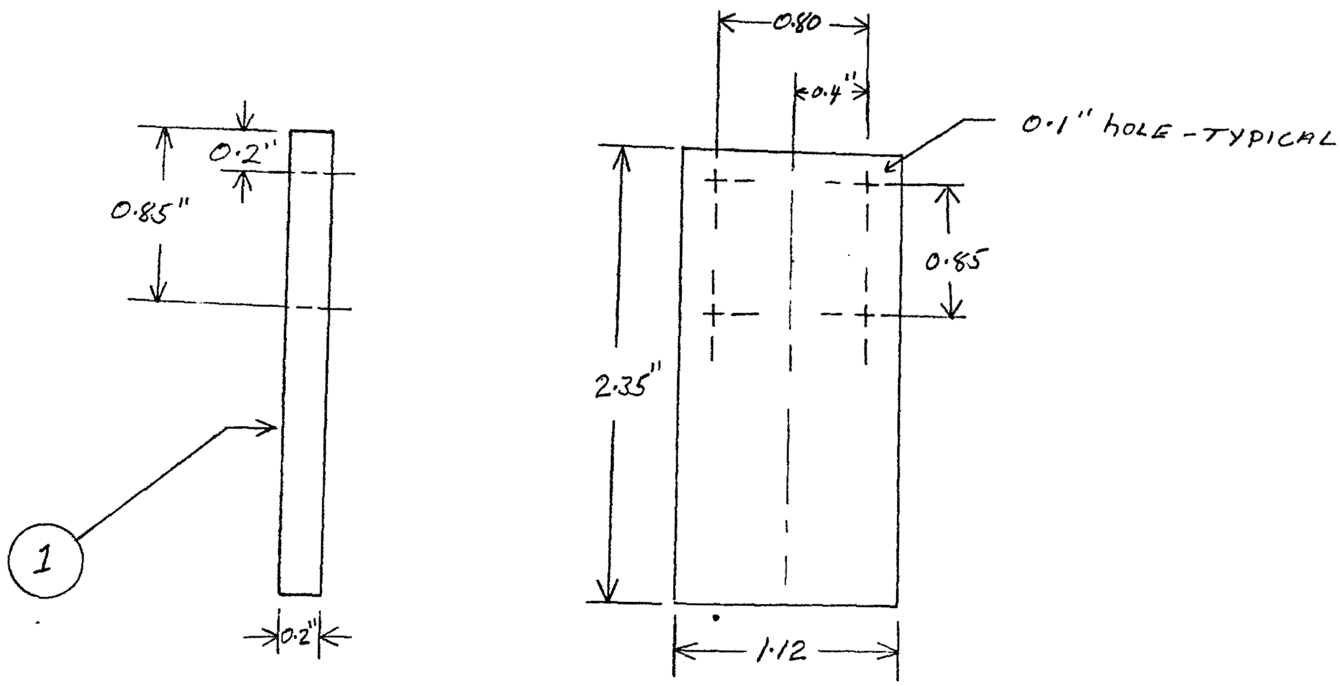



NOTE: TAP & THREAD TWO HOLES IN ACCOMPANYING GEAR

GFE

TOLERANCE

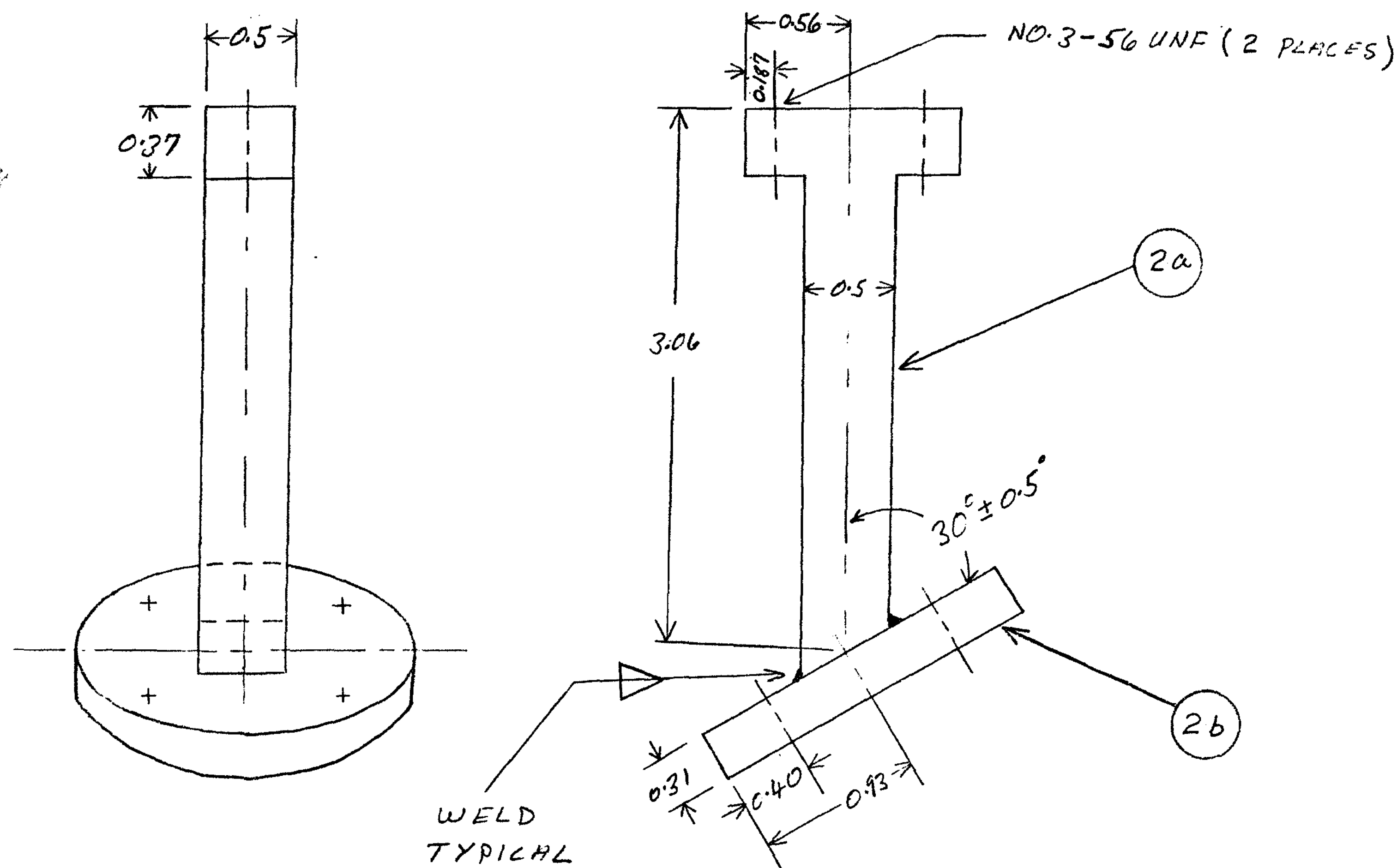
.101

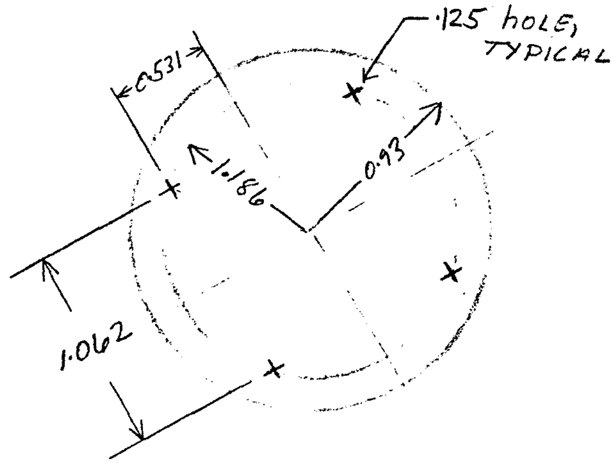



MAT'L: NYLON

| TOLERANCE |
|---|
| .X - .030 |
| .XX - .010 |
| .XXX - .005 |

| THE BOEING CO. | 1-1-69 |
|---|---|
| SUPPORT PLATE, OPT. TECH. MOUNT | |
| PART NO. GRE-102 | |



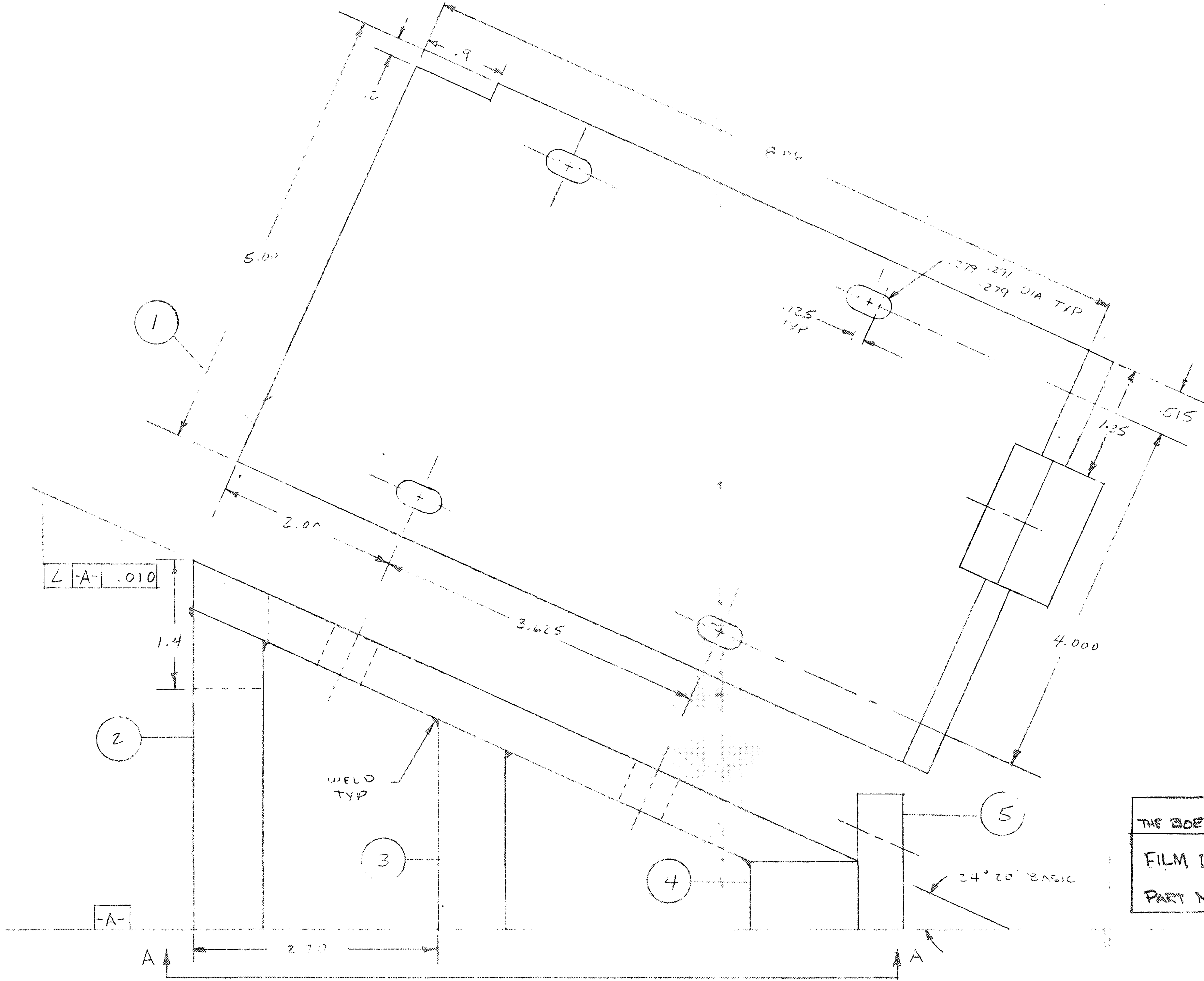




MAT'L: 6061 T6 AL

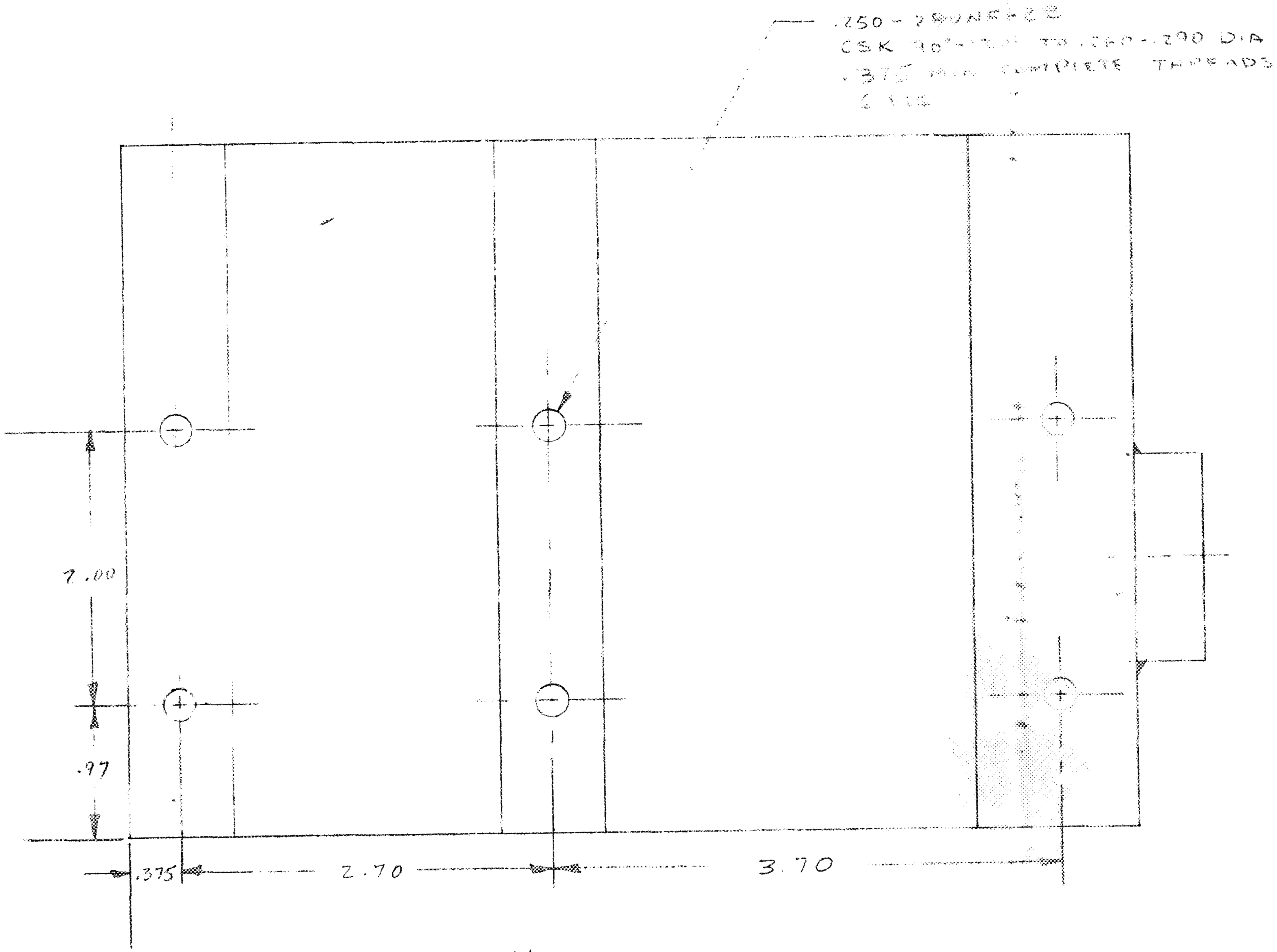
| TOLERANCE |
| --- |
| .X - .030 |
| .XX - .010 |
| .XXX - .005 |

| | |
| --- | --- |
| THE [illegible] | 12/5/69 |

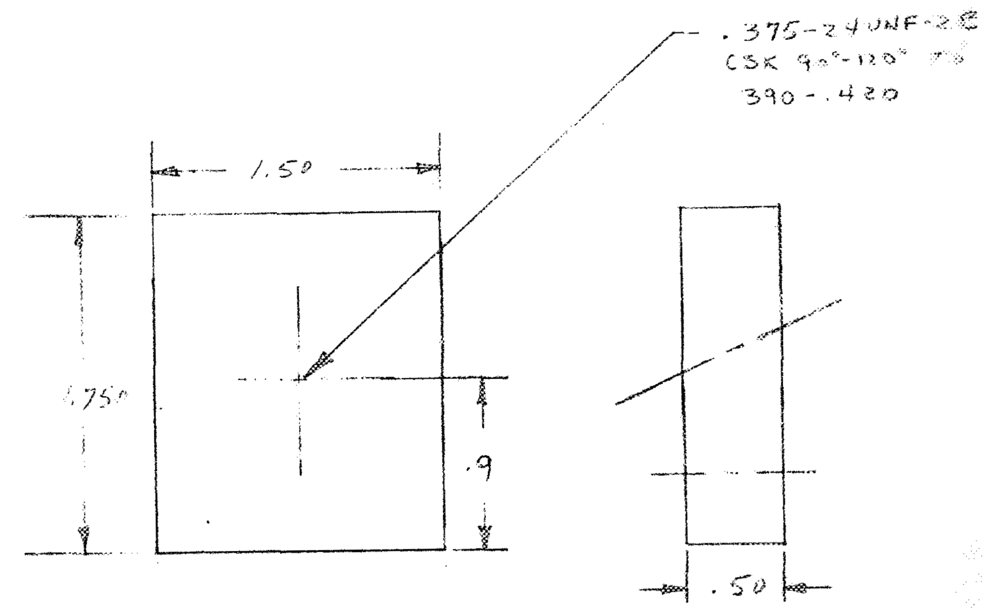
SUPPORT ASSY, OPT. TACH. MOUNT
PART NO. [illegible] -103



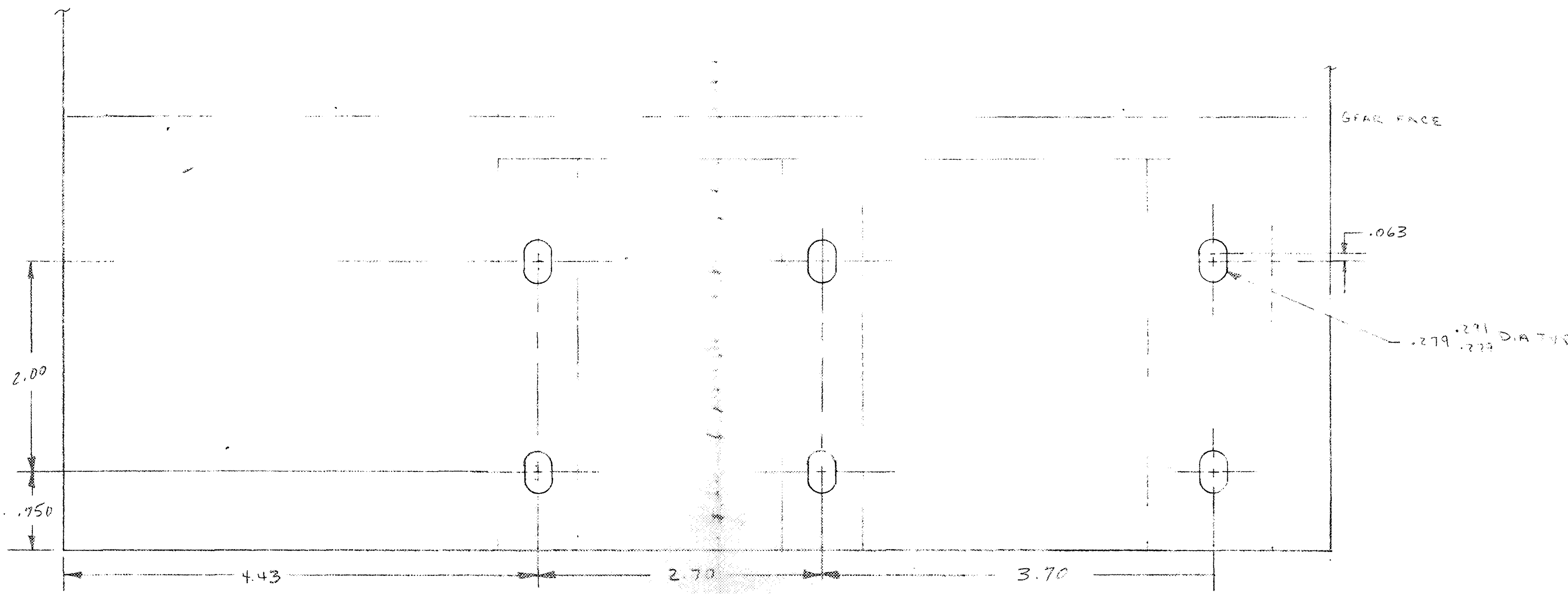

| | | |
|---|---|---|
| THE BOEING CO. | 7/25/69 | TOLERANCE<br>.X - .030<br>.XX - .010<br>.XXX - .005 |
| FILM DRIVE MOTOR MOUNT | | |
| PART NO GRE-1C4 | | |
| | | SH 1 OF 3 |



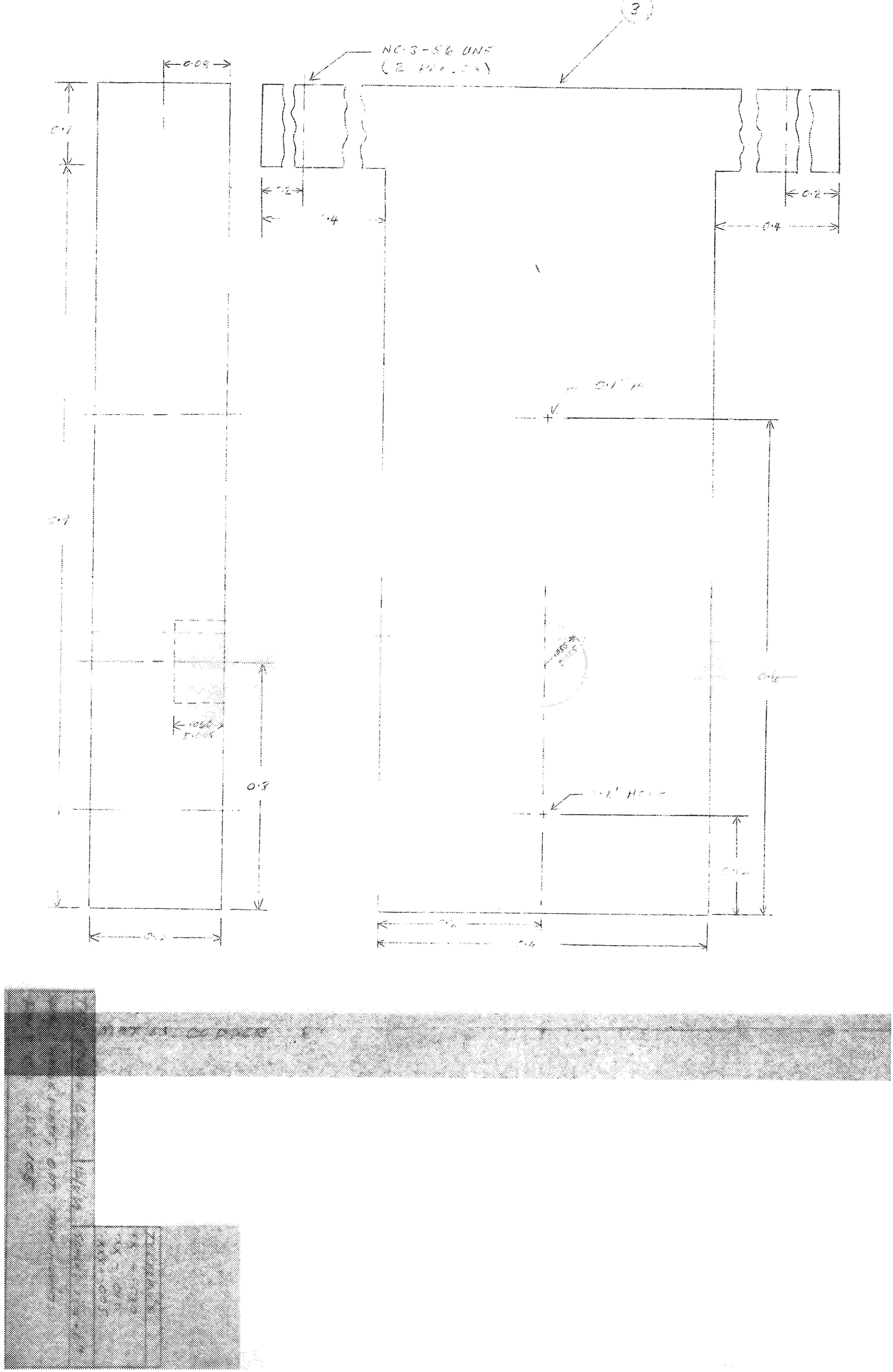

VIEW A-A

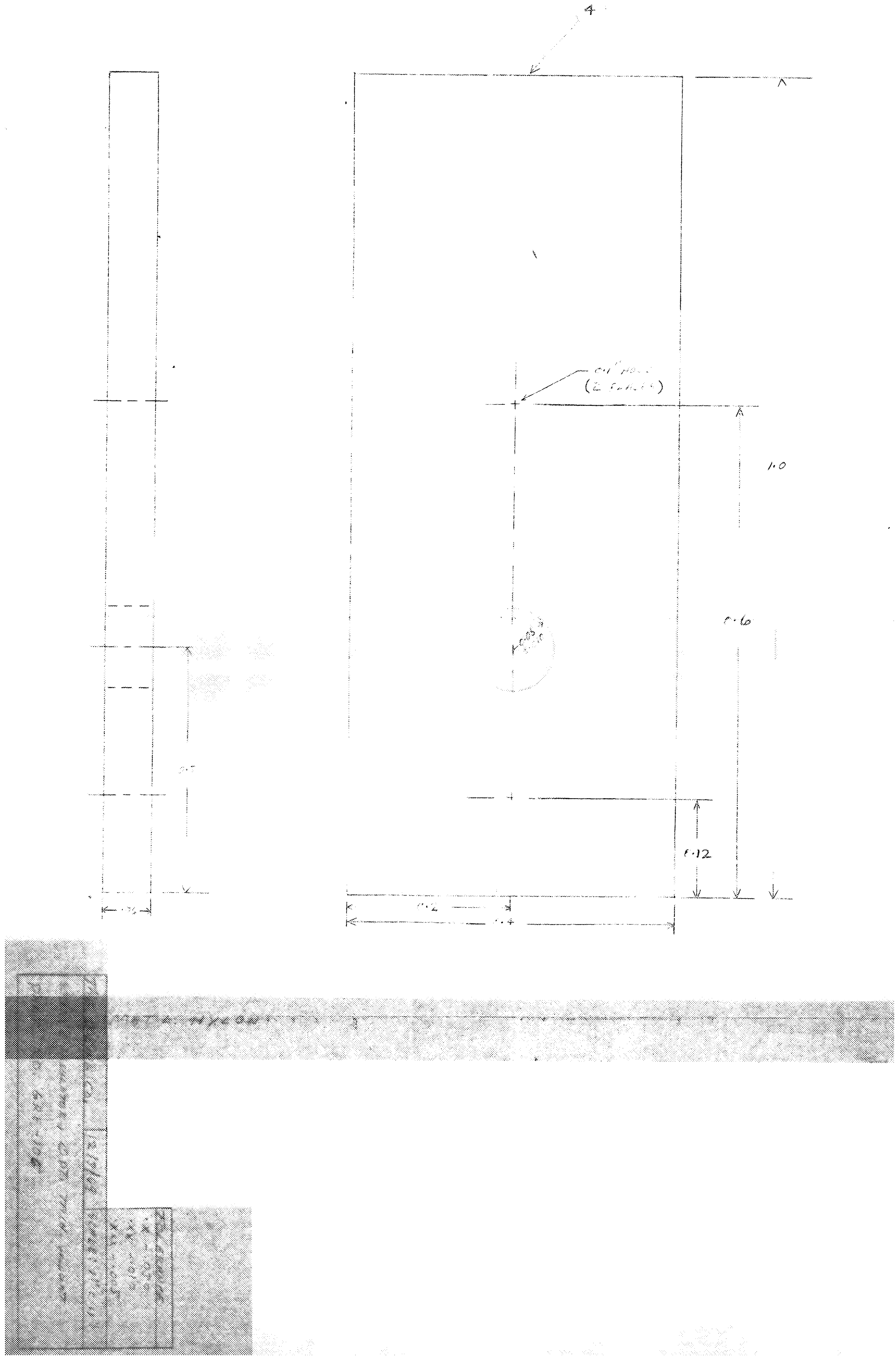


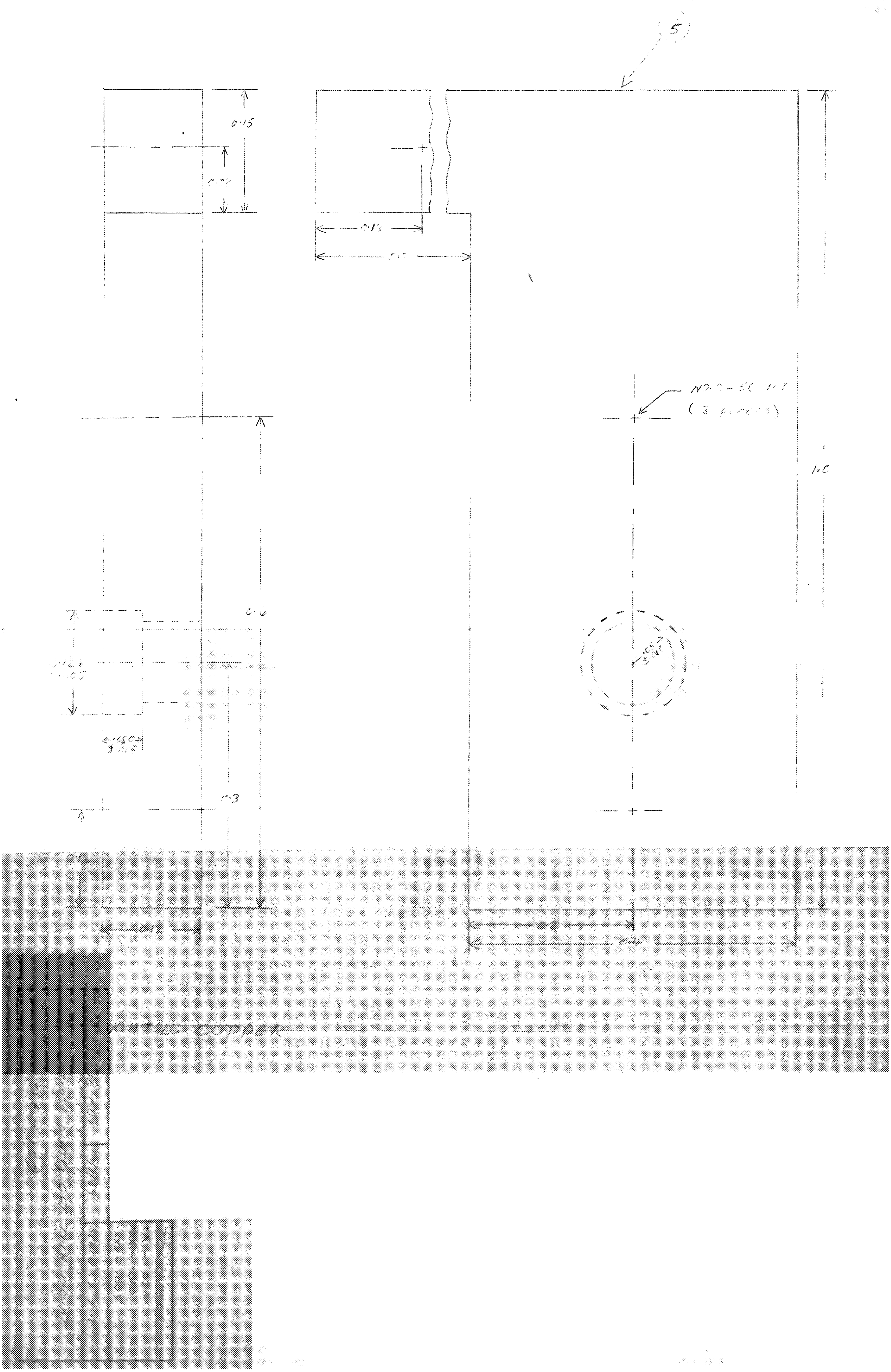

FILM DRIVE MOTOR MOUNT
PART NO. GRE-104
SH 2 OF 3

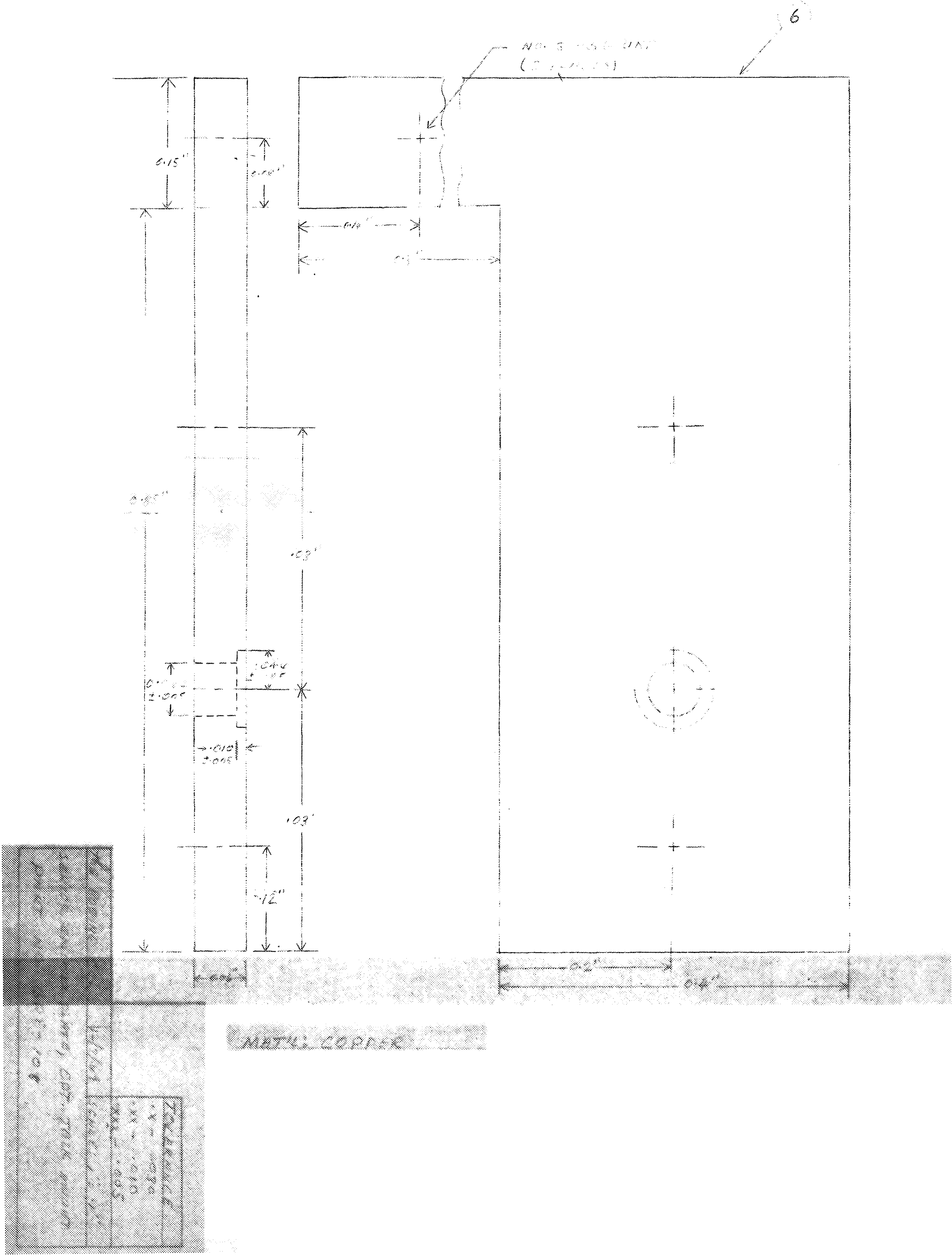



FILM DRIVE MOTOR MOUNT
PART No GRE-104
SH 3 of 3

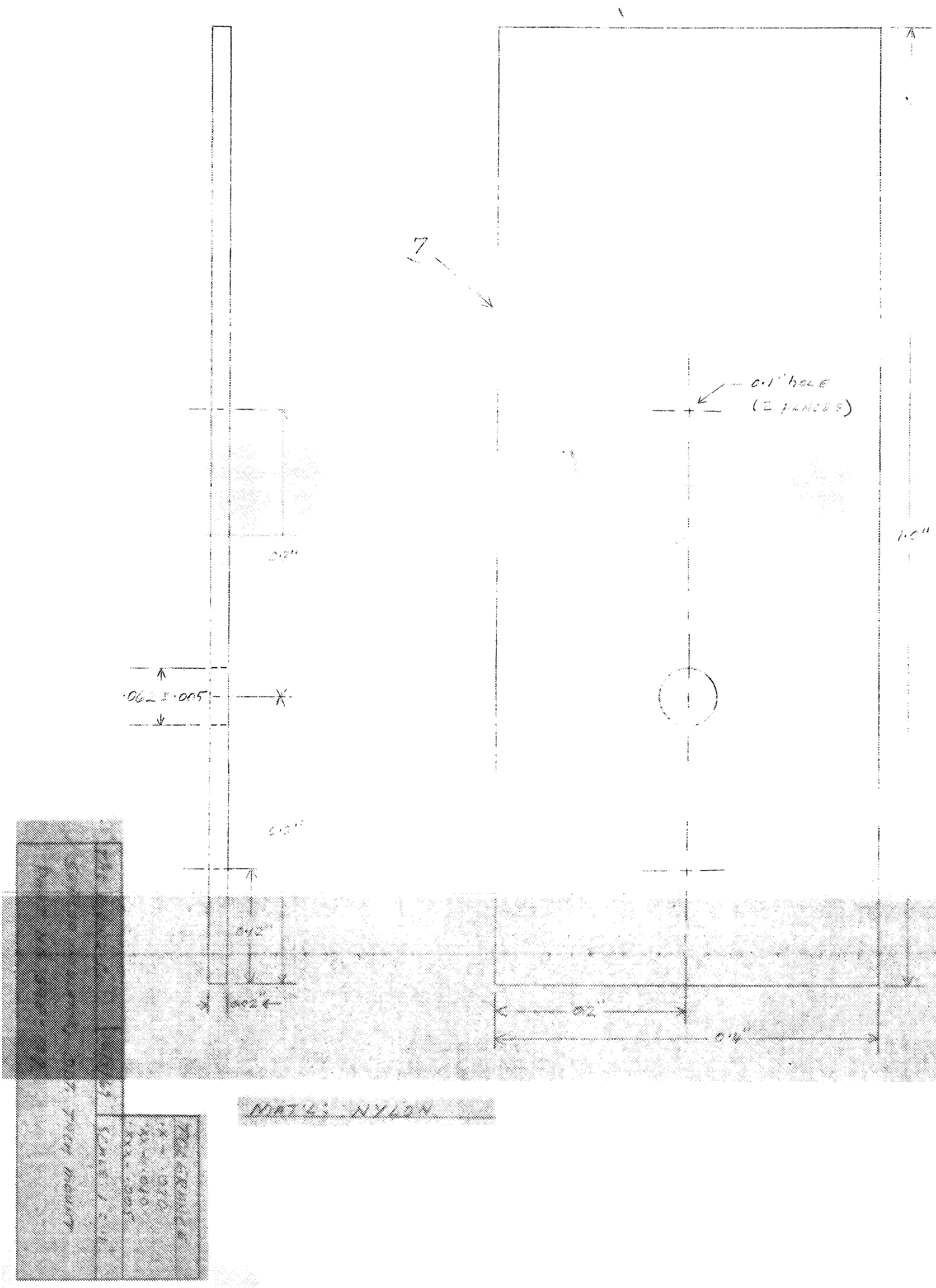

3
NC-3-56 UNF
0.09
0.7
0.2
0.4
0.3

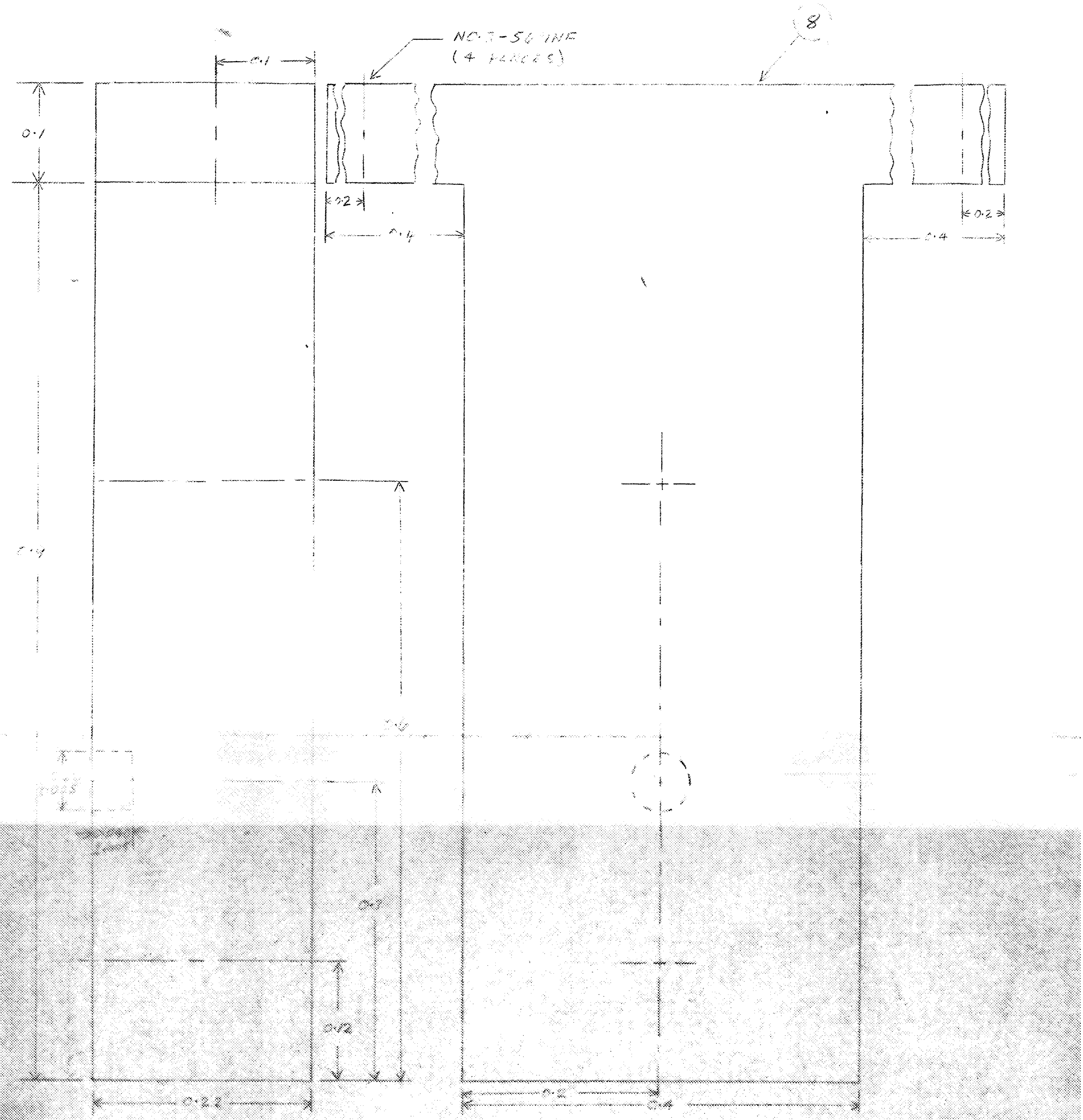

4
1.0
0.12


5
0.15
0.08
0.15
NO. 2-56 TAP
(3 places)
1.0
0.6
0.124
0.3
0.12
0.2
0.4
MATL: COPPER

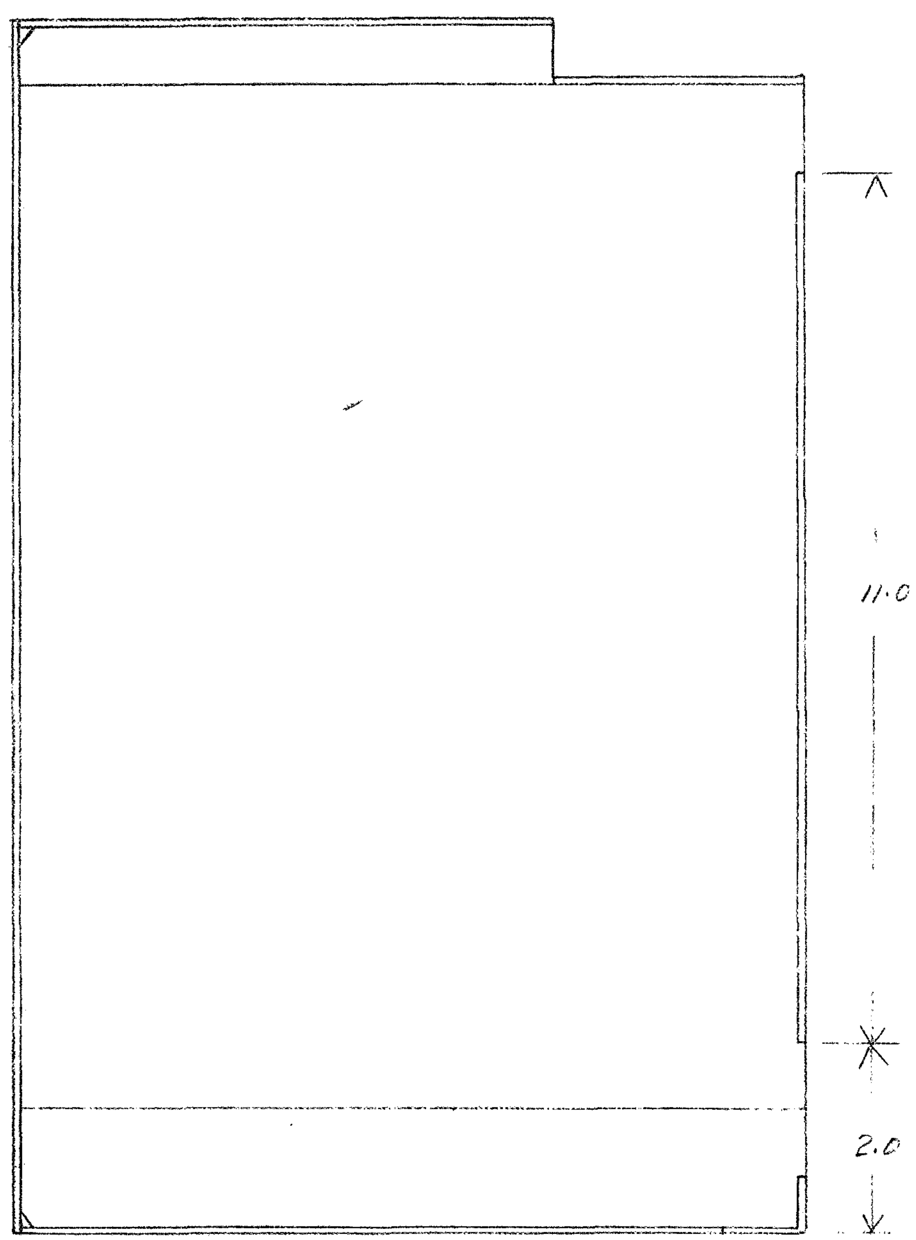


6
0.15"
.12"
1.03"
MATL: COPPER


0.1" hole
(2 places)
1.0"
0.2"
.062 ± .005
7
.02"
0.4"
MAT'L: NYLON




MAT'L: COPPER

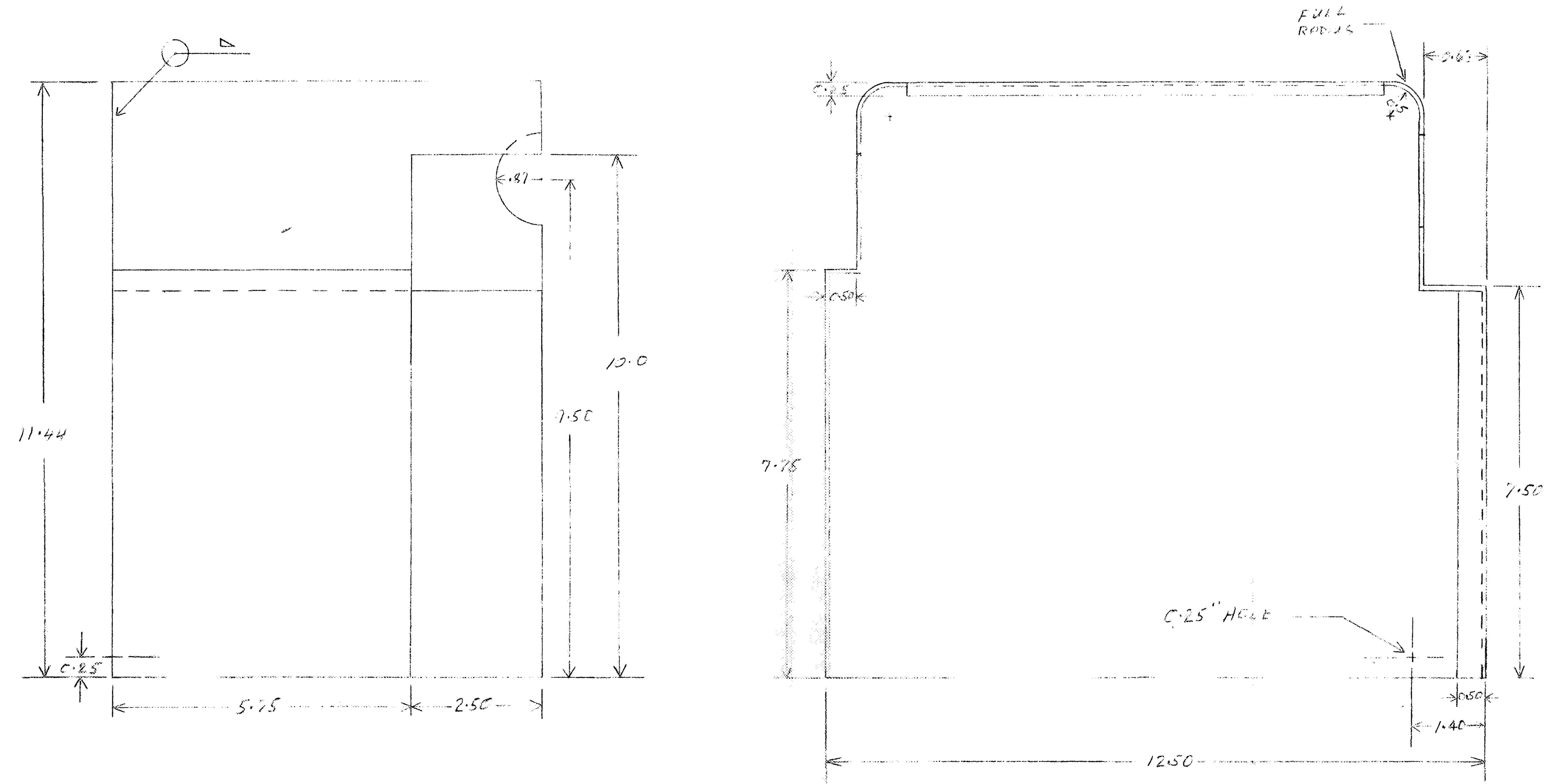



MAT'L: .063" 6061 AL. ALUM

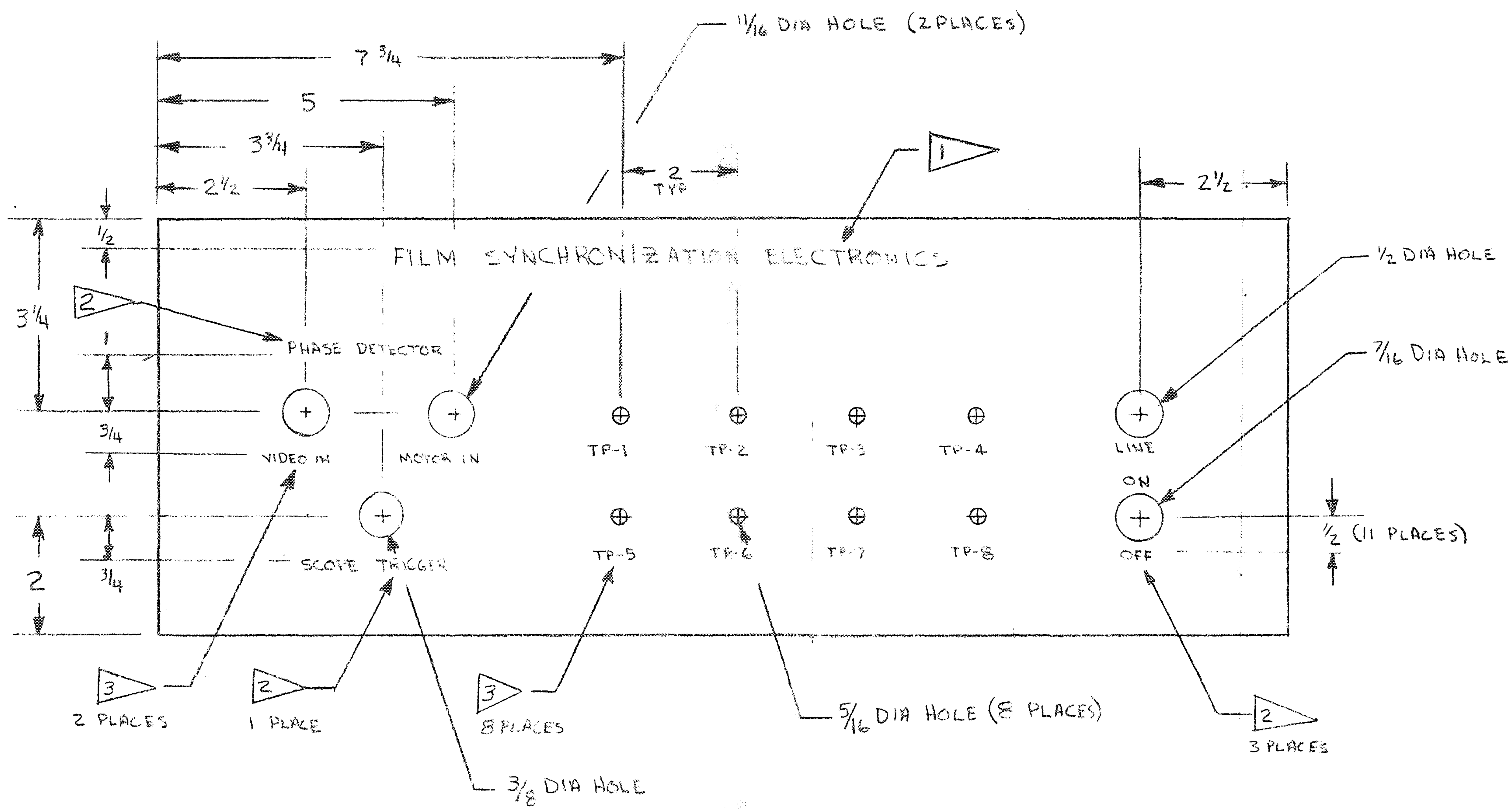
NOTE: PAINT EXTERIOR GOVERNMENT GREY

PAINT INTERIOR BLACK

| | | |
|---|---|---|
| | | TOLERANCE |
| | | .X - .030 |
| | | .XX - .010 |
| | | .XXX - .005 |
| The Boema Co. | 3/25/70 | SCALE: 1/2 |
| GRB #2 COVER | | |
| PART NO. GRB-111 | | |
| | | SH 1 of 2 |




GRC #2 COVER
PART NO. GRC-111
SH 2 OF 2




FLAG NOTES

1. ENGRAVE 1/4 IN HIGH BLOCK LETTERS, HORIZONTALLY CENTERED, BLACK
2. ENGRAVE 3/16 IN HIGH BLOCK LETTERS, BLACK
3. ENGRAVE 1/8 IN HIGH BLOCK LETTERS, BLACK
4. MAKE FROM A 7" x 17" BLANK PANEL.

| The Foxens Co. | 3/16/70 | Scale 1/2 |
|---|---|---|

PANEL - GRE 2
FILM SYNCHRONIZATION ELECTRONICS
PART NO. G1 112