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CBS LABORATORIES

ELECTROSTATIC CAMERA SYSTEM

FUNCTIONAL DESIGN STUDY

FINAL REPORT

25 February 1972

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ABSTRACT

A functional design study for an Electrostatic Camera System for application to planetary missions is presented. The Electrostatic Camera can produce and store a large number of pictures and provide for transmission of the stored information at arbitrary times after exposure. Preliminary configuration drawings and circuit diagrams for the system are illustrated. The camera system's size, weight, power consumption, and performance are characterized. Trade offs between system weight, power and storage capacity are identified.

SUMMARY

The objective of this study was to prepare a functional design of an Electrostatic Camera System for possible application on an Outer Planet spacecraft. The scope of the study was limited to the preparation of a functional design for an Electrostatic Camera which completely characterized the weight, size, power consumption, configuration and performance of the system. In addition, trade studies were conducted to identify trade offs between system variables, and the influence of interference effects on system performance was analyzed.

The Electrostatic Camera can simultaneously expose and store a large number of pictures within the camera tube and provide for transmission of the data at arbitrary times following optical exposure. The Electrostatic Camera System will significantly increase the quantity of data handled, will remove mission limitations imposed by the buffer store/magnetic tape recorder used in the baseline system and will improve overall system performance. The camera system will resolve 1000 lines x 1000 pixels at a minimum of 20% response over a dynamic range of greater than 64:1. At an exposure of 0.04 ergs/cm^2 the signal-to-noise ratio will be 50 to 1 or greater. The camera system will provide at least 30 frames of storage which may be retained for many weeks before being transmitted. The stored information may be repeatedly scanned without degradation.

Functional block diagrams were first prepared for the system and an analysis of the performance of the blocks was conducted. Preliminary configuration drawings of the camera system were prepared. This was followed by a weight and power analysis. The camera head can be packaged

within a 4 1/2" high x 8 1/4" wide x 22" long volume, and will weigh approximately 16 pounds exclusive of the optical assembly. Two complete camera systems, minus optical packages, will weigh about 41 pounds. A maximum power consumption of 27.1 watts will be required if both tubes are operated with one camera in the readout mode while the other is being exposed. Operation of a single camera simultaneously in both the expose and readout modes will require less than 23 watts of power.

A reel to reel camera configuration with a storage capacity of 500 frames has been described. Also presented is an electromagnetically focused version of the Electrostatic Camera. Details of these systems are presented.

Circuit diagrams and detailed component board layouts for the electronics of the camera system have been prepared in order to perform an accurate power and weight analysis. These circuit drawings along with circuit descriptions are located in Appendix II.

The next logical step in advancing the Electrostatic Camera System concept is to develop a demonstration model applicable to future planetary missions. A developmental program sponsored by NASA is recommended and appears justified based on the potential capabilities presented in this report.

SECTION I

INTRODUCTION

1.0 GENERAL

The objective of this study was to prepare a functional design of an Electrostatic Camera System (ECS) for possible application on an Outer Planet spacecraft. The design study involved both a mechanical and electrical analysis and has resulted in the determination of the size, weight, power consumption, configuration and performance estimates for the camera system.

The outer planet missions will be unique in many respects. Missions will be very long punctuated by brief encounters with the planets being explored. Data acquisitions must generally be stored on board the spacecraft during these encounters and then transmitted during post encounter periods. The data gathering system consequently must have a large capacity, long shelf life and be capable of reliable reactivation and operation. In the baseline imaging system magnetic tape recorders are used in conjunction with an electronic buffer to store data received by the camera. The ECS achieves these tasks by combining the image sensing and data storage functions into a single operation within the camera head. The system can simultaneously expose and store a large number of pictures within the camera tube and provide for transmission of the data at arbitrary times following optical exposure. Mission profile limitations imposed by the buffer store/magnetic tape recorder are relieved as these components are no longer required. The Electrostatic Camera System concept appears highly suited to long missions requiring repetitive visual imaging and high capacity data storage.

Long planetary missions impose stringent demands on the visual sensing instruments. The camera systems must be lightweight, consume little power and produce high resolution pictures over a wide range of light levels while operating unattended. They must be rugged to withstand the hazards of launch, radiation and space debris, and must perform properly within the planetary magnetic environments. This study will address these requirements and show how they relate to the ECS.

The functional design characteristics and performance requirements for the ECS have been defined by the Jet Propulsion Laboratory and are compiled under Technical Exhibit No. 1 in Appendix I. These requirements, taken in conjunction with the environmental design characteristics and restraints covered in TOPS-3-300, were used of the design criteria for this study. The camera was designed to meet the performance goals established by these documents. In general, these requirements do not represent the limiting capacities of the ECS. The system has considerable flexibility and can be changed to match a variety of mission requirements. The camera system can potentially grow with the overall spacecraft system to match increased data rates, improved optics, more demanding resolution requirements and other future needs.

The need for an improved camera system for planetary exploration is clearly evident. CBS Laboratories has a long and continuing history of successful sensor development for space applications. The laboratories has maintained modest, in-house, study programs over the past several years which closely paralleled the technology required to develop the ECS. All of the critical concepts of combining image data acquisition and storage in one device have been experimentally proven. No new technology is required. We have the highest confidence that this technological base of proven concepts and components can be combined to produce the ECS.

The Imaging Science Team, responsible for the visual characterization of the outer planets, has recognized the need for the development of the ECS, also called the Dielectric Tape Camera (DTC). The report of the Imaging Science Team, Part 1, dated February 1, 1972 on the Grand Tour Outer Planet Missions Definition Phase contains the following two statements:

"One instrument, the Dielectric Tape Camera (DTC) appears well suited to the Outer Planet Missions, although it is still in the early stage of development. In addition, the camera itself provides long term storage for several pictures, thereby eliminating the need for an auxiliary storage device such as a magnetic tape recorder. The team believes that the potential capabilities of the DTC are so great that a vigorous developmental program sponsored by NASA is justified."

"The DTC would be an ideal choice for the Grand Tour missions except that it is not a fully developed instrument."

The scope of this study is limited to the preparation of a functional design for an electrostatic camera. The study was divided into a number of major tasks. First, functional block diagrams of the system were prepared which identified and showed the relationship among the major functioning blocks of the system. A functional block analysis was then conducted in which the performance of each block was analyzed. Preliminary configuration drawings of the camera system were prepared.

With this information in hand, a weight analysis of the system was completed and an estimate of the parts count obtained. This was followed by an analysis of the total system power consumption in each of the system's operating modes. This resulted in a complete characterization of the weight, size, power consumption, configuration and performance of the camera system.

Additional tasks included trade studies to identify trade offs between system weight, power and storage capacity. Different imaging methods were also considered. The influence of interference effects were analyzed as they relate to the performance of the camera system. Finally, our previous experience applicable to the development of the ECS was reviewed.

SECTION II

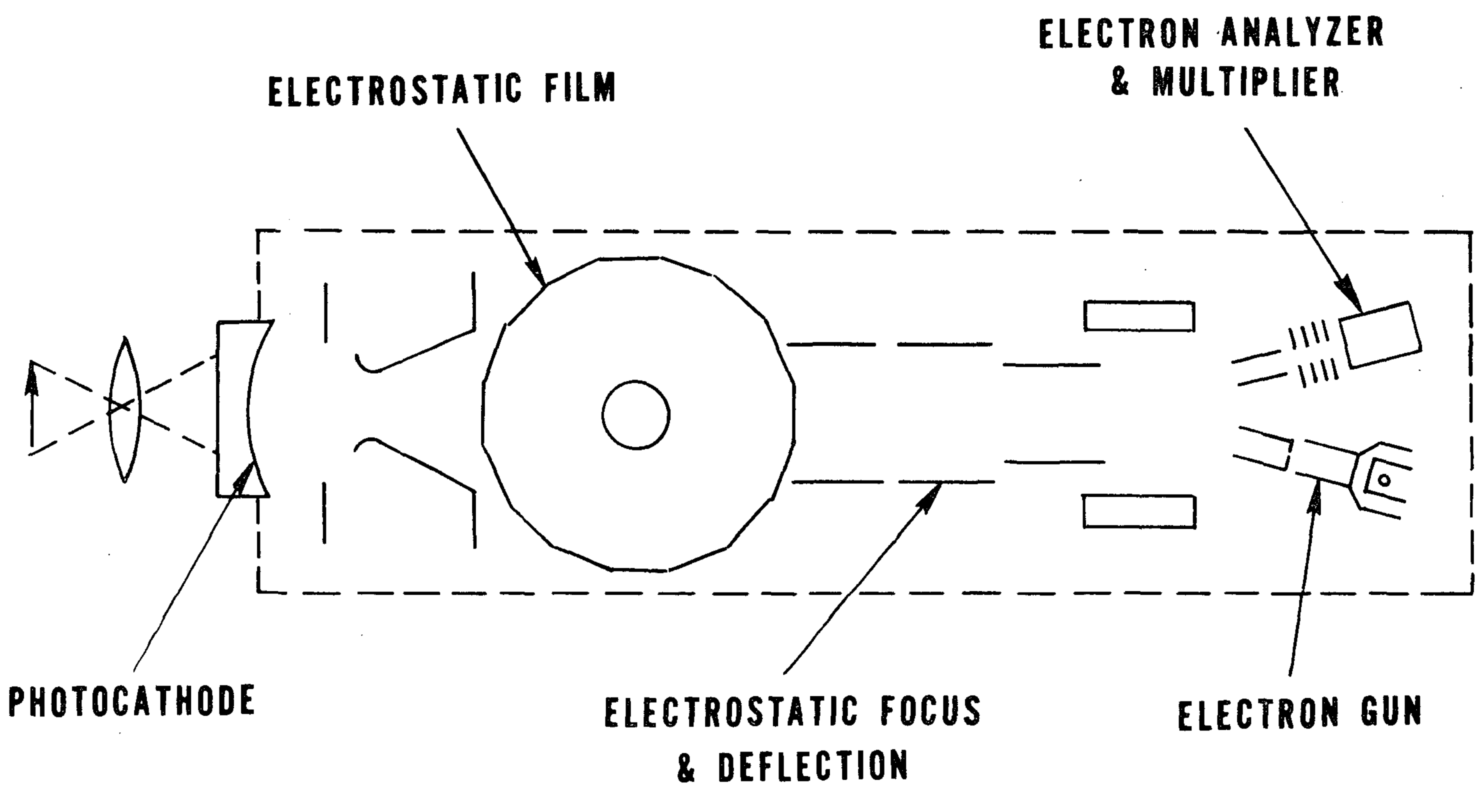
TECHNICAL DISCUSSION

2.0 GENERAL

The Electrostatic Camera is schematically shown in Figure 2.1-1. An electrostatic image section, storage film and storage film transport are used to produce, record and store a large number of high resolution pictures during planet encounters. The stored information can be converted into an electrical signal a frame at a time by the readout section for transmission to earth.

2.1 CAMERA TUBE OPERATION

Camera operating functions consist of priming, exposure, storage and readout. Prior to exposure, a selected portion of the storage film is moved into the priming position where it is flooded with low energy electrons. The priming serves to remove previous potential patterns from the storage surface and to prepare the film for subsequent recording. During exposure the image section serves to convert optical images into electrostatic charge patterns on the storage film. The charge pattern generated on the film surface is the result of electron-bombardment conductivity induced in the silicon dioxide by high energy photoelectrons. The high gain inherent in this process is required for high signal-to-noise ratio considerations and results in quantum noise limited camera operation over most of the desired dynamic range. The film with a sequence of stored images can be retained for subsequent reading as desired. During readout, the frame selected for transmission is moved into the reading position where it is scanned by a reading beam. The scanning electrons land on the storage target and create



ELECTROSTATIC CAMERA

Figure 2.1-1

a secondary electron return beam. The return beam is reflected back to an electron analyzer/multiplier assembly where a modulated output signal is produced corresponding to the stored charge pattern. A time varying output signal of the image is generated in this manner for processing and transmission over the communications data link. The reading process does not erase and the images may be repeatedly scanned.

2.2 FUNCTIONAL BLOCK DIAGRAM

The preliminary functional block diagram, Figure 2.2-1, illustrates the overall ECS. The basic camera tube is represented by functional blocks #1 through #8. The camera's optical subsystem including optical assembly, cover, filter wheel, shutter, and optics heater, does not constitute a portion of this study. They are shown in the functional block diagram to illustrate interfacing functions, but will not be included in the weight analysis or configuration drawings.

For purposes of description, it is convenient to separate the functional blocks pertaining to the various operating modes of the ECS, namely; exposure, drum transport, and readout or erase modes.

2.2.1 THE EXPOSURE MODE FUNCTIONAL BLOCKS

Operation of the ECS in the exposure mode is required to produce and record a frame of pictorial information on the storage medium.

The control and conditioning logic matrix, block #33, will receive and decode all of the appropriate camera commands during exposure. A preliminary list of commands is shown. The control logic matrix will direct the decoded commands to the appropriate block or control function. It will allow

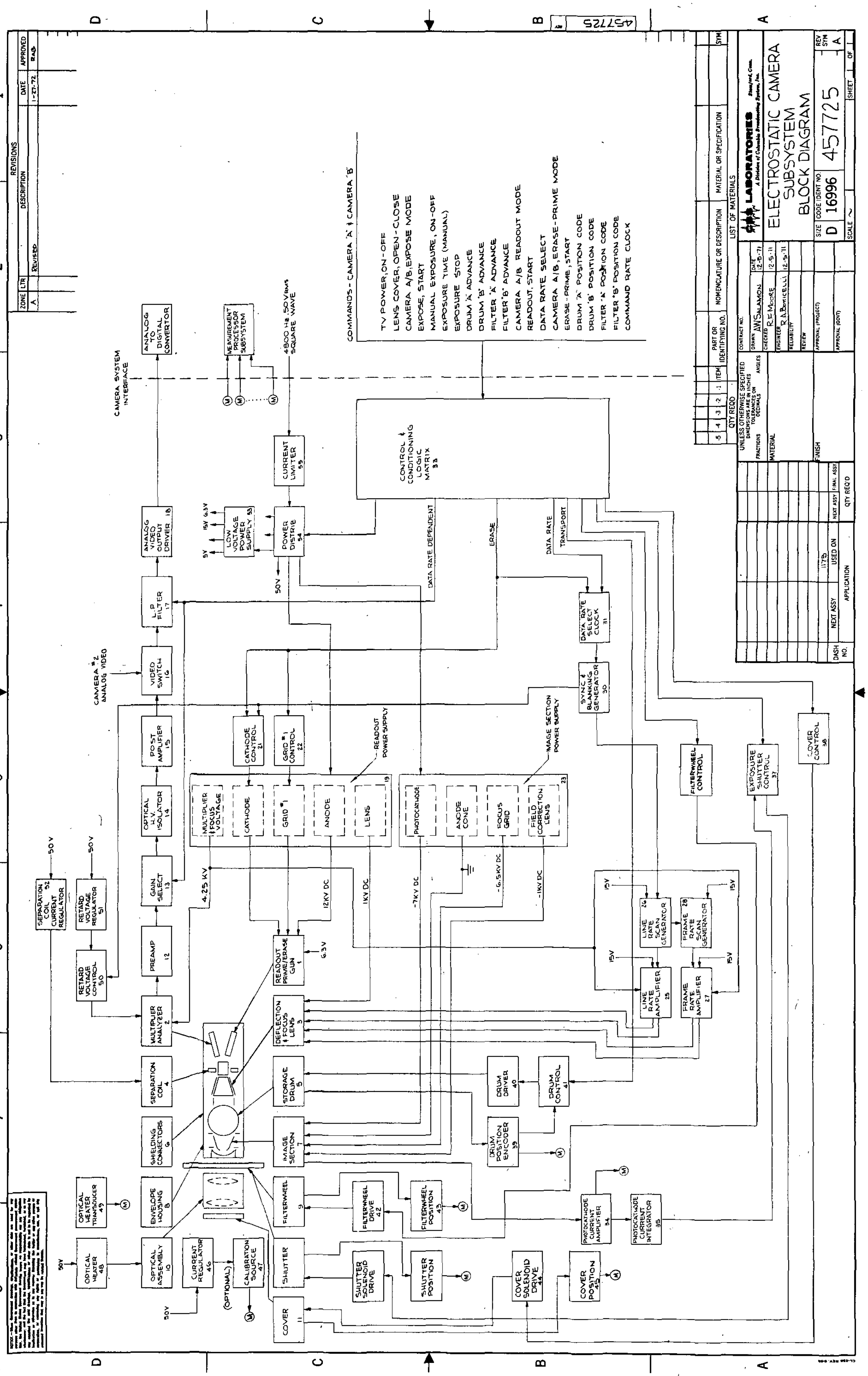

ELECTROSTATIC CAMERA SUBSYSTEM BLOCK DIAGRAM
CBS LABORATORIES A Division of Columbia Broadcasting System, Inc. Stamford, Conn.
D 16996 457725
COMMANDS - CAMERA 'A' & CAMERA 'B'
TV POWER, ON-OFF
LENS COVER, OPEN-CLOSE
CAMERA A/B, EXPOSE MODE
EXPOSE, START
MANUAL EXPOSURE, ON-OFF
EXPOSURE TIME (MANUAL)
EXPOSURE STOP
DRUM 'A' ADVANCE
DRUM 'B' ADVANCE
FILTER 'A' ADVANCE
FILTER 'B' ADVANCE
CAMERA A/B READOUT MODE
READOUT, START
DATA RATE SELECT
CAMERA A/B, ERASE-PRIME MODE
ERASE-PRIME, START
DRUM 'A' POSITION CODE
DRUM 'B' POSITION CODE
FILTER 'A' POSITION CODE
FILTER 'B' POSITION CODE
COMMAND RATE CLOCK
CAMERA SYSTEM INTERFACE
CONTROL & CONDITIONING LOGIC MATRIX 33
ANALOG TO DIGITAL CONVERTOR
MEASUREMENT PROCESSOR SUBSYSTEM
4800 Hz 50VRMS SQUARE WAVE
CURRENT LIMITER 55
LOW VOLTAGE POWER SUPPLY 53
POWER DISTRIB 54
ANALOG VIDEO OUTPUT DRIVER 18
L.P. FILTER 17
VIDEO SWITCH 16
CAMERA #2 ANALOG VIDEO
POST AMPLIFIER 15
OPTICAL H.V. ISOLATOR 14
GAIN SELECT 13
PREAMP 12
MULTIPLIER ANALYZER 2
SEPARATION COIL 4
SHIELDING CONNECTORS 6
ENVELOPE HOUSING 8
OPTICAL ASSEMBLY 10
COVER 11
SHUTTER
FILTERWHEEL 9
IMAGE SECTION 7
STORAGE DRUM 5
DEFLECTION & FOCUS LENS 3
READOUT PRIME/ERASE GUN 1
CATHODE CONTROL 21
GRID #1 CONTROL 22
READOUT POWER SUPPLY 19
MULTIPLIER & FOCUS VOLTAGE
CATHODE
GRID #1
ANODE
LENS
IMAGE SECTION POWER SUPPLY 23
PHOTOCATHODE
ANODE CONE
FOCUS GRID
FIELD CORRECTION LENS
DATA RATE SELECT CLOCK 31
SYNC & BLANKING GENERATOR 30
LINE RATE SCAN GENERATOR 26
FRAME RATE SCAN GENERATOR 28
LINE RATE AMPLIFIER 25
FRAME RATE AMPLIFIER 27
FILTERWHEEL CONTROL
EXPOSURE SHUTTER CONTROL 37
COVER CONTROL 38
DRUM DRIVER 40
DRUM CONTROL 41
DRUM POSITION ENCODER 39
FILTERWHEEL DRIVE 42
FILTERWHEEL POSITION 43
PHOTOCATHODE CURRENT AMPLIFIER 34
PHOTOCATHODE CURRENT INTEGRATOR 35
SHUTTER SOLENOID DRIVE
SHUTTER POSITION
COVER SOLENOID DRIVE 44
COVER POSITION 45
SEPARATION COIL CURRENT REGULATOR 52
RETARD VOLTAGE REGULATOR 51
RETARD VOLTAGE CONTROL 50
OPTICAL HEATER TRANSDUCER 49
OPTICAL HEATER 48
CURRENT REGULATOR 46
CALIBRATION SOURCE 47
(OPTIONAL)
DATA RATE DEPENDENT
ERASE
DATA RATE
TRANSPORT
4.25 KV
12KV DC
1KV DC
-7KV DC
-6.5KV DC
-1KV DC

Figure 2.2-1

independent use of the image section during exposure or the readout section for power conservation by controlling the power distribution circuit. The power distribution circuit, block #54, routes power to only the desired circuits. The current limiter provides overload protection for the spacecraft power source.

The image section power supply, block #23, provides all of the necessary potentials to operate the image section during exposure. The photocathode at -7 KV dc, the focus grid at -6.5 KV dc, and the field correction lens at -1 KV dc are all controlled by this supply. The anode cone is at ground potential.

The cover, shutter and filter wheel in the optical assembly will also be controlled by the control and conditioning logic matrix. Each will be operated by a solenoid drive and activated by discharging a capacitor bank into the solenoid windings. The position of each element will be determined and routed to the measurements processing subsystem.

Exposure can be either automatic or manual. Several different automatic control systems have been considered. The method used on Mariner Mars 1971 remains a good choice, but suffers from the limitation that the exposure is set during the previous frame. The alternative used in this study sets the automatic exposure while the current frame is being exposed. The exposure shutter control, block #37, provides a reference signal which is proportional to the charge density required to store a picture. The average charge density required for proper exposure of the storage medium remains constant from picture to picture. When the shutter open command is received by the exposure shutter control, it energizes the shutter drive and starts the exposure. The photocathode current is sensed and amplified by block #34, then integrated and compared to the reference signal. When the integrated photocathode current equals the reference signal, a shutter close pulse is initiated which ends the exposure.

2.2.2 DRUM TRANSPORT FUNCTIONAL BLOCKS

The storage drum provides a 30 frame expose and store capability. The drum must be rotated after each frame is exposed. Drum advance pulses will come from the control and conditioning logic matrix on command.

Blocks #39 through #41 represent the drum transport circuits. The drum will be advanced by discharging a capacitor into the drum solenoid coils. Drum position will be determined using a photodetection circuit which consists of five phototransistors positioned opposite five light emitting diodes. The storage drum which contains a series of coded holes will be interposed between these detection elements. The drum position encoder, block #39, receives the binary coded five bit input signal from the photodetectors and routes the information to the measurements processing subsystem. The drum position circuitry is designed to be fully automatic, so that the drum will continue to advance until the desired position is reached. The drum advance system may be simplified if desired so that each command advances the drum one position.

2.2.3 READOUT MODE FUNCTIONAL BLOCKS

The ECS must operate in the readout mode in order to transmit stored pictures. Simultaneous operation in the exposure and readout modes using two frames is possible.

The readout power supply, block #19, provides dc potentials to the electron gun and multiplier. The largest voltage is 12KV dc which supplies the anode. Also supplied are the retard voltage, block #52, and the separation coil current, block #51.

The scanning system, functional blocks #25 through #32, provides the dynamic voltages required to readout or erase a single video frame, depending on the operating mode selected. The scan rates may be varied to accommodate the various transmission rates and erase mode. The system has been designed to operate at four different transmission rates. The data rate select clock will generate clock pulses in accordance with the data rate selected. The sync generator processes the clock pulses to form blanking pulses. These are applied to the readout section of the camera during line retrace. Clock pulses are also fed to the scan generators where 1000 step ramp voltages are formed at the line and frame frequencies. Class A feedback amplifiers with a voltage gain of 100 provide the push-pull deflection voltages which are applied to the deflection plates of the camera tube.

The video signal processing chain, functional blocks #12 through #18, is a base band video system chosen because of the narrow bandwidth necessary for data transmission rates. An alternative considered was a pulse amplitude-modulation system as used in Mariner Mars 1971. The video system consists of a dc coupled video amplifier followed by a gain selection amplifier. The gain selector has four gain states, one for each of the data transmission rates that can be selected. The gain selection switch is required to compensate for the differences in signal current and provide a uniform driving level independent of the transmission rate selected. An optical high voltage isolator is used to isolate the post amplifier from previous stages. These stages operate at multiplier anode potential to permit dc coupling of the video amplifier. The post amplifier will provide the final signal amplification, with sufficient gain to drive the low-pass filter, output stage, and A/D converter input at an appropriate signal level. A video switch following the post amplifier will permit the switching of cameras so that the readout video from either camera can be directed to the A/D converter for transmission. The low-pass filter has been provided to attenuate signal and noise outside of the desired bandwidth. The cutoff frequency of this low-pass filter will be varied in accordance with the data rate selected. Finally, an analog video output driver is used to provide a low output impedance for driving the A/D converter.

All circuits used during readout are also used during the prime/erase mode. During prime/erase the clock frequency is increased to 36 KHz. This reduces the time required to erase a frame to 29.2 seconds. The electron gun is set at a higher grid drive for more beam current to erase and prime the storage medium.

2.3 FUNCTIONAL BLOCK ANALYSIS

2.3.1 CIRCUIT ANALYSIS

In order to obtain reasonably accurate weight and power estimates, each major functional block had to be analyzed in considerable detail. For each major block a circuit diagram was developed, component board layouts were prepared, component lists were compiled, and weight and power estimates performed. This level of effort went into the preparation of each of the following circuits:

A. Low voltage power supply

B. Readout power supply

C. Image section power supply

D. Power distribution and current limiter

E. Control and conditioning logic matrix

F. Line and erase clock

G. Line or frame rate scan generator

H. Deflection amplifier

I. Video chain

J. Exposure system electronics

K. Filter wheel and drum position

Detailed descriptions of these circuits along with circuit diagrams and component board layouts are located in Appendix II of this report.

2.3.2 PERFORMANCE CURVES

An analysis was performed for the ECS to characterize the noise properties which contribute to the desired exposure/signal-to-noise performance. The predicted signal-to-noise performance of the ECS as a function of exposure is indicated in Figure 2.3-1. Curves were calculated using a spatial frequency of 30 lp/mm, an S-20 photodetector with a sensitivity of 150 $\mu A/\ell$, and a 6000°K source.

Starting with the ideal case where the camera is quantum noise limited with zero loss of light, noise terms are added in succession until the entire system is characterized. The upper most curve shows the ideal photoelectron signal-to-noise ratio for 100% light transmission at the faceplate. The second curve from the top, for photoelectron signal-to-noise with 80% light transmission at the faceplate, reflects the loss in transmission associated with the fiber optics window. All noise processes which affect the camera prior to the return beam's entrance into the electron multiplier

SIGNAL / NOISE ANALYSIS

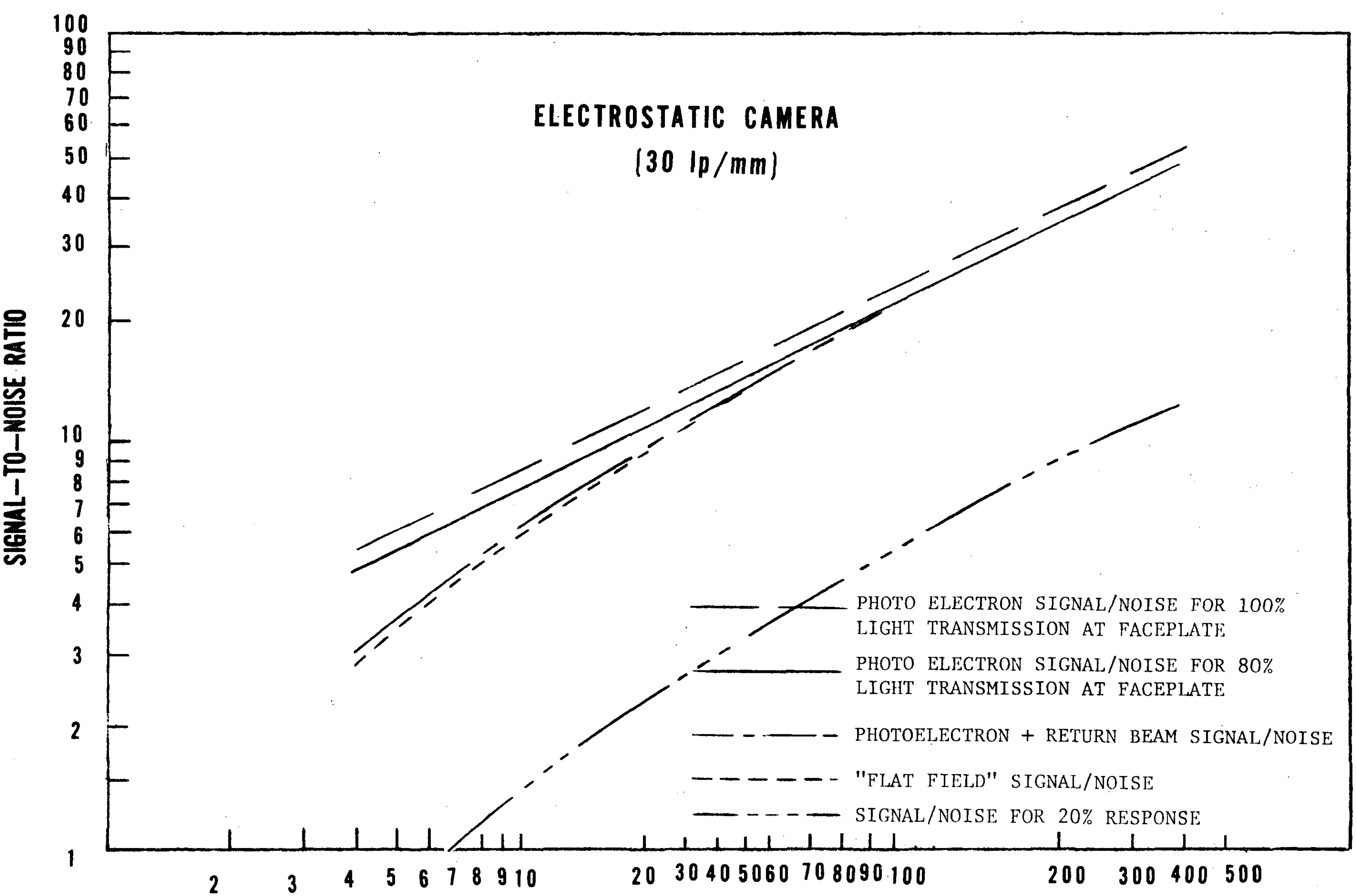


Figure 2.3-1

EXPOSURE (ERGS/CM^2 × 10^{-4})

contribute to the third curve. The fourth curve illustrates the "flat field" signal-to-noise ratio for the camera system. Finally, the bottom curve predicts the Electrostatic Camera System's signal-to-noise performance for 30 lp/mm at 20% response.

Considering the "flat field" performance of the system, a signal-to-noise ratio of 50 to 1 is obtained at an exposure of 4.2×10^{-4} ergs/cm^2. Looking at an exposure of 4.2×10^{-6} ergs/cm^2, which represents an approximate dynamic range of 100, the signal-to-noise ratio is 3 to 1.

Performance limitations can be improved in several ways. The MTF limit can be increased by using a larger input format while operating with the same number of scan lines. However, this will add weight to the optical assembly and tube. An increased MTF at 30 lp/mm can be obtained by using the electromagnetic image section approach described in Section 2.7.2.

2.4 ELECTROSTATIC CAMERA CONFIGURATIONS

Preliminary drawings of the proposed configurations for the camera system have been prepared which include major dimensions. These drawings were essential in performing a detailed weight analysis and in estimating the parts count.

2.4.1 BASIC CAMERA TUBE

The basic Electrostatic Camera tube design is shown in Figure 2.4-1. The front of the tube consists of the image section, with an S-20 photocathode on a fiber optics faceplate. A focus grid, anode cone, and field correction electrode are provided for proper image section operation.

A simple storage drum with thirty facets was selected for the storage section. Facets are 19mm wide to accommodate a 16mm x 16mm format.

ELECTROSTATIC CAMERA TUBE

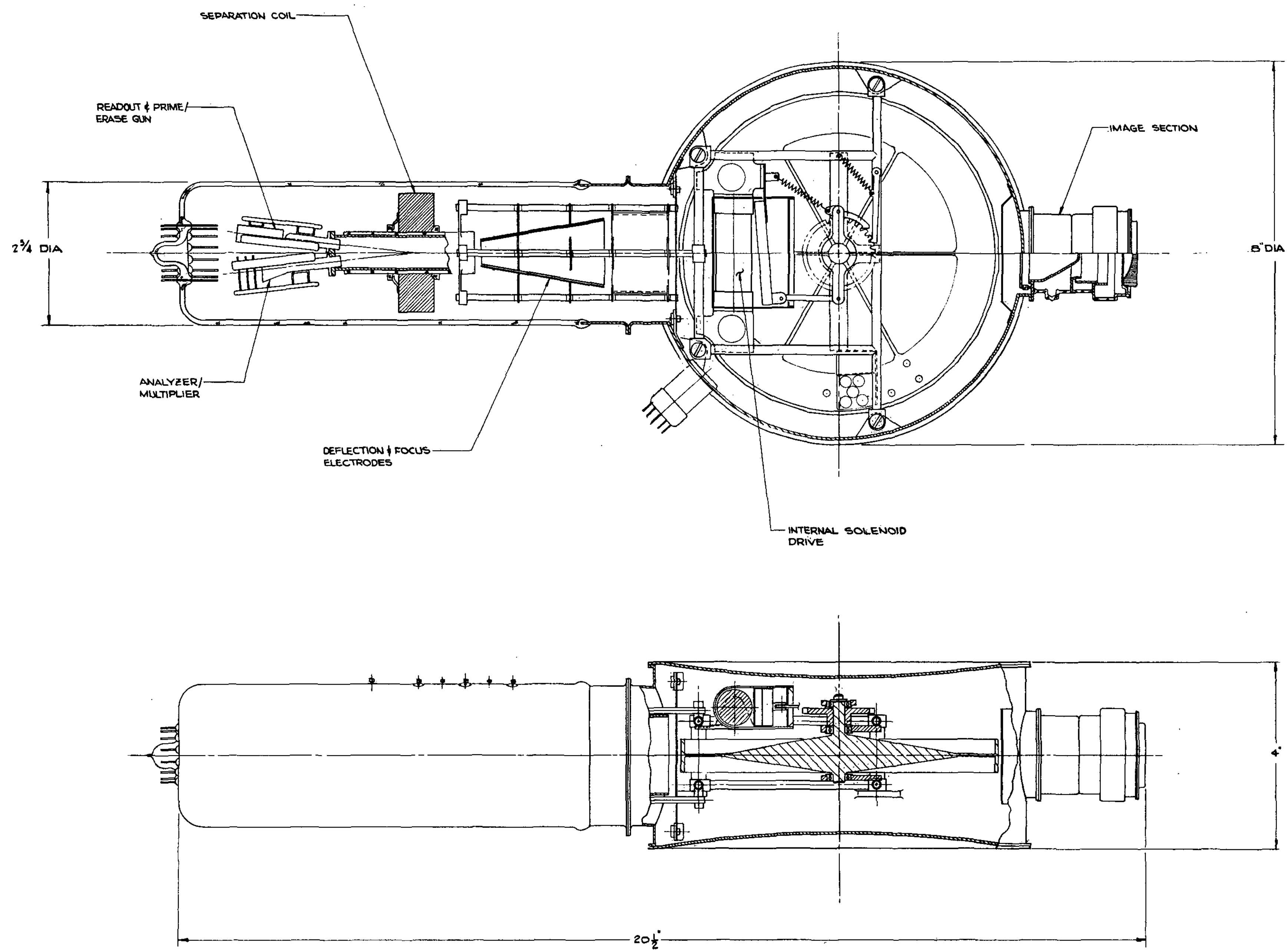


Figure 2.4-1

These are coated with the silicon dioxide storage medium. Several alternative storage drum drive mechanisms have been designed. An internal solenoid drive is shown which activates an indexing ratchet mechanism when pulsed. The mechanism is similar in operation to the wide-angle shutter mechanism used in Mariner Mars 1969. An alternative drive mechanism considered utilizes an external stepping motor.

The readout section design is straight forward. It contains the electron gun assembly, analyzer/multiplier assembly, the separator coil and the deflection and focus electrodes.

Design of the tube housing conforms to standard tube technology practices. It is made of a combination of stainless steel, Kovar and #7052 glass. Joints consist of glass to metal seals and heliarc welded metal to metal seams. High voltages in the readout section are applied through buttons sealed in the glass envelope. Low voltages are applied to the two multi-pin stems. An alternate housing design which incorporates a metal envelope instead of glass is also feasible and will increase the reliability of the tube. The weight would be about the same, but high voltage connections would be more complex requiring insulated feedthroughs. Concaved dished flanges were used as transport section covers in order to reduce the thickness of the material required. Convex flanges would be subject to buckling stresses and require additional thickness. Internal magnetic shielding has been provided around the solenoid within the tube.

The weight of the basic unhoused camera tube is 5.9 pounds, and it contains approximately 258 parts.

2.4.2 ELECTROSTATIC CAMERA HEAD

The Electrostatic Camera head, shown in Figure 2.4-2, represents the total package that will be mounted on the scan platform per camera system. It consists of the basic tube, lead connections, and potting around all the high-voltage elements and stems. A magnetic shield shrouds the readout section and protects the tube from magnetic interference effects. A smaller similar shield is used around the image section. The camera head electronics are mounted in packages placed on both sides of the storage section. Tube leads are affixed to these electronic packages using appropriate connectors. A protective aluminum shield covers the electronic packages and storage section. Mountings, and connectors for the bus electronics, have been provided. The entire camera head weighs 15.7 lbs. and contains approximately 874 parts.

The lower electronics package is shown in Figure 2.4-3. It contains the image section power supply, one deflection amplifier, the exposure system electronics, the photocathode pre-amplifier, the drum position circuit, and filter wheel position circuit. This package forms part of the camera head, weighs 2.1 pounds, and contains approximately 267 parts.

The upper electronics package, shown in Figure 2.4-4 is similar. It contains the readout section power supply, the other deflection amplifier, and the video amplifier. This package weighs 2.7 pounds and contains approximately 276 parts.

2.4.3 BUS ELECTRONICS

The bus electronics assembly, Figure 2.4-5, will be mounted with the spacecraft electronics rather than on the scan platform. It will supply two cameras. Contents include the low-voltage power supplies, the control and conditioning logic matrix, line or erase clock scan generators, low-pass

ELECTROSTATIC CAMERA HEAD

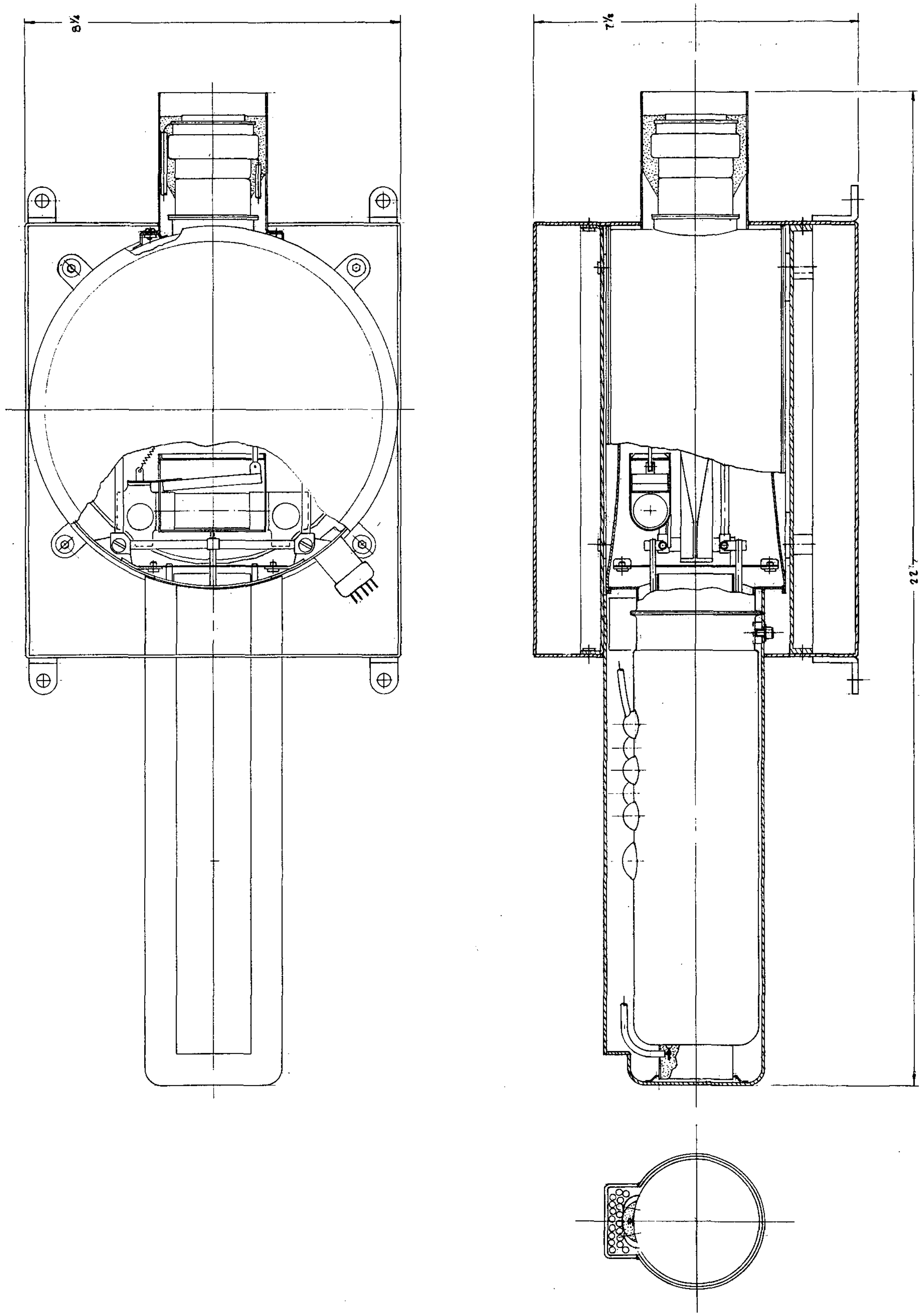
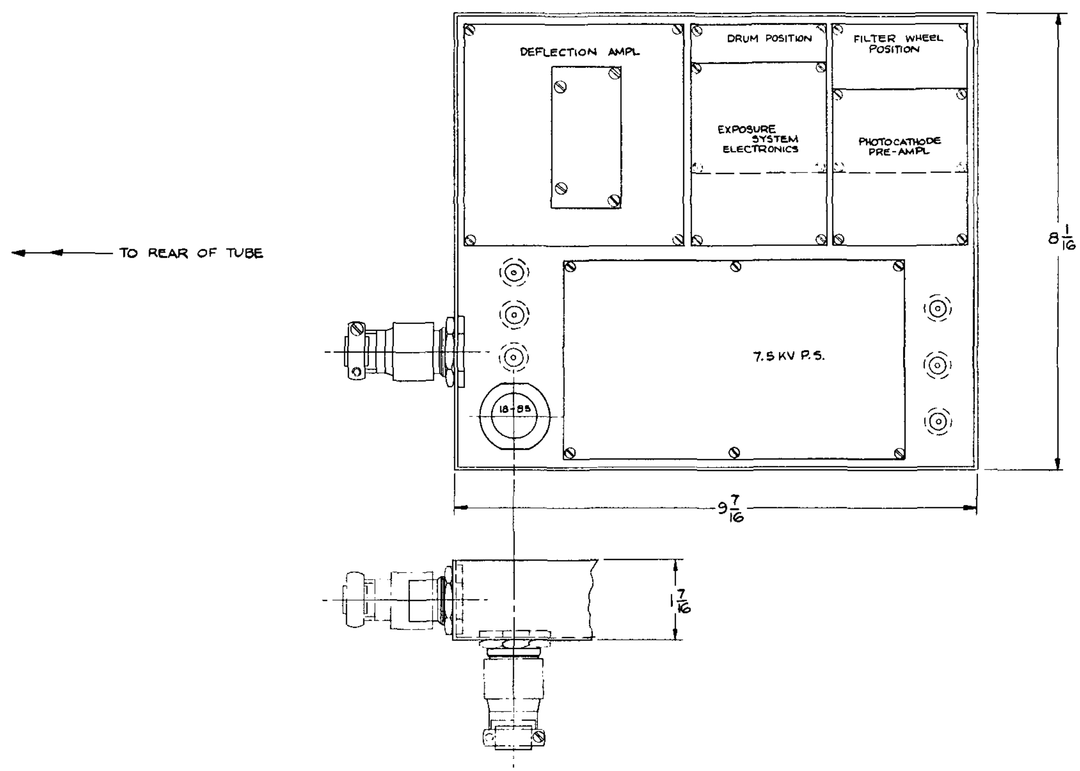


Figure 2.4-2



QTY REQD -1	ITEM	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR SPECIFICATION	WT. GRAMS	SYM
A/R	19		WIRE		12.00	
2	18		RECEPTACLE & PLUG	AMP ASTRO 16-55	144.24	
2	17		MAGNETIC SHIELD		70.00	
A/R	16		POTTING COMPOUND		60.00	
60	15		SCREW	CRES	34.20	
30	14		SPACER	NYLON	5.40	
6	13		H.V. RECEPTACLE		24.00	
1	12		RECEPTACLE & PLUG	AMP ASTRO 18-85	89.28	
1	11	08	FILTER WHEEL POSITION		12.60	
1	10	08	DRUM POSITION		12.60	
1	9	10	PHOTOCATHODE PRE AMPL		26.30	
1	8	10	EXPOSURE SYSTEM ELECTR		20.50	
1	7	04	DEFLECTION AMPL		121.86	
1	6	01	7.5 KV PWR. SUPPLY		146.40	
1	5	12-1	BOX ASSY	AL ALY	166.84	
	4					
	3					
	2					
X	1	12	ELECTRONIC PKG (LOWER)	TOTAL WT	946.23	

LIST OF MATERIALS

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

MATERIAL

FINISH

CONTRACT NO.

DRAWN R. Jambusiil DATE 1-19-72

CHECKED

ENGINEER R. Moore

RELIABILITY

REVIEW

APPROVAL (PROJECT)

APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn. A Division of Columbia Broadcasting System, Inc.

ELECTRONIC PACKAGE (LOWER)

SIZE D | CODE IDENT NO. 16996 | 12 | REV SYM

SCALE 1/1 | SHEET OF

DASH NO. | NEXT ASSY | USED ON | APPLICATION | NEXT ASSY | FINAL ASSY | QTY REQ'D

REVISIONS: ZONE | LTR | DESCRIPTION | DATE | APPROVED

Figure 2.4-3

CBS LABORATORIES

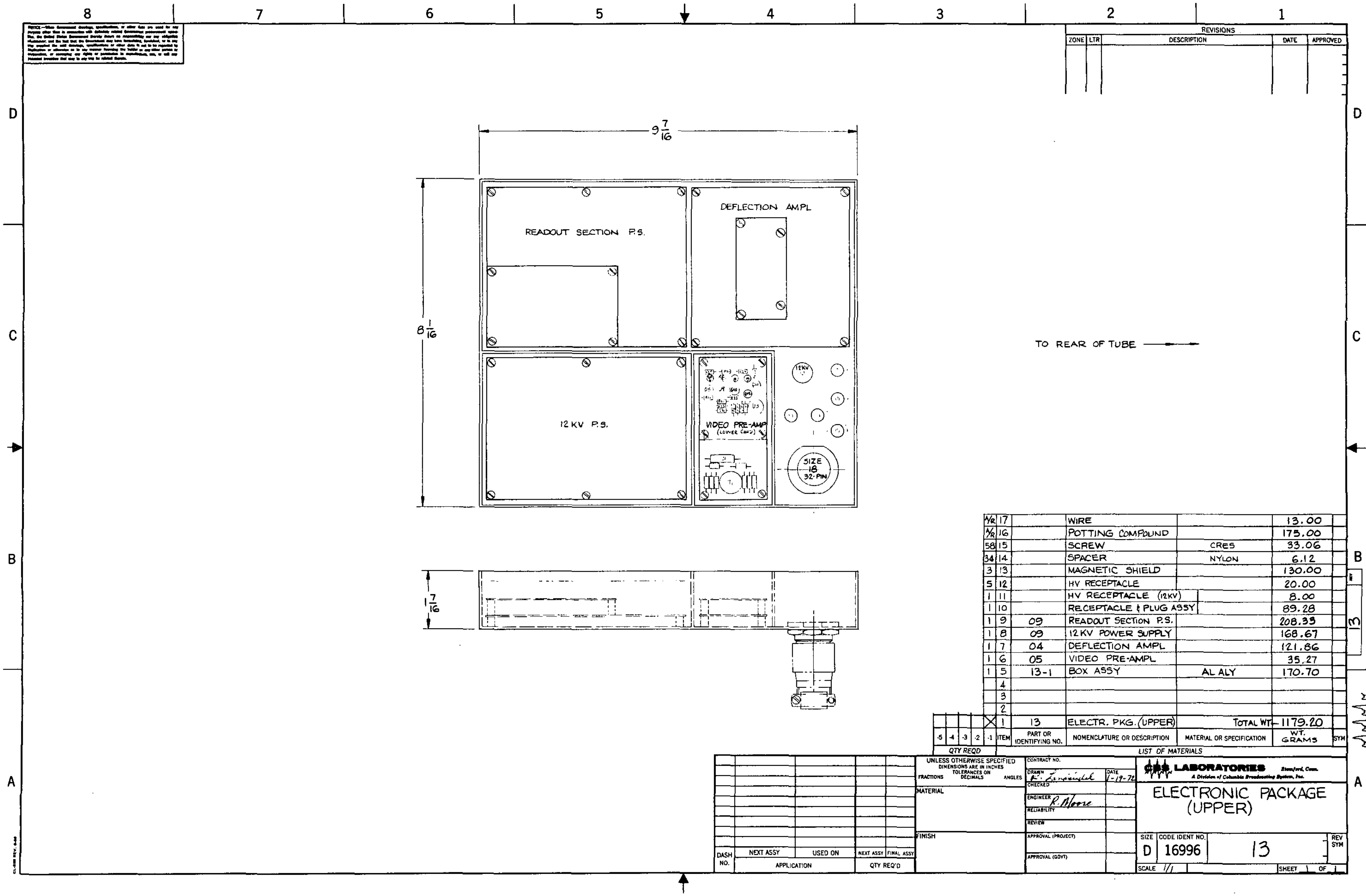


Figure 2.4-4

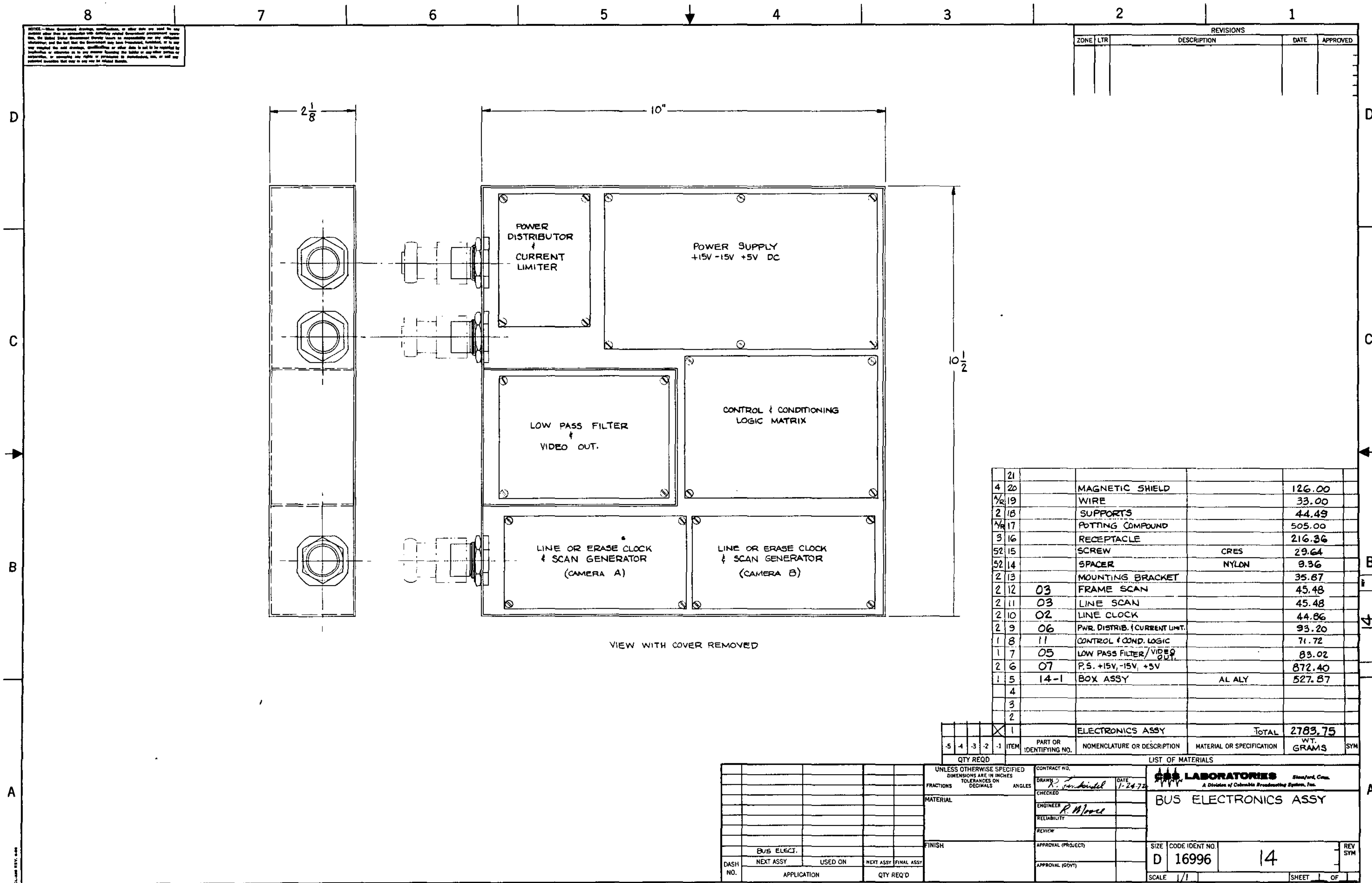

POWER DISTRIBUTOR ¢ CURRENT LIMITER
POWER SUPPLY +15V -15V +5V DC
LOW PASS FILTER ¢ VIDEO OUT.
CONTROL ¢ CONDITIONING LOGIC MATRIX
LINE OR ERASE CLOCK ¢ SCAN GENERATOR (CAMERA A)
LINE OR ERASE CLOCK ¢ SCAN GENERATOR (CAMERA B)
VIEW WITH COVER REMOVED
10"
$10\frac{1}{2}$
$2\frac{1}{8}$
REVISIONS
4 20 MAGNETIC SHIELD 126.00
½ 19 WIRE 33.00
2 18 SUPPORTS 44.49
½ 17 POTTING COMPOUND 505.00
3 16 RECEPTACLE 216.36
52 15 SCREW CRES 29.64
52 14 SPACER NYLON 9.36
2 13 MOUNTING BRACKET 35.67
2 12 03 FRAME SCAN 45.48
2 11 03 LINE SCAN 45.48
2 10 02 LINE CLOCK 44.86
2 9 06 PWR. DISTRIB. ¢ CURRENT LIMIT. 93.20
1 8 11 CONTROL ¢ COND. LOGIC 71.72
1 7 05 LOW PASS FILTER/VIDEO OUT. 83.02
2 6 07 P.S. +15V, -15V, +5V 872.40
1 5 14-1 BOX ASSY AL ALY 527.87
1 ELECTRONICS ASSY TOTAL 2783.75
LIST OF MATERIALS
CBS LABORATORIES
BUS ELECTRONICS ASSY
D 16996 14
BUS ELECT.

Figure 2.4-5

filters, and power distribution and current limiter circuits.

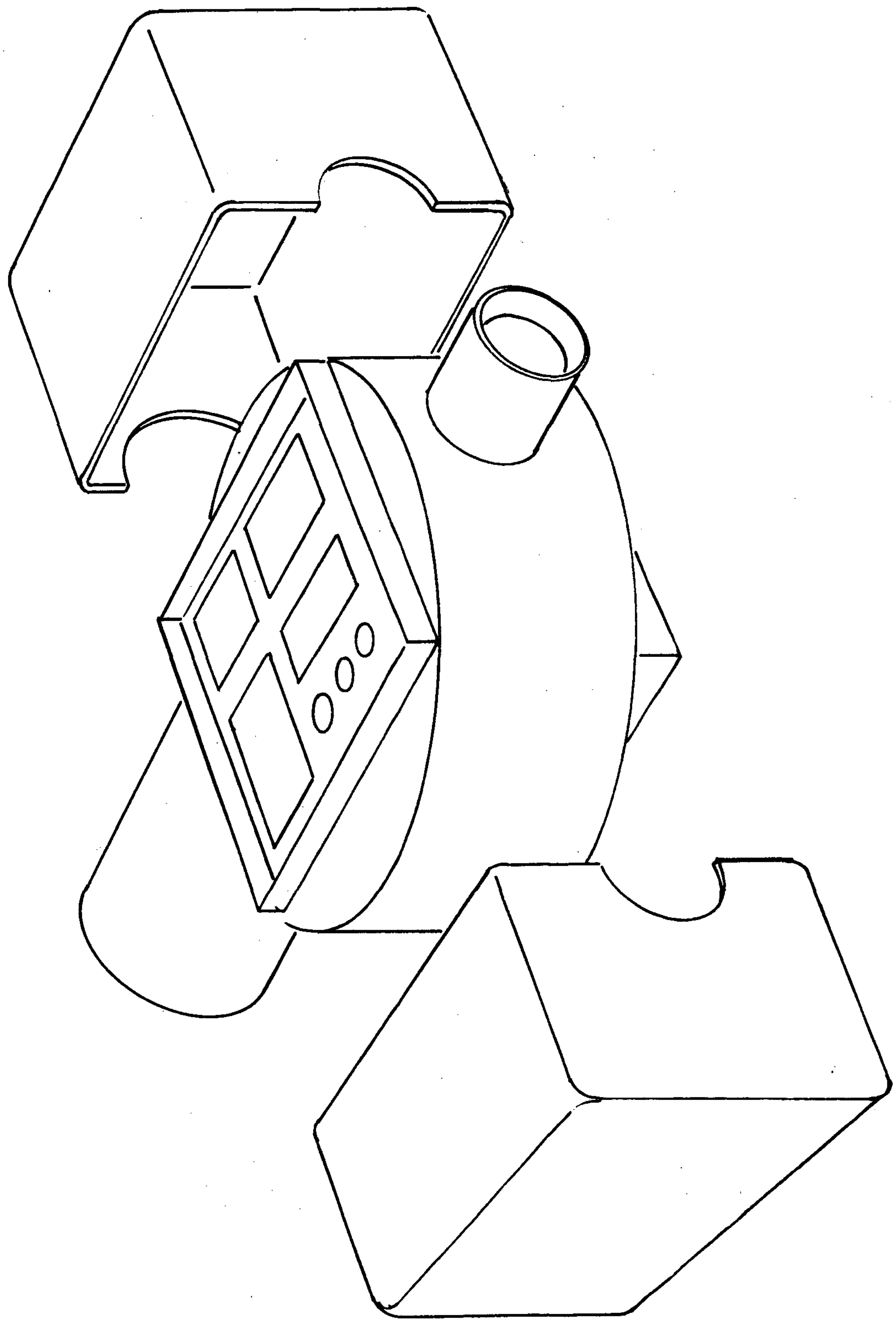
The bus electronics weighs 6.1 pounds and contains approximately 455 parts. The dimensions of the package were arbitrarily selected because the standard sizes for the spacecraft electronics were not known. The bus electronics requires 220 cubic inches of volume. This volume can be packaged in any reasonable form.

2.4.4 ALTERNATIVE PACKAGING METHODS

The packaging method used for the Electrostatic Camera head represents only one possible configuration. This approach is shown again in Figure 2.4-6 in sketch form so that comparisons may be made. The basic weight analysis has been performed for this configuration. Basically, electronic packages are mounted above and below the storage section of the tube and a protective shield covers the assembly.

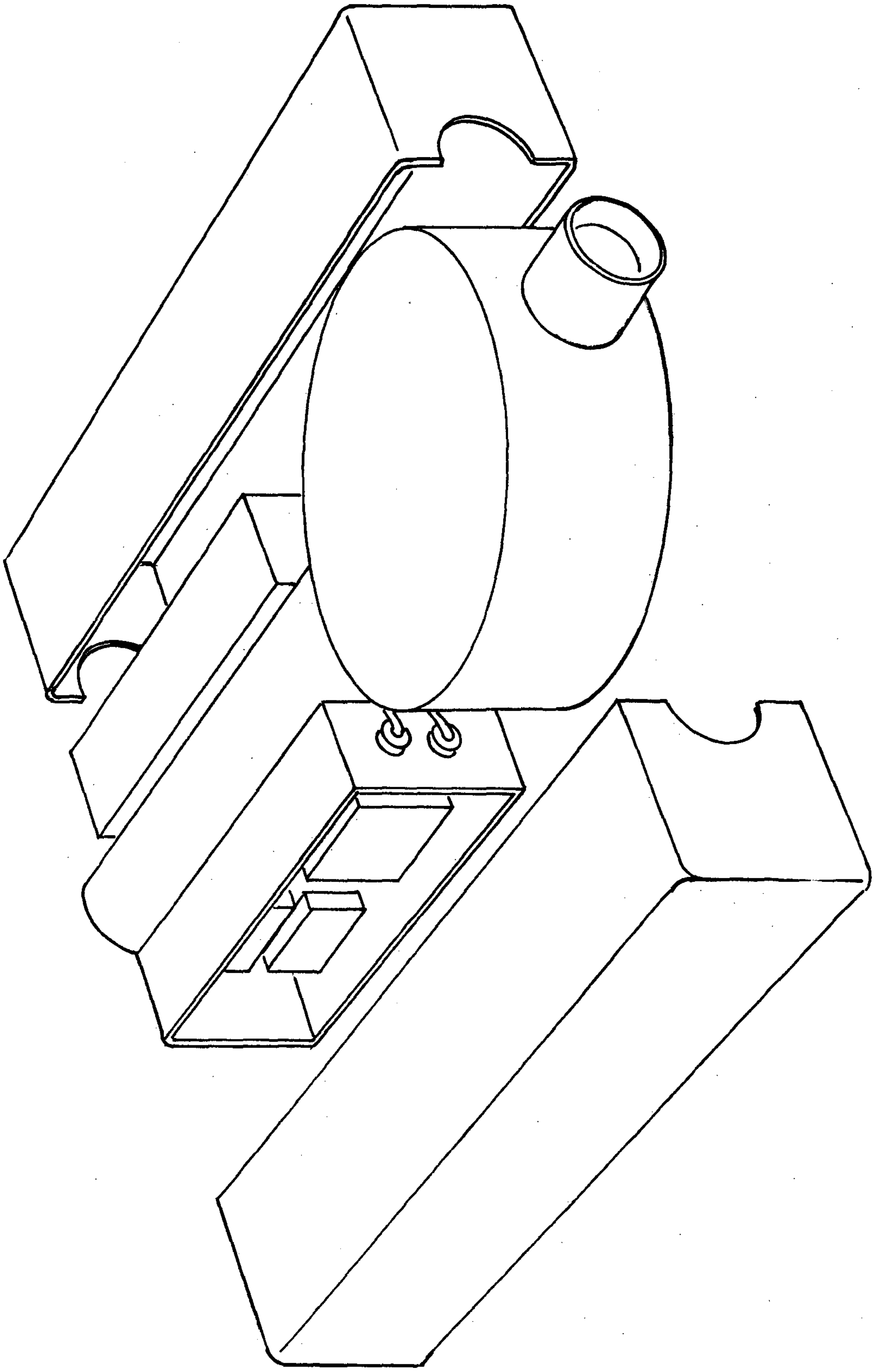
This arrangement has the advantage of concentrating material around the storage tape area. If radiation effects on the storage tape proved to be troublesome, the additional shielding would result in increased attenuation of the radiation levels. This consideration is not meant to imply that radiation will be harmful. To the contrary, we do not anticipate a problem.

Packaging alternative No. 2, Figure 2.4-7, results in a more compact camera head. Electronic packages have been changed in shape, but remain equal in volume to the previous alternative. The electronic packages are mounted on both sides of the readout section and the protective cover extends over the entire rear of the camera head. This configuration provides a compact, stable unit that can be readily mounted to a baseplate. Overall dimensions are reduced to 4 1/2" high x 8 1/4" wide x 22" long. This alternative packaging method will weigh 0.4 pound more than alternative No. 1.



PACKAGING ALTERNATIVE #1

Figure 2.4-6



PACKAGING ALTERNATIVE #2

Figure 2.4-7

Micro-meteoroid protection is optimized over the entire structure by using this design. Strip heaters can easily be mounted to the cover to keep the camera head at a constant temperature. However, the need for heaters is not clearly evident. Packaging alternative #2 is the recommended approach. A preliminary outline drawing of the package is shown in Figure 2.4-8.

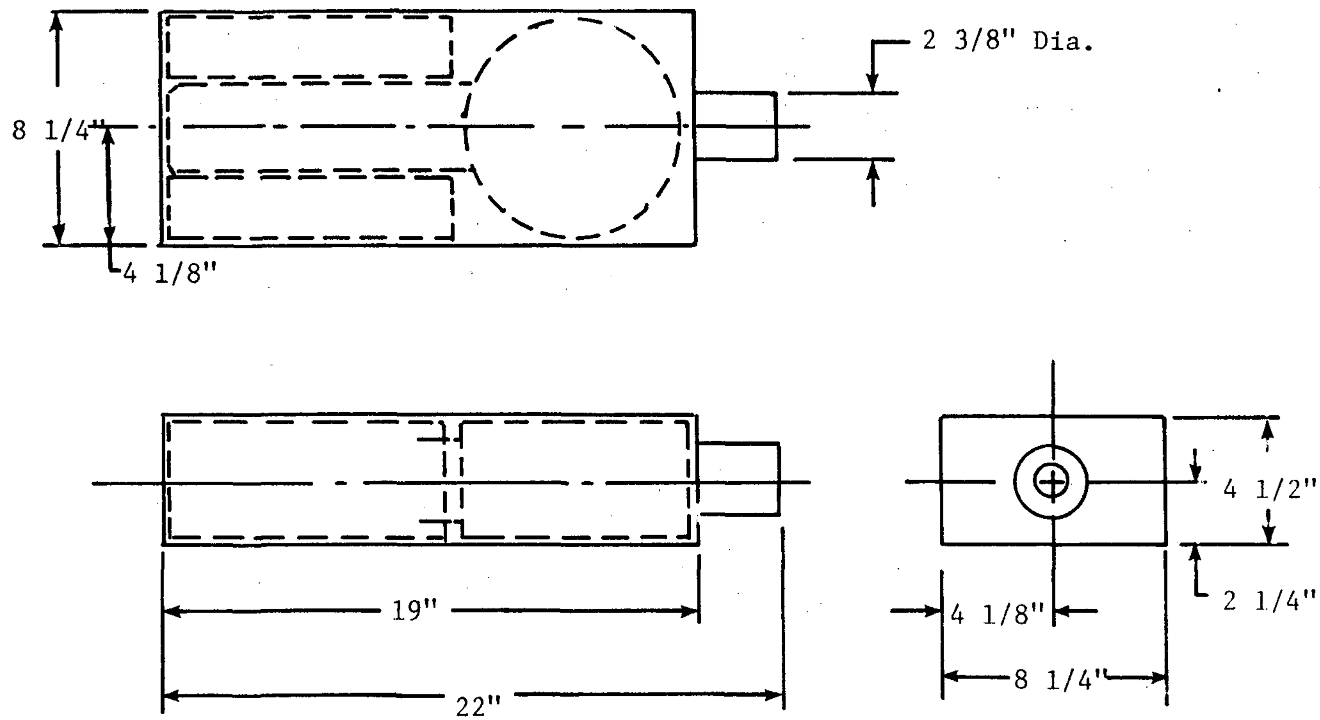
Packaging alternative No. 3 shown in Figure 2.4-9 can be used to conserve weight. This alternative will weigh approximately 1.0 pound less than alternative No. 1. One large enclosed electronics package will be used as the base for the camera tube. This package offers minimal radiation and meteoroid protection because of the lack of a protective cover.

There is considerable flexibility in the manner in which the camera head can be configured. Packaging trade offs are numerous. This design flexibility can be used to advantage when the optical assembly and scan platform interfaces are defined. The configuration can then be optimized to satisfy environmental requirements.

2.5 WEIGHT ANALYSIS

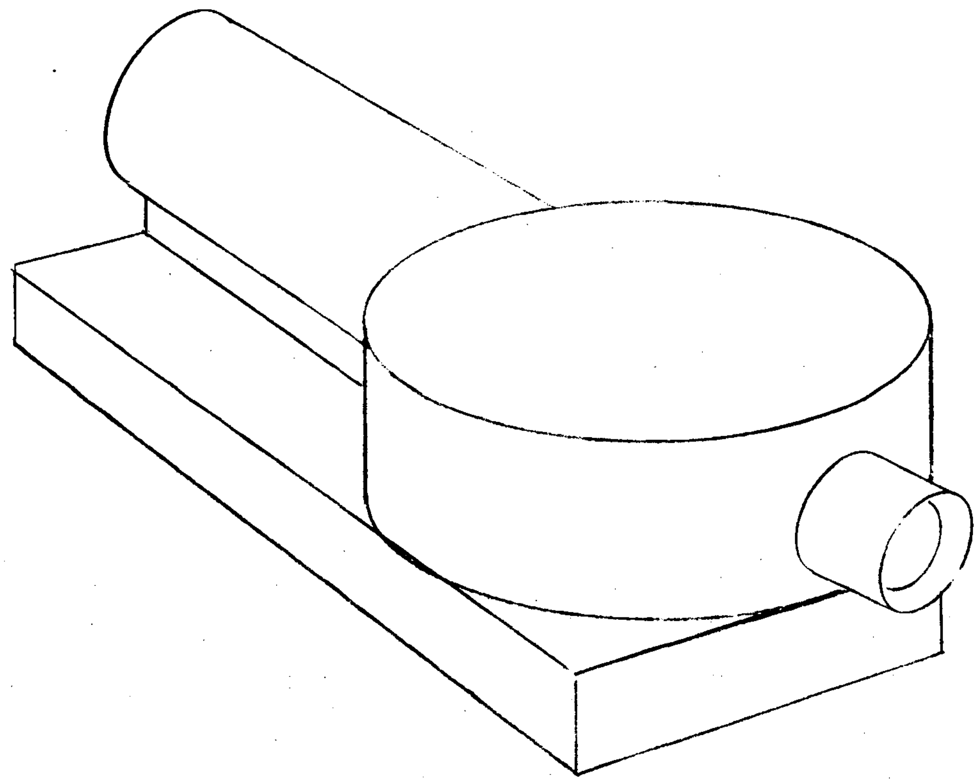
The weight analysis consisted of a detailed determination of the weight of the ECS. Each of the functional block weights were calculated and an estimate of the parts count was obtained. Estimates for circuit weights were obtained from the detailed circuit diagrams shown in Appendix II. A summary of these weights follows on the next page.

NOTE: LOCATION OPTIONAL FOR
6 MOUNTING FLAGES



ALTERNATIVE PACKAGING METHOD
ELECTROSTATIC CAMERA HEAD

Figure 2.4-8 PACKAGING ALTERNATIVE #2 OUTLINE DRAWINGS



PACKAGING ALTERNATIVE #3

Figure 2.4-9

ELECTROSTATIC CAMERA WEIGHT SUMMARY

Camera Head	Weight	Parts Count
Basic Camera Tube	5.9 lbs.	258 parts
Magnetic Shielding	2.4	37
Electronic Package #1	2.6	267
Electronic Package #2	2.1	276
Cover, Mountings, Misc.	2.7	36
Total for Camera Head	15.7 lbs.	874 parts
Two Identical Cameras		
Camera Heads	31.4 lbs.	1,748
Bus Electronics	6.1	455
Cables	3.0	4 assy.
Total Two Cameras	40.5 lbs.	2,207 parts

2.6 POWER ANALYSIS

The total Electrostatic Camera System power consumption was determined for each of the system's operating modes. Power requirements were estimated from the detailed circuit analysis. A summary of the power analysis follows:

ELECTROSTATIC CAMERA POWER SUMMARY

Camera	Functional Mode	Power
	Cruise (off)	0.3 W
A	Expose	10.8 W
B	Off	

ELECTROSTATIC CAMERA POWER SUMMARY, Continued

Camera	Functional Mode	Power
A	Readout	18.1 W
B	Off	
A	Expose	19.8 W
B	Expose	
A	Readout and Expose	22.8 W
B	Off	
A	Readout	27.1 W
B	Expose	

Cameras can be operated singularly, alternately or both simultaneously. A single camera can be operated in the readout and expose modes simultaneously. The only impossible combination would be to readout both cameras at the same time, however this is a limitation of the transmission system. Power consumption for the practical operating combinations have been shown. The erase mode power will be identical to the readout power requirement.

2.7 TRADE OFF STUDY

Selected trade studies were conducted to identify trade offs between weight, power, format size, storage capacity, and system complexity. The affect on performance was determined for several special cases.

2.7.1 500 FRAME CAMERA SYSTEM

The storage drum concept provides a good simple design for the Electrostatic Camera up to about 50 frames of 16mm x 16mm format size. Beyond this storage capacity alternative storage film transport systems appear more attractive, particularly from a weight and size viewpoint. A reel-to-reel, 500 frame capacity camera system has been analyzed in this study. A reel-to-reel system configuration is more complex than a simple drum system. The reliability and quality control aspects of the design would be more demanding.

One possible configuration for a 500 frame electrostatic camera tube is shown in Figure 2.7-1. Only the transport section differs from the 30 frame drum version. The tape is loaded on a supply reel and transferred to a take-up reel between exposures. The reels are held under constant tension by tension spring drivers. The storage tape consists of a .002" thick stainless steel substrate on which the SiO_2 storage medium is coated. A bi-directional stepping motor drives the storage tape in either direction. Idlers are required to keep the tape flat at the exposure and readout positions. A spacer tape is required between layers of the coiled film to keep the surface from being discharged during storage.

The basic tube shown weighs 9.4 pounds and contains approximately 294 parts. Overall dimensions of the tube are 7 3/16" high x 8" wide x 21" long.

The 500 frame camera tube can be packaged into a camera head as shown in Figure 2.7-2. Magnetic shielding has been provided and all leads are potted as was done with the 30 frame camera. Electronic packages will be mounted on both sides of the readout section, and the entire assembly will be encased in a protective support shield. Overall dimensions of the camera head are given.

The power and weight of the reel-to-reel camera system will now be summarized and compared to the drum type camera.

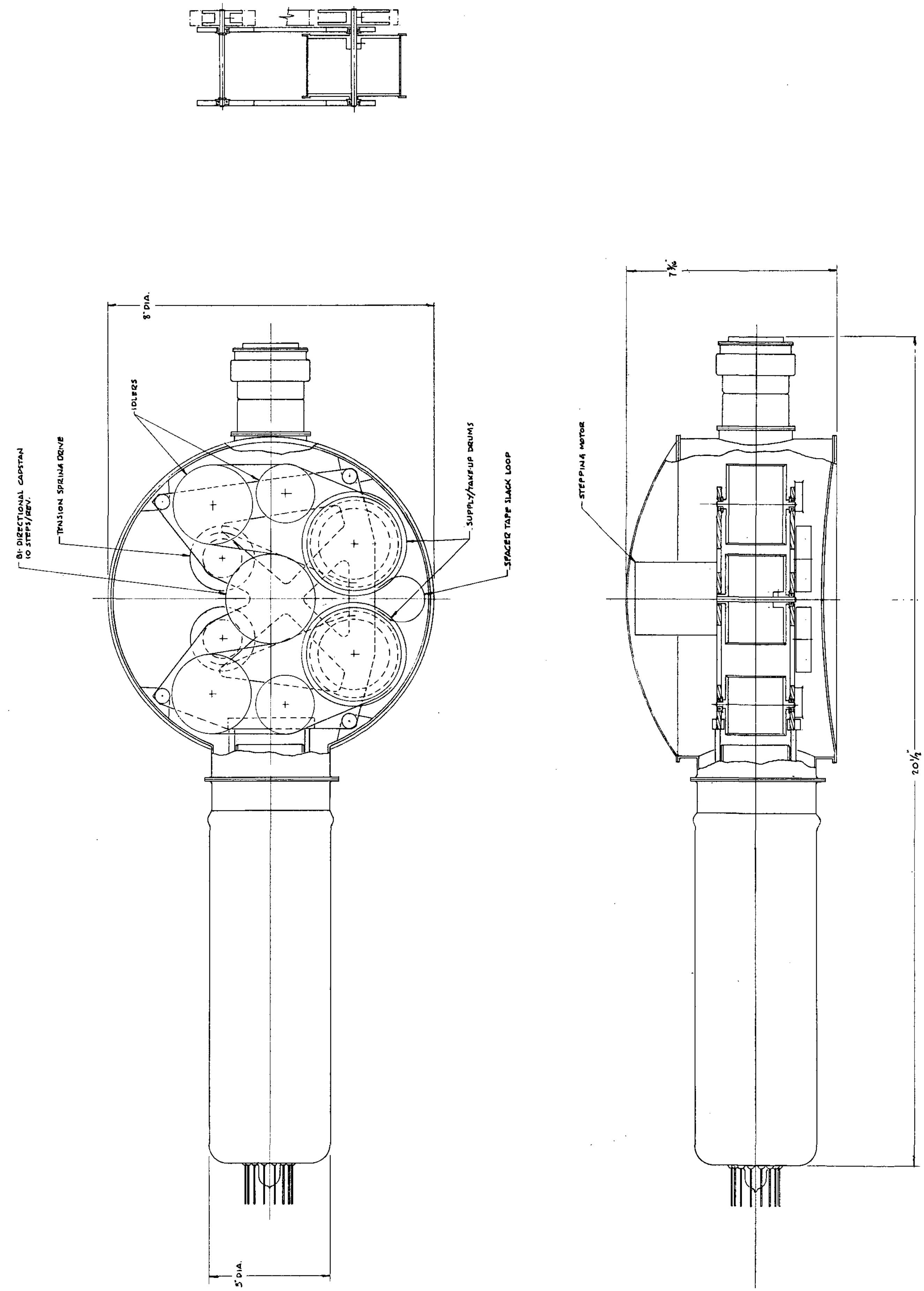


Figure 2.7-1 500 Frame Electrostatic Camera Tube

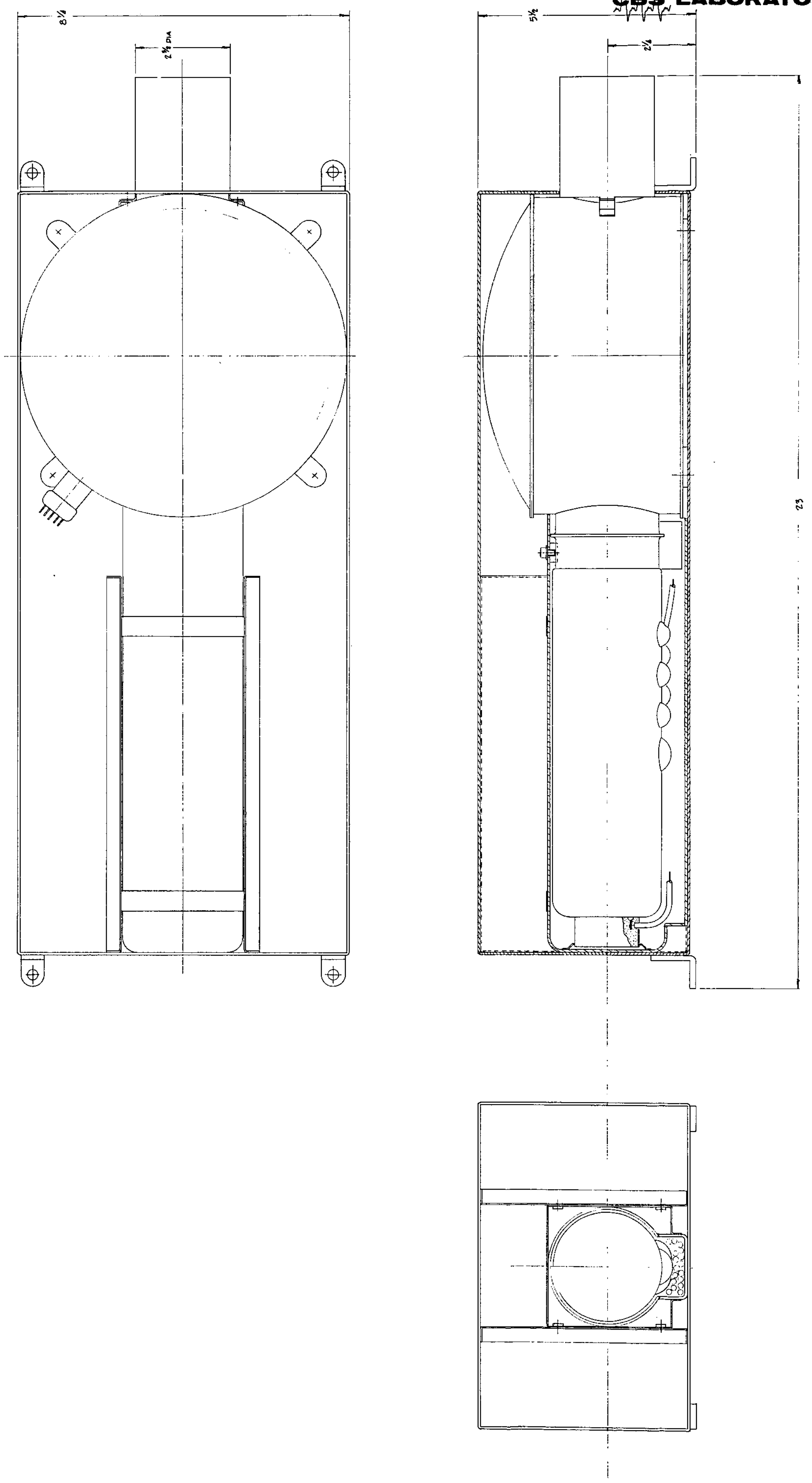


Figure 2.7-2 500 Frame Electrostatic Camera Head

STORAGE CAPACITY TRADE OFF SUMMARY

Weight	Drum Camera (30 Frames)	Reel-to-Reel Camera (500 Frames)
Camera Head	15.7	20.0
Electronics, Cables	6.7	6.7
	22.4 lbs.	26.7 lbs.
Two Camera Heads	31.4	40.0
Electronics, Cables	9.1	9.4
	40.5 lbs.	49.4 lbs.
Power		
Camera A Expose Camera B Off	10.8 W	11.5 W
Camera A Readout Camera B Off	18.1 W	18.5 W
Camera A Expose Camera B Expose	19.8 W	20.5 W

2.7.2 ELECTROMAGNETIC FOCUS CAMERA

A trade off study was performed in which an electromagnetically focused camera was analyzed and compared to the performance of the electrostatically focused camera system.

For this camera configuration an electromagnetic image section replaces the electrostatic image section. Figure 2.7-3 illustrates the input end of a camera utilizing electromagnetic focusing. The electromagnetic image section contains a flat window instead of a curved fiber optics faceplate. It

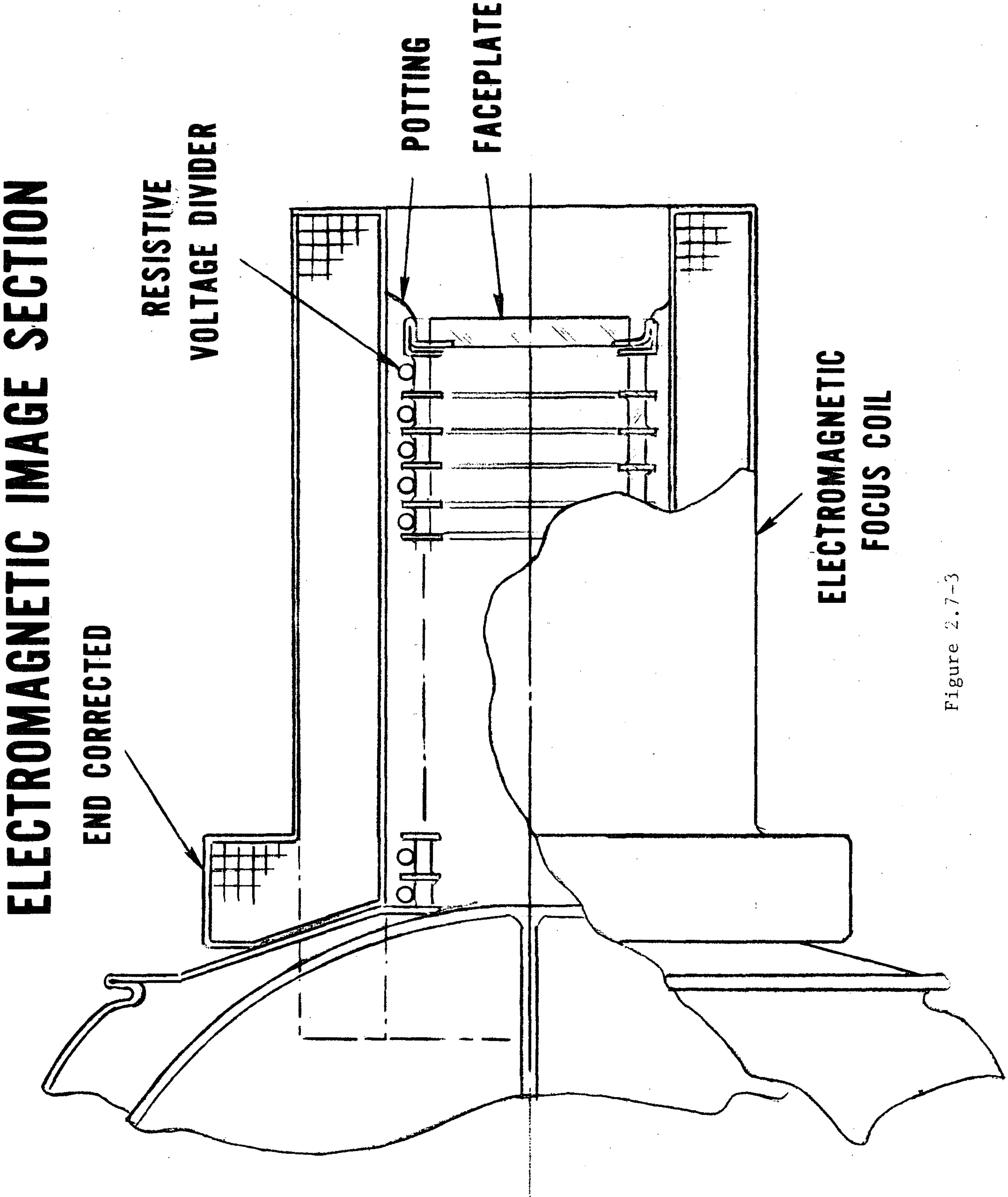

ELECTROMAGNETIC IMAGE SECTION
END CORRECTED
RESISTIVE
VOLTAGE DIVIDER
POTTING
FACEPLATE
ELECTROMAGNETIC
FOCUS COIL

Figure 2.7-3

consists of a series of flat electrodes connected to a voltage divider network. These electrodes provide a uniform electrostatic field which accelerates the photoelectrons from the photocathode to the storage drum. An axial magnetic field must also be provided to focus the photoelectrons at the storage surface. This field is generated by the external electromagnetic focus coil.

The advantages of using a magnetically focused camera mainly relate to improved performance. The modulation transfer function of the magnetic image section is 95% response at 30 lp/mm compared to 30% response for the electrostatically focused image section. Because of the improved image section performance, the overall camera MTF is increased to 67% response at 30 lp/mm as compared to 20% for the electrostatic case. Elimination of the fiberoptics faceplate and its associated transmission losses effectively increased the quantum efficiency by 20 to 25 percent. Exposure times can be correspondingly shortened. This in effect reduces smear caused by image motion. Image distortion caused by the magnetic image section is minimized because of the parallel electrode configuration and the orthogonal nature of the electrostatic and magnetic fields.

Disadvantages of using magnetic focusing are primarily associated with the magnetic field producing component. An electromagnetic focus coil adds considerable weight to the camera system and requires additional power. The design shown weighs 7.9 pounds and consumes 11.8 watts. In addition, the shielding of stray magnetic fields radiating from the image section becomes more difficult.

The weight and power totals for the electromagnetic focus camera will now be summarized and compared to the electrostatically focused camera.

IMAGE SECTION TRADE OFF STUDY SUMMARY

Weight	Electrostatic Focus Drum Camera	Electromagnetic Focus Drum Camera
Camera Head	15.7	22.4
Electronics, Cables	6.7	7.9
	22.4 lbs.	30.3 lbs.
Two Camera Heads	31.4	44.8
Electronics, Cables	9.1	11.7
	40.5 lbs.	56.5 lbs.
Power		
Camera A Expose Camera B Off	10.8 W	22.6 W
Camera A Readout Camera B Off	18.1 W	18.1 W
Camera A Expose Camera B Expose	19.8 W	44.7 W

Many trade offs are possible with the electromagnetic design. The weight of the focus coil can be reduced at the cost of more power. This can be accomplished by changing the form factors (major dimensions) of the coil. Another trade off is based on the conductor material. If aluminum rather than a copper conductor were used, the weight would decrease by a factor of 3.2 while the power would only increase by a factor of 1.7.

A permanent magnet focus assembly can also be used instead of an electromagnetic coil. No power would be required for this system. The weight of a permanent magnet focus coil will be slightly less than an electromagnetic coil which uses copper as a conductor. The major disadvantage of a permanent magnet system is that it cannot be turned off. However, a well designed magnetic sheild may offset this disadvantage by attenuating the stray magnetic field.

2.7.3 FORMAT SIZE

The design configurations described so far all were concerned with a 16mm x 16mm format size. A decrease in format size offers little advantage as the weight of the system goes down slowly as a function of frame area.

An increase to a 24mm x 24mm format results in little extra weight, but buys a lot in performance as more lines can be added due to the increase in format size. Only 22 frames of this format size can be packaged onto a 7" diameter storage drum. A 10" diameter drum will be required to accommodate 30 frames of information. Beyond 30 frames, the reel-to-reel type transport should be considered for a 24mm square format.

2.8 INTERFERENCE EFFECTS

The environmental design characteristics and restraints covered in TOPS-3-300 provided a basis for the design of the ECS. The camera system must survive the radiation and vibration environments specified and be able to operate in the stated thermal and magnetic environments. Emphasis during this task was placed on magnetic interference, meteoroid protection, and the radiation environment.

2.8.1 MAGNETIC INTERFERENCE

The magnetic interference enviornment encountered during an Outer Planet mission imposes a number of design requirements on the camera system. Electromagnetic shielding must be provided so that camera system functions within tolerable limits. The primary requirements of this study are: First, that the camera performs satisfactorily in a maximum magnetic field of 30 Gauss at Jupiter encounter. Second, that the camera system's static magnetic field will be limited to one gamma at 3 feet after exposure to 25 oersted. Finally, that the dynamic magnetic fields from DC to 200 KHz generated by the camera system are attenuated to specified levels.

The design approach was to use several nested shields around the critical camera components for optimum protection. A computer program was written to solve the design equations for nested shields. The analysis was performed in considerable depth for a range of material thicknesses and system transformer locations. Calculations were made to determine attenuation factors, raster displacement, degradation of electron beam spot size, optimum material thickness, and the magnetic field strength at 3 feet from the system. Both static and dynamic magnetic fields were factored into the study.

The optimum solution resulting from this work indicated use of a nested shield consisting of an inner layer of .020" thick Hypernom, with an outer layer of .020" thick Hyperco 50, separated by a .010" thick aluminum spacer. Both magnetic shielding materials are produced by Westinghouse. This combination of materials resulted in a magnetic field attenuation of 300 or 49 db. Satisfactory operation of the camera will result using this shielding, both static and dynamic fields will be adequately attenuated. The shielding design is expected to satisfy the residual field requirement.

2.8.2 METEOROID PROTECTION

Protection of the camera system from meteoroid penetration was considered. Preliminary calculations were based on meteoroid data in TOPS-3-300, material perforation formulas for single-walls, and Poissons distribution to determine the probability of no penetrations occurring.

The degree of protection obtained is largely dependent on the packaging configuration selected. Consider packaging alternative No. 1 shown in Figure 2.4-6, this configuration has a probability that no penetrations will occur of greater than 99.4%. Meteoroids with a mass greater than approximately 10^{-4} grams, however, could penetrate portions of the system.

Packaging alternative #2, Figure 2.4-7, offers additional protection as it forms a double shield which is much more effective than a single wall. Meteoroids of 2.1×10^{-3} grams, the largest mass listed in TOPS-3-300, should be stopped by the system without affecting performance. This alternative offers the best meteoroid protection.

Packaging alternative #3, Figure 2.4-9, offers only a 96% probability that no penetration of the camera system will occur. Meteoroids weighing more than 10^{-5} grams could penetrate the .020" thick exposed camera envelope.

2.8.3 THE RADIATION ENVIRONMENT

Radiation effects on materials used in space have been thoroughly documented in the literature. The literature will not be rehashed here, although a considerable amount of effort went into reviewing radiation effects.

The effects of radiation on the ECS should be very similar to the SIT vidicon camera system. Both camera systems contain essentially the same type of materials and electronic components. The only significant difference of interest is that the Electrostatic Camera has a SiO_2 storage target. In reviewing the radiation literature to determine the effects on the storage medium, several conclusions were formed. First, that radiation may tend to partially discharge the storage tape. However, no permanent damage of the dielectric will occur. The SiO_2 storage surface can be returned to its original state by simply repriming the surface.

The question considering the effect of radiation on the storage film cannot be fully answered without conducting an experimental study. Nevertheless, we do conclude that the discharging effect may not be significant. Radiation fluence during the storage period will be low compared to the total mission fluence. In addition, some radiation shielding will be provided to protect the storage surface.

2.9 APPLICABLE PREVIOUS EXPERIENCE

The purpose of documenting applicable previous experience related to the ECS will be to aid in determining the status of CBS Laboratories' technology and to help identify areas which may require additional expertise to develop the camera system. Applicable previous experience in the design, fabrication and testing of the major functional blocks such as the image transport, readout, and electronic control sections will be described.

CBS Laboratories' qualification to successfully develop and fly space qualified subsystems can best be demonstrated by citing the Lunar Orbiter series of space probes. The CBS Laboratories Scanning Subsystem was used successfully in all five Lunar Orbiter Missions with a resolution in excess of 100 lp/mm with extended dynamic range. The Reconotron, an electrostatic image dissector tube, was developed for the Jet Propulsion Laboratory and used as a Canopus Star Tracker. The most recent missions on which the Reconotron was used were Mariner VI and VII. The Reconotrons, even after 19 months of deep space flight, functioned successfully, holding the roll axis of the craft stable by locking on the star Canopus. In addition, CBS Laboratories has developed many aerospace qualified subsystems including; photomultiplier tubes, laser image recorders, the JIFDATS Image Transmission Subsystem, and various film processors.

Previous experience related to image section development has been extensive. Electrostatic image sections have been used in our Reconotron image dissectors and Lumatron storage tube. Image sections similar to the one proposed for the ECS had been constructed in the laboratories for image intensifier programs in the early 1960's. Electromagnetic focusing sections have also been developed and used with the Linotron, a multiaperture image dissector used in photocomposition systems; the Luxicon, a low light level storage tube; the Retentatron storage tube, and special Reconotrons.

Storage section development includes both storage tape and transport drive related experience. Many in-house programs have been conducted related to SiO_2 storage properties, aging studies, and the deposition of uniform coatings. No further storage tape development is required, however, experiments should be performed to determine radiation effects. The Reconotron, is an example of a line scan tube which contains a continuous loop flexible dark trace storage unit with an SiO_2 target. Experience with drive mechanisms can be illustrated by pointing out that the Lunar Orbiter line scan tubes contain a rotating drum, bearings and dry-film lubricant. Our electronic video recorder uses a continuous motion drive, and the ERTS recorder contains an accurate servo controlled drive mechanism. The design of the transport section of the Electrostatic Camera is straight forward and should not present any new problems.

In-house readout section studies have received strong support for many years. Studies have included readout beam separation techniques, electron analyzer/multiplier studies, and the experimental evaluation of readout section performance. Readout section components have been used in electronic video recorders, the Lunar Orbiter, Graphotron (CRT modules), and special line scan tubes. Electron beam technology is one of the areas of strongest experience. A readout section for an electrostatic camera will represent a scaled down versions of existing designs.

A large number of electronic systems have been developed by CBS Laboratories including; the Lunar Orbiter Phototransmission System, the JIFDATS Image Transmission Subsystem, Laser Image recorders for airborne use, electron beam recorders, the Linotron Photocomposition System and many others. Our Electronics Systems Group has extensive experience with electronic system development. Circuitry for the ECS will have to be developed, however, experienced personnel and facilities are available.

SECTION III

CONCLUSIONS

3.0 GENERAL

A functional design of the ECS has been prepared which when developed should exceed most of the requirements of Technical Exhibit #1 and TOPS-3-300. The camera system will resolve 1000 lines x 1000 pixels at a minimum of 20% response over a dynamic range of greater than 64:1. At an exposure of 0.04 ergs/cm^2 the signal-to-noise ratio will be 50 to 1 or greater. The camera system will provide at least 30 frames of storage which may be retained for many weeks before being transmitted. The stored information may be repeatedly scanned without degradation.

The electrostatic camera head can be packaged within a 4 1/2" high x 8 1/2" wide x 22" long volume, and will weigh approximately 16 pounds exclusive of the optical assembly. Two complete camera systems, minus optical packages, will weigh about 41 pounds. A maximum power consumption of 27.1 W will occur if both tubes are operated with one in the readout mode while the other camera is being exposed. A single camera operating simultaneously in both the readout and expose modes will consume less than 23 watts of power. The weight and power profile of the ECS appear to be in line with preliminary baseline objectives for an outer planet mission.

A reel-to-reel camera configuration will allow the storage capacity to increase to 500 frames. The weight of two systems minus the optics assembly will be approximately 50 pounds. Power consumption will be slightly higher than for the drum storage design. The reliability and quality control aspects of the reel-to-reel design would be more demanding because of the added transport section complexity.

An electromagnetically focused version of the Electrostatic Camera System is also feasible and would provide superior performance. The overall camera MTF will be increased to 67% response at 30 lp/mm. The system will operate at a 20 percent higher quantum efficiency and perform with less image distortion. The system's size will be comparable to the electrostatically focused case but will weigh more and require additional power to drive the focus coil. Two complete systems without optics will weigh about 57 pounds. Approximately 45 watts will be required to operate two cameras in the expose mode simultaneously.

SECTION IV

RECOMMENDATIONS

4.0 GENERAL

1. The next logical step in advancing the Electrostatic Camera System concept is to develop a demonstration model applicable to future planetary missions. A developmental program sponsored by NASA appears justified based on the potential capabilities presented in this report and the beliefs of the Imaging Science Team.

2. The development of a demonstration camera with a drum store of 30 frames is recommended initially for simplicity and economical reasons as opposed to a reel-to-reel configuration. The requirements of Technical Exhibit No. 1 will be an excellent basis for establishing the performance specifications for a demonstration camera system.

SECTION V

NEW TECHNOLOGY

5.0 GENERAL

The contents of this report presents a functional design study for an Electrostatic Camera System. No reportable items of new technology have been identified. This program did not contain a hardware development phase.

APPENDIX I

TECHNICAL EXHIBIT NO. I

OPGT

DIELECTRIC TAPE IMAGING SYSTEM

FUNCTIONAL DESIGN CONTRACT

Contract No. 9553301
Technical Exhibit No. 1
29 September 1971
Rev. A. 15 December 1971

OPGT

ELECTROSTATIC CAMERA

FUNCTIONAL DESIGN STUDY

I. Introduction

This document describes the functional characteristics, requirements, and modes for a dielectric tape imaging system/data storage unit, for possible application on an Outer Planet spacecraft. It is the intent of this study to result in a functional design and mechanical and electrical analysis for usch a system. Due to severe weight and life-time constraints, it is essential that the contractor seek to minimize system weight and to maximize system reliability.

II. Functional Description of Dielectric Tape Imaging System

A. 2 bore-sighted identical cameras

B. Format size: 1000 lines x 1000 samples at the sampling frequency corresponding to 20% response on the sensor MTF.

C. Spectral response: .35 - .8μ (10% response points)

D. Storage: 30 frames

E. Storage time: 1 week

III. Functional Requirements

A. Environmental - The system shall be capable of meeting the environmental requirements specified in TOPS-3-300. The system shall be required to survive the vibration and radiation environments specified and shall be required to operate in the stated thermal and magnetic environments.

B. Exposure/Signal-to-Noise - It is desirable that at 60 scan lines/mm, the system exhibits the following exposure/noise properties when exposed to a 6000 degree K light source.

Exposure	Signal-to-Noise
4.2×10^{-2} ergs/cm^2	50 to 1
4.2×10^{-4} ergs/cm^2	5 to 1

C. Dynamic Range - At any fixed exposure setting, the science imaging subsystem shall provide a dynamic range of 64:1 in radiance as exhibited by the ability to distinguish at least 13 grey levels separated by $\sqrt{2}$ in radiance in a single frame.

D. Photometric Accuracy

Relative - The video data returned by the science imaging subsystem shall be such that using only real time ground calibration and processing*, it is possible to measure the relative radiances of two extended objects in the same frame to a 1σ error of less than 20% of full scale. With subsequent processing, it shall be possible to reduce this uncertainty to 2% of full scale.

In order to meet this photometric accuracy requirement, the science imaging subsystem may be required to provide for in-flight flat field calibration of system response.

E. Coherent Noise - Coherent Noise is that due to EMI or other sources which is correlated from pixel to pixel within a frame. The peak-to-peak amplitude of coherent noise shall not exceed 5% of full scale video, and shall not limit the ability to meet the photometric accuracy requirements of Section D.

F. Quantization Levels - The analog video signal shall be quantized by an equal increment encoder having a resolution equivalent to 7 binary bits.

G. Residual Image - The science imaging subsystem shall be free of residual images to the extent that a full scale black to white transition occurring in any one frame not appear in any subsequent frame (after priming) with an amplitude exceeding 3% of full scale. After three frames and for all subsequent frames, the residual image shall not be detectable above the random noise level.

H. Geometric Accuracy - The data returned by the science imaging subsystem shall be such that, using only real time ground processing and calibration, it would be possible to measure the distance between any two points within a single frame with a maximum 1σ error of 5% or their true separation of 5 pixels whichever is larger. It shall be possible with subsequent processing to reduce this uncertainty to 1% or 1 pixel (1σ).

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* For these purposes, real time processing is used to denote that which is performed within 1 hour or receipt of the transmitted video.

In order to meet this requirement on geometric accuracy, the science imaging subsystem shall include a system of reseau marks in the plane of the optical image.

I. Frame Time - Each camera shall be able to expose a frame within 5 seconds of the end of its previous exposure.

J. Number of Frames - The science imaging subsystem shall be capable of returning the following minimum number of frames at each planet:

Planet	Minimum Number of Frames Returned
Jupiter	4500
Saturn	3000
Uranus	1000
Neptune	1000
Pluto	600

K. Lifetime - The science imaging subsystem shall be designed to meet the following lifetime requirements:

Mode	Lifetime
Storage	12.4 years
Standby	4500 hours
Operating	2400 hours

In standby mode, operating environment will be maintained.

L. Design Reliability and Redundancy - In order to meet the extreme lifetime requirements of paragraph K, maximum use of design reliability, redundancy, and functional independence, consistent with weight and power constraints, shall be used.

M. Exposure Control - The system shall have a shutter (mechanical or electric) which provides a range of exposure times from 5 milliseconds to 10 seconds. There shall be 2 modes of selecting exposure time: (1) algorithm, and (2) manual. Algorithm control shall use the actual scene radiance to preset the exposure. Manual control shall execute specific shutter times commanded either from the spacecraft computer or transmitted from the ground.

N. Interfaces

1. Electrical - functions commanded remotely

(a) Power on/off
(b) Dark current measurement
(c) Filter wheel advance and filter wheel selection
(d) Automatic/manual exposure mode selection
(e) Manual exposure time
(f) Shutter
(g) Readout start/stop, resolution selection, data rate selection
(h) Line start/stop
(i) Priming start/stop
(j) Shutter reset (for mechanical shutter only)

2. Optical - the image plane shall be flat to $\pm$.01mm.

O. Safety Considerations - High voltages present within the science imaging camera heads will not present a safety hazard when fully assembled. Possible use of radiation activated phosphors will not present a safety hazard to spacecraft or operating personnel.

IV. Functional Modes

A. Exposure/record

B. Multiple readout at various sensor resolutions and at the following data rates:

(1) 13000 bits/second
(2) 3000 bits/second
(3) 800 bits/second
(4) 400 bits/second

C. Priming

D. Transport

E. Consecutive single camera operation

F. Alternating two camera operation

G. Simultaneous shuttering of both cameras

APPENDIX II

FUNCTIONAL BLOCK ANALYSIS

CIRCUIT DIAGRAMS AND DESCRIPTIONS

APPENDIX II

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APPENDIX II

1.0 BASIC ELECTRONIC SYSTEM CONSIDERATIONS

The electronic system proposed for operation of the Electrostatic Camera Tube represents a preliminary system design prepared primarily for the purpose of system weight, volume, and power determination. It should be treated as a reference system required to implement this study and not construed as the optimum design. Many alternative circuit designs may prove superior upon subsequent detailed analysis.

The design represents a complete camera system which may be remotely programmed by digital commands. Emphasis was placed on utilizing digital techniques and linear integrated circuitry wherever practical to minimize the discrete component count. It is recognized that in the final hardware design, space qualified components will be required and therefore, no attempt has been made to apply LSI techniques. Low power TTL logic was selected because of the relative low speed of the system and for minimum power drain. Most operational amplifier and transistor applications in the system are not critical as to frequency response or voltage breakdown so that space qualified equivalent components are readily available.

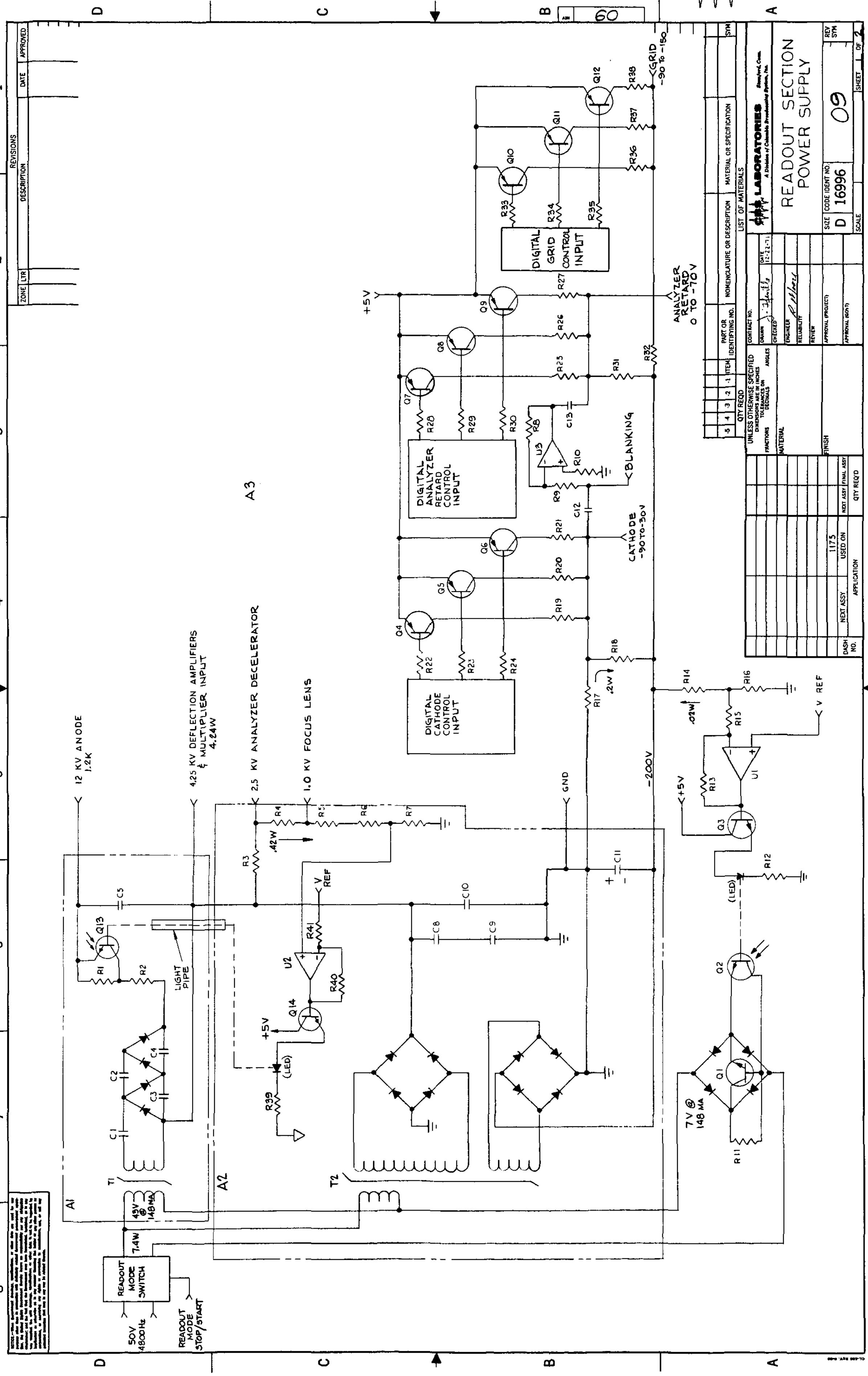
Weight and power estimates for components are based on the manufacturer's specifications. Board weight estimates are based on 1/32 inch G10 material with 1 oz. copper circuits. Estimates for transformer shielding and circuit board potting weights have been included with the electronic packaging details.

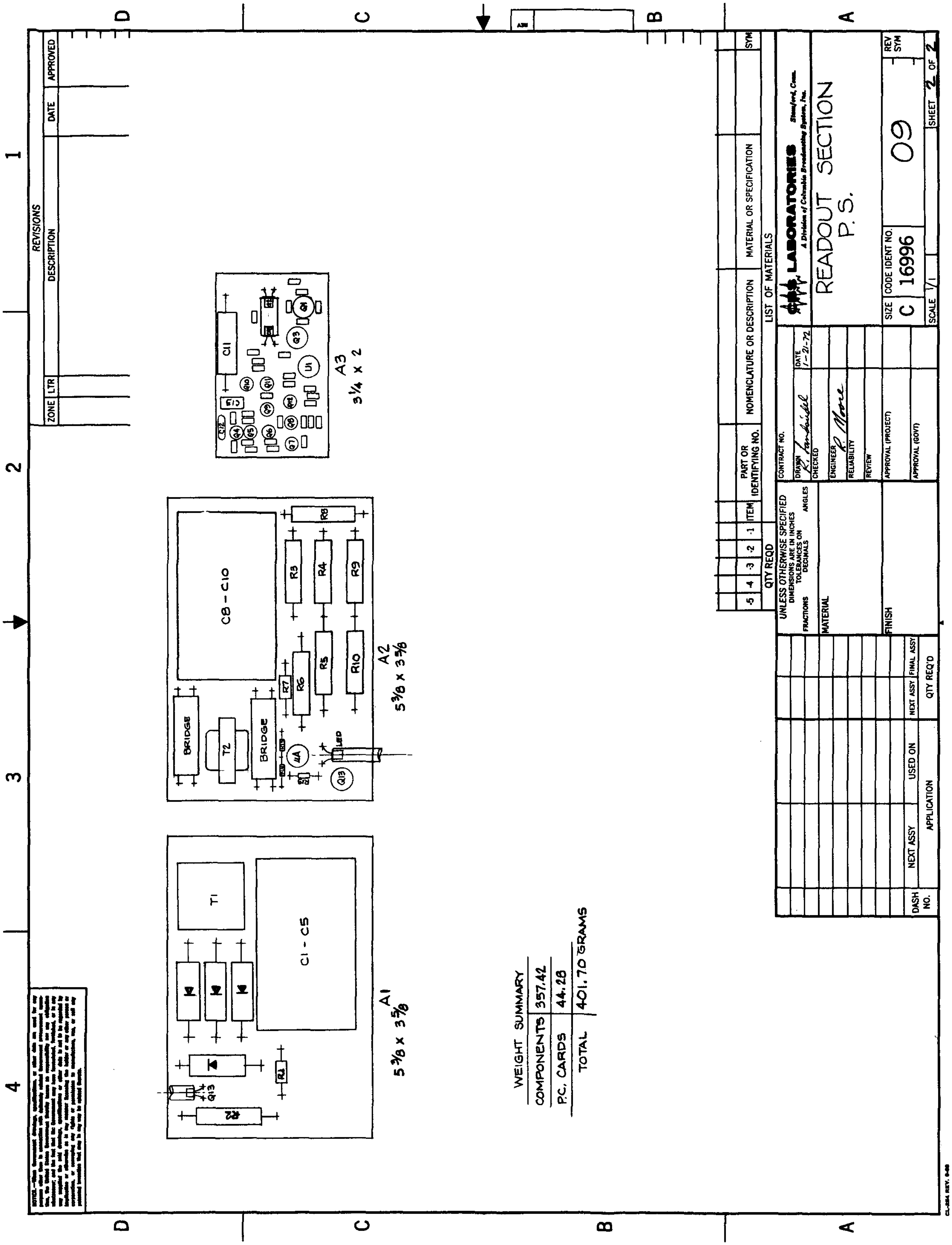
2.0 READOUT SECTION POWER SUPPLY

The readout section power supply, drawing #9, provides the potentials necessary to operate the camera in both the readout and erase modes of operation. The supply consists of two full wave bridge rectifiers developing -200 volts and +4250 volts. The 12KV anode potential is produced by a voltage quadrupler which is floated on the +4250 volt supply. This effectively reduces the voltage required from the bridge circuit and also allows the anode and focus voltages to track one another. An optically coupled regulation circuit is employed to insure tracking of the voltages keeping the tube in focus. If the 4250V supply voltage increases, more current is supplied to the LED by Q14 and its light output increases. This in turn, causes phototransistor, Q13, to conduct more current increasing the 12KV output proportionally.

The 4250 volt output voltage supplies the operating potential for the DC coupled deflection amplifiers which provide the focus voltage and represents the largest power drain from the supply. Since the deflection amplifiers are constant current differential amplifiers and the remainder of the readout tube is essential constant current, load regulation is not a cirtical parameter in the supply. Input line regulation is provided by another optically coupled regulator. Again, an increase in supply output voltage causes an increase in the light output which causes Q2 to conduct more current. This effectively shunts some of the base drive current for Q1. As this drive current to Q1 decreases, it causes a large Vce drop across Q1 which reduces the applied voltage to transformers T1 and T2 causing their output voltage to decrease. This circuit therefore regulates the output voltage of the readout power supply against changes in the 50V, 4800 Hz, input supply and also changes in the output caused by load variations. The -200 volt supply is employed as the regulator reference as it provides the cathode current to the tube. Therefore, the regulator will be sensitive to changes in tube current. It is estimated that this type of regulation system will provide line and load regulation in the order of 0.5 to 1.0 percent depending on the gain in the feedback loop. The LED and phototransistor may be supplied as a prepackaged unit or as separate components which is necessary for the 12KV regulator because of the voltage isolation required. In either case, careful design will be required to provide stable output voltage levels over the operating temperature range.

The readout section requires different grid, cathode, and analyzer retard potentials depending on the data rate or erase mode operation. Transistor switches Q4 through Q12 provide the potential changes necessary for the various operating modes by changing the divider voltages supplying the tube elements. For example, all switches may be on for the erase mode. Different switching combinations will be used for the various data rates. The control and conditioning logic matrix provides the correct drive signal for these switches depending on the operating mode.

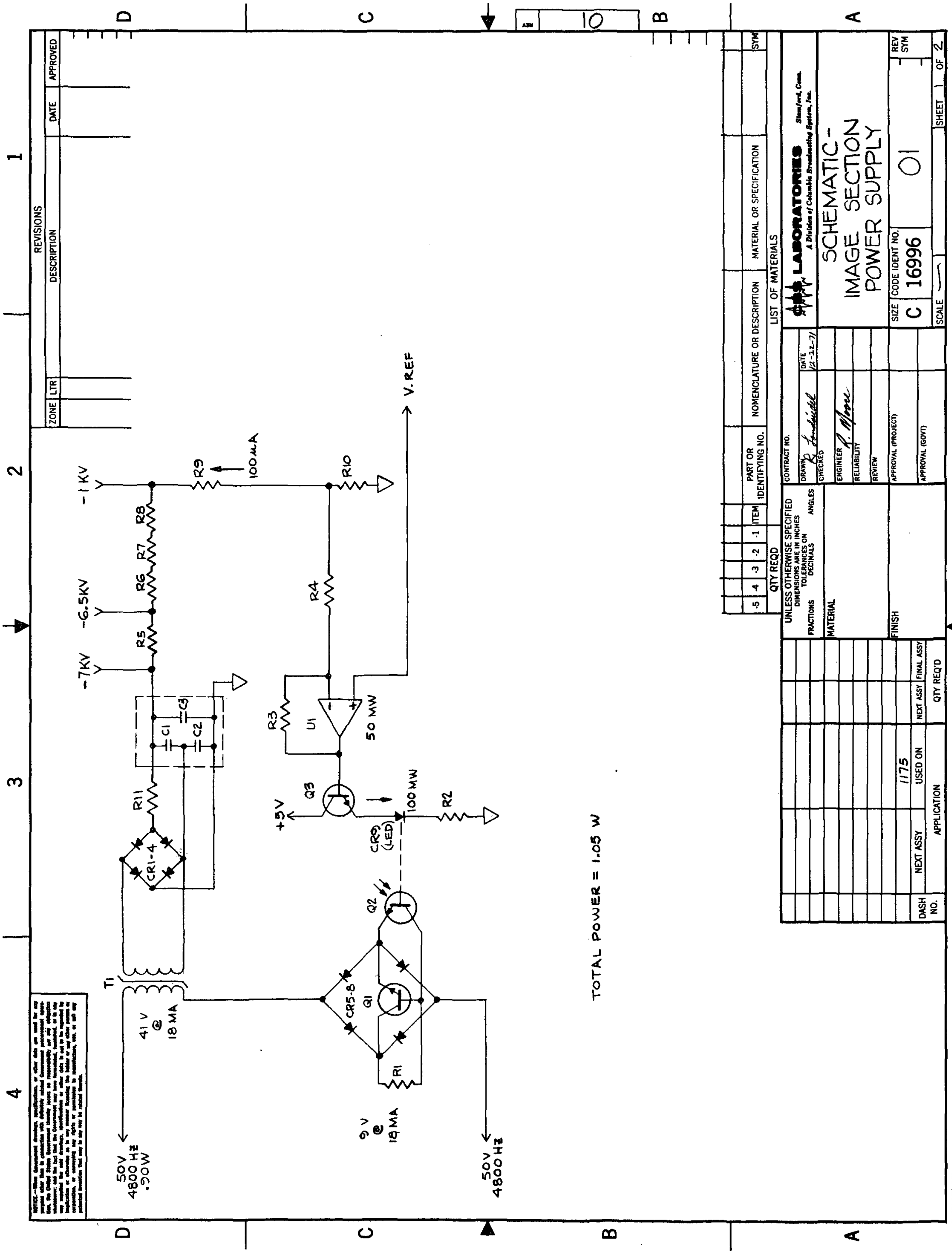

READOUT SECTION
POWER SUPPLY
D 16996
09
CBS LABORATORIES
A3
A1
A2
12 KV ANODE
1.2K
4.25 KV DEFLECTION AMPLIFIERS & MULTIPLIER INPUT
4.24W
2.5 KV ANALYZER DECELERATOR
1.0 KV FOCUS LENS
DIGITAL CATHODE CONTROL INPUT
DIGITAL ANALYZER RETARD CONTROL INPUT
DIGITAL GRID CONTROL INPUT
CATHODE -90 TO -30V
ANALYZER RETARD 0 TO -70V
GRID -90 TO -150
BLANKING
READOUT MODE SWITCH
50V 4800Hz
READOUT MODE STOP/START
LIGHT PIPE
-200V
GND
V REF
+5V
7V @ 148 MA
45V @ 148MA
7.4W
REVISIONS
LIST OF MATERIALS


REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
WEIGHT SUMMARY
COMPONENTS 357.42
P.C. CARDS 44.28
TOTAL 401.70 GRAMS
A1
5 3/8 x 3 5/8
A2
5 3/8 x 3 3/8
A3
3 1/4 x 2
T1
C1 - C5
R1
R2
Q13
C8 - C10
R3
R4
R5
R6
R7
R8
R9
R10
BRIDGE
T2
BRIDGE
LED
U1
C11
QTY REQD
ITEM
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR SPECIFICATION
LIST OF MATERIALS
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON
FRACTIONS DECIMALS ANGLES
MATERIAL
FINISH
CONTRACT NO.
DRAWN
DATE 1-21-72
CHECKED
ENGINEER R. Moore
RELIABILITY
REVIEW
APPROVAL (PROJECT)
APPROVAL (GOVT)
CBS LABORATORIES Stamford, Conn.
A Division of Columbia Broadcasting System, Inc.
READOUT SECTION
P. S.
SIZE C
CODE IDENT NO. 16996
09
SCALE 1/1
SHEET 2 OF 2
REV SYM
DASH NO.
NEXT ASSY
USED ON
APPLICATION
NEXT ASSY
FINAL ASSY
QTY REQ'D

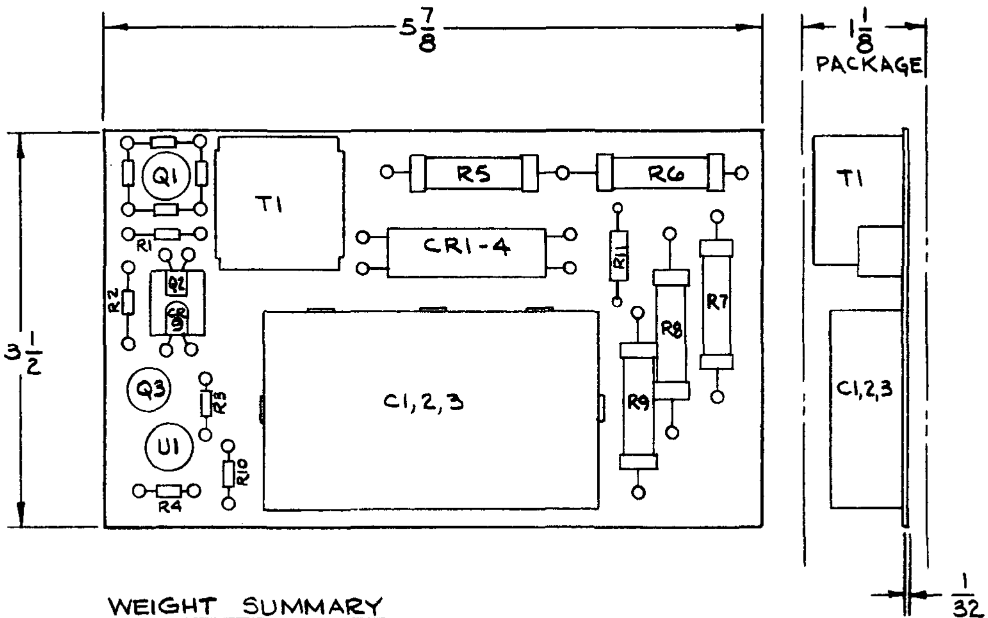
3.0 IMAGE SECTION POWER SUPPLY

The image section power supply, shown in drawing #1, provides all the necessary potentials for operation of the image section in the exposure operating mode. The basic power supply is a full wave bridge voltage doubler supply. Regulation of the supply is accomplished with an optically coupled regulation stage whose operation is identical to the line-load regulation system employed in the readout supply. Regulation is in the order of 0.5 to 1.0 percent.

Initial system concepts indicated that electronic shuttering would be possible by controlling one potential in the image section or by switching the image supply on and off as required by the exposure time. This concept was abandoned in favor of the mechanical shutter system because of the problem of controlling the rise and fall time of the high voltage developed by the image supply.


SCHEMATIC - IMAGE SECTION POWER SUPPLY
CBS LABORATORIES Stamford, Conn.
A Division of Columbia Broadcasting System, Inc.
SIZE C
CODE IDENT NO. 16996
01
SHEET 1 OF 2
DRAWN
DATE 12-22-71
CHECKED
ENGINEER
RELIABILITY
REVIEW
APPROVAL (PROJECT)
APPROVAL (GOVT)
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES
MATERIAL
FINISH
LIST OF MATERIALS
QTY REQD
ITEM
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR SPECIFICATION
NEXT ASSY
USED ON
1175
APPLICATION
FINAL ASSY
QTY REQ'D
DASH NO.
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
10
-7KV
-6.5KV
-1KV
R5
R6
R7
R8
R9
100 µA
R10
V. REF
R4
R3
U1
50 MW
C1
C2
C3
R11
CR1-4
+5V
Q3
100 MW
R2
CR9 (LED)
Q2
Q1
CR5-8
R1
T1
41 V @ 18 MA
9 V @ 18 MA
50V 4800 Hz .90W
50V 4800 Hz
TOTAL POWER = 1.05 W

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



LINEAR COMPLIMENT	QTY
2N2219	2
µA741	1
OPTICAL COUPLER	1
DIODE BRIDGE	1
DIODE	4

COMPONENTS	
TRANSFORMER	1
HV CAPACITOR MODULE	1
HV RESISTORS	5
1/8W RESISTORS	5
1/2W RESISTORS	1

WEIGHT SUMMARY

COMPONENTS	128.40
CARD	18.00
TOTAL	146.40

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
		1175		
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.

DRAWN J. Fenille DATE 1-3-72

CHECKED

ENGR. R. Moore

REVIEW

APPROVAL (PROJ)

APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn. A Division of Columbia Broadcasting System, Inc.

COMPONENT BOARD, IMAGE SECTION POWER SUPPLY

SIZE B | CODE IDENT NO. 16996 | 01 | REV SYM

SCALE 1/1 | SHEET 2 OF 2

CL-253 REV. 6-68

GRAPHIC CONTROLS CORP.

CBS LABORATORIES

F

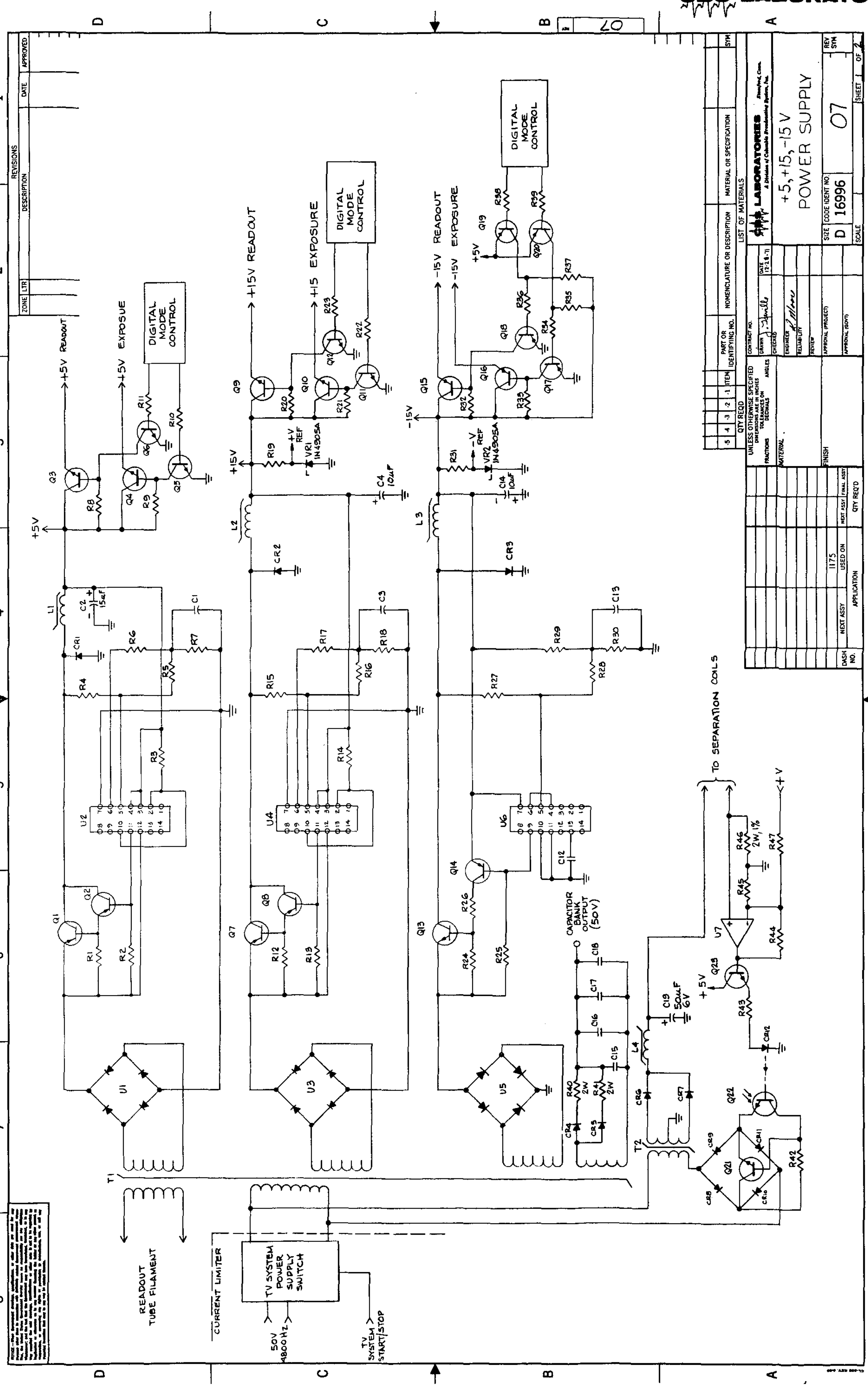
4.0 LOW VOLTAGE POWER SUPPLY

The low voltage power supply is shown in drawing #7. The +5, +15, and -15 volt supplies for the camera are regulated by three separate switching regulators operating at about 20KHz. Switching regulators were selected because of their higher efficiency as compared by conventional series regulators. Integrated regulators UA 723 are used for the regulating device. A stable zener diode controls the reference voltage outputs used for the LED regulation circuits employed for regulation of other power supplies.

A capacitor bank is used to store energy to drive the various solenoid circuits. The capacitor bank is charged to 50 volts by a half wave rectifier, storing energy of about 2.7 joules. This is an arbitrary selection, the final selection will be made to conform with system requirements as determined by shutter, drum, and filter wheel solenoid designs.

Both the readout filament and separation coil are energized with the low voltage supplies. This adds about 4 watts to the expose mode operation that could be eliminated if the mission profile indicated expose and readout modes at entirely different time periods. These devices remain energized to improve operating stability. This may not be necessary as long as there is a short warm-up period for the readout mode.

Regulation of the separator coil current is critical with estimated regulation of 0.05% being required. Again, the optically coupled regulator will be employed with R46 performing the current sensing. R46 and the regulator will have to be carefully designed to obtain the required regulation accuracy.


CBS LABORATORIES
+5, +15, -15 V
POWER SUPPLY
D 16996
07
+5V READOUT
+5V EXPOSUE
+15V READOUT
+15 EXPOSURE
-15V READOUT
-15V EXPOSURE
DIGITAL MODE CONTROL
DIGITAL MODE CONTROL
DIGITAL MODE CONTROL
TO SEPARATION COILS
CAPACITOR BANK OUTPUT (50V)
READOUT TUBE FILAMENT
CURRENT LIMITER
TV SYSTEM POWER SUPPLY SWITCH
50V 4800Hz
TV SYSTEM START/STOP
1175

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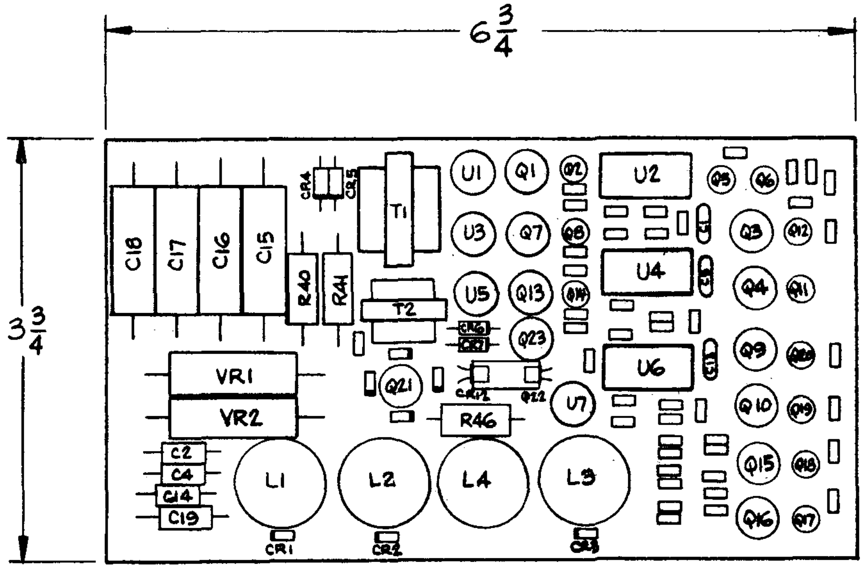
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY	
COMPONENTS	408.2
CARD	28.0
TOTAL GRAMS	436.2



DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.	
DRAWN R. [illegible]	DATE 1-24-72
CHECKED	
ENGR R. Moore	
REVIEW	
APPROVAL (PROJ)	
APPROVAL (GOVT)	

CBS LABORATORIES Stamford, Conn.
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POWER SUPPLY- +15V, -15V, +5V D.C.

SIZE B | CODE IDENT NO. 16996 | 07 | REV SYM

SCALE 1/1 | SHEET 2 OF 2

CL-223 REV. 6-66

GRAPHIC CONTROLS CORP.

CBS LABORATORIES

5.0 POWER DISTRIBUTION AND CURRENT LIMITER

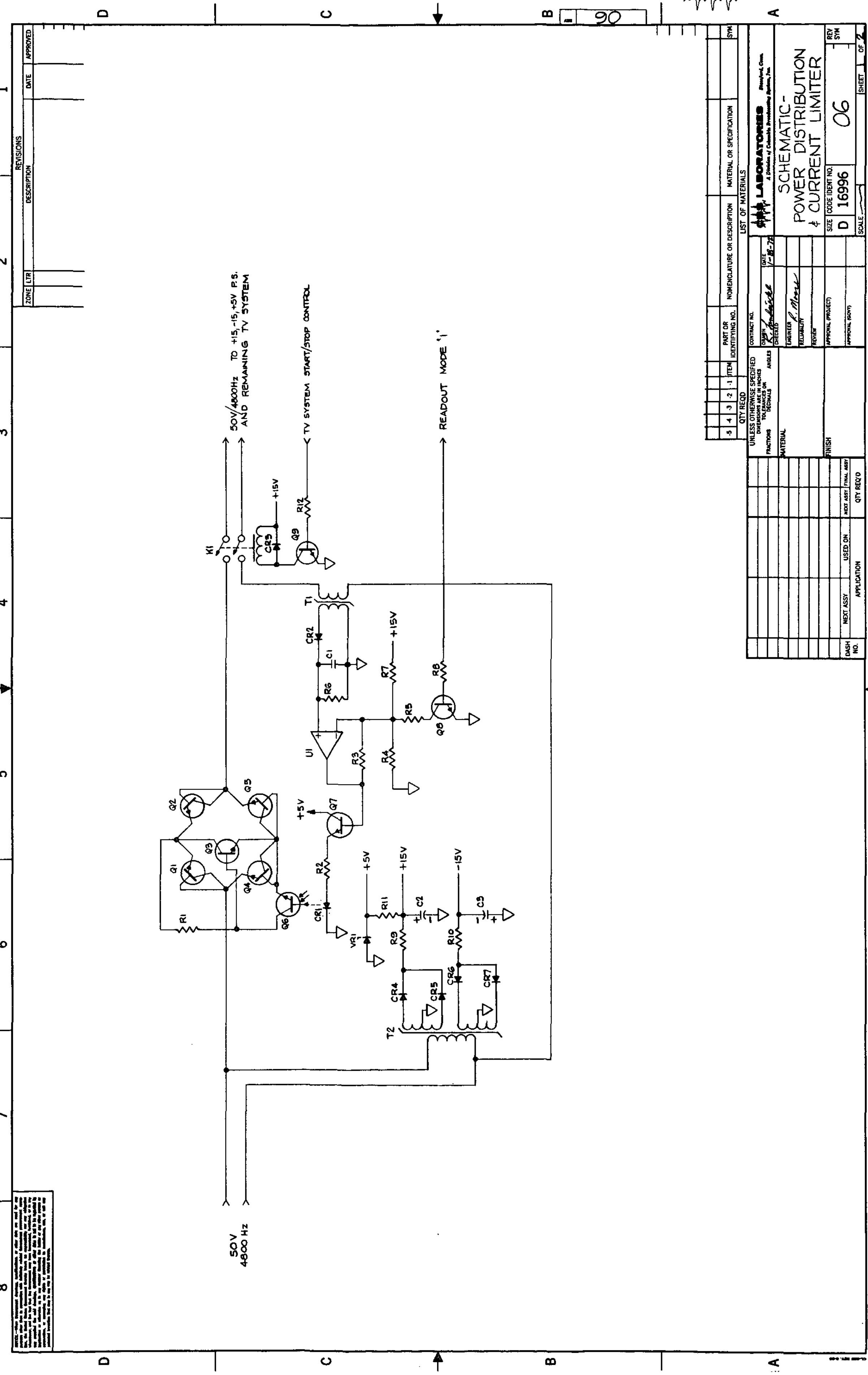
A power distribution and current limiting system will supply each camera so that an overload condition in one camera will not disable the other. The circuit, shown in drawing #6, supplies all of the 50V, 4800Hz power to the camera. Transformer T2 supplies the DC power necessary for the current limiter and those circuits required to energize the system.

The circuit operates when the camera "on" command is received, causing Q9 to close the relay and apply power to the camera system. The current flowing into the camera system is detected by transformer T1 and its output is rectified and becomes the non-inverting input to operational amplifier U1. Normally, the reference voltage applied to the inverting input of U1 holds Q7 nearly off and little light is emitted by the LED. The gain of U1 is made large so as to make it operate as a comparator. When an overload condition exists, the output of T1 increases and causes U1 to turn on Q7. The LED light output causes phototransistor Q6 to shunt the base drive to Q3 which then becomes a high impedance in the 50V line feeding the camera. The time constant of R6 and C_1 is made long since this method of limiting is oscillitory in nature. As Q3 reduces the current, the output from T_1 decreases and would allow Q7 to turn-off except for the long time constant. Eventually, the voltage C1 decays power is again applied to the camera. If an overload still exists, the cycle will repeat. Monitoring of camera low voltage by the measurements processor will detect this condition and allow the camera to be shut down.

Because the power consumption of the camera is different depending on its operating mode, the required comparison voltage for U1 is altered to set a different overload current limit for each mode.

Transistors are employed in the bridge circuit to maintain the correct voltage polarity on Q3 in order to reduce the power dissipation. The Vce drop for transistors is less than that of silicon diodes.

A simple overload indicator could be employed in place of the limiter if temporary overloads can be tolerated. Transformer T1 can be placed in series with the camera load, its output rectified, and processed by the measurement processor for monitoring. An overload would produce an abnormally high output voltage and the camera could be automatically or manually de-energized.


SCHEMATIC-
POWER DISTRIBUTION
& CURRENT LIMITER
D 16996
06
50V 4800 Hz
50V/4800Hz TO +15,-15,+5V P.S. AND REMAINING TV SYSTEM
TV SYSTEM START/STOP CONTROL
READOUT MODE '1'

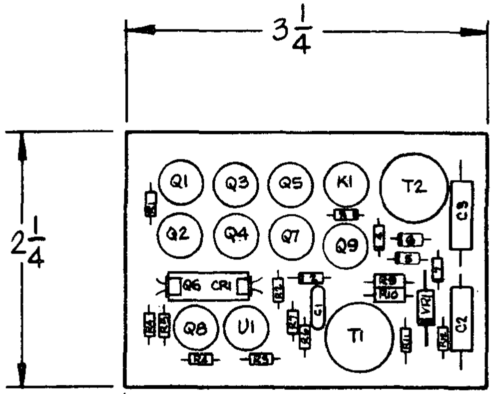
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY

COMPONENTS	37.5
CARD	8.9
TOTAL GRAMS	46.4

POWER SUMMARY

50 V 4800 Hz	722 MW EXPOSE MODE 850 MW READOUT MODE



DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.

DRAWN R. Landsiedel DATE 1-24-72

CHECKED

ENGR. R. Moore

REVIEW

APPROVAL (PROJ)

APPROVAL (GOVT)

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POWER DISTRIBUTOR & CURRENT LIMITER

SIZE B | CODE IDENT NO. 16996 | 06 | REV SYM

SCALE 1/1 | SHEET 2 OF 2

CL-255 REV. 6-66

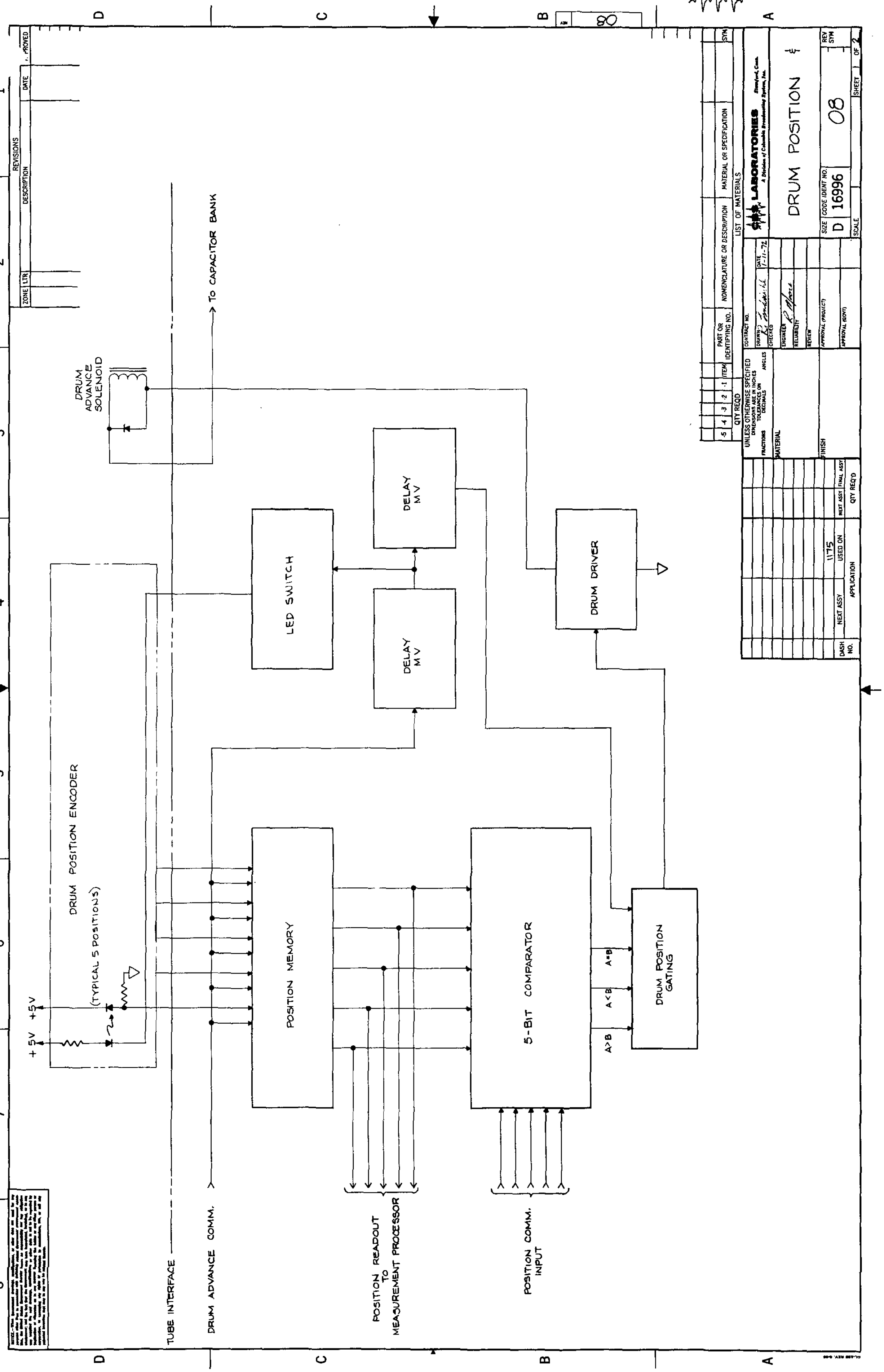
GRAPHIC CONTROLS CORP.

6.0 DRUM POSITION SYSTEM

The drum position system and filter position system, drawing #8, are identical in operation. The only significant difference is the number of positions required and therefore the number of bits required to establish the position.

The system employed is designed to be fully automatic so that once a new position and drum advance command is received, the drum advances until the new position is reached. The drum position code from the control & conditioning logic matrix (CCLM) is fed directly into a 5-bit comparator. The drum advance command provides a repetitive pulse train to the drum position circuit. The repetition rate is such that the drum is capable of advancing one position between pulses. This pulse resets the drum position memory. The delay multivibrator switches on the position LED's of the drum encoder. The output from the corresponding photodiodes is entered into the position memory. This information is then compared by the comparator to the command position code. When the codes are different, the output gating is such that the pulse from the second delay multivibrator switches on the drum driver to advance the drum one position. At this time, another pulse occurs on the drum advance line and the sequence is repeated until the command code and the drum position code are identical. When this occurs, no pulse is applied to the drum driver switch. A command is returned to the CCLM which resets the drum advance latch. The position of the drum is critical to system operation, so its code must also be returned to the measurement processor.

The drum advance system may be simplified so that each command from earth advances the drum one position. This would delete the comparator and position gating. A drum advance pulse would simply energize the drum driver and then energize the position encoder to establish the new position information in the memory for the measurement processor.


DRUM ADVANCE SOLENOID
TO CAPACITOR BANK
DELAY MV
DELAY MV
LED SWITCH
DRUM DRIVER
DRUM POSITION ENCODER
(TYPICAL 5 POSITIONS)
+5V
+5V
POSITION MEMORY
5-BIT COMPARATOR
A>B
A<B
A=B
DRUM POSITION GATING
TUBE INTERFACE
DRUM ADVANCE COMM.
POSITION READOUT TO MEASUREMENT PROCESSOR
POSITION COMM. INPUT
REVISIONS
LIST OF MATERIALS
CBS LABORATORIES
DRUM POSITION
D 16996
08
1175
SHEET 1 OF 2

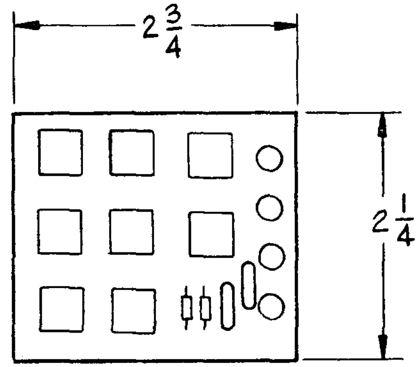
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY

COMPONENTS	6.5
CARD	6.1
TOTAL GRAMS	12.6

POWER SUMMARY

+5V — 310 MW



LOGIC COMPLIMENT

54L73	3
54L00	1
54L04	1
54L122	2
93L24	1

LINEAR COMPLIMENT

2N3904	4

COMPONENTS

CAPACITORS	2
1/8W RESISTORS	2

	PART NO
FILTER WHEEL	-1
DRUM POSITION	-2

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
1				
2				
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.

DRAWN R L DATE 1-26-72

CHECKED

ENGR. R Moore

REVIEW

APPROVAL (PROJ)

APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn. A Division of Columbia Broadcasting System, Inc.

FILTER WHEEL DRUM POSITION

SIZE B | CODE IDENT NO. 16996 | 08 | REV SYM

SCALE | SHEET 2 OF 2

CL-323 REV. 6-68

GRAPHIC CONTROLS CORP.

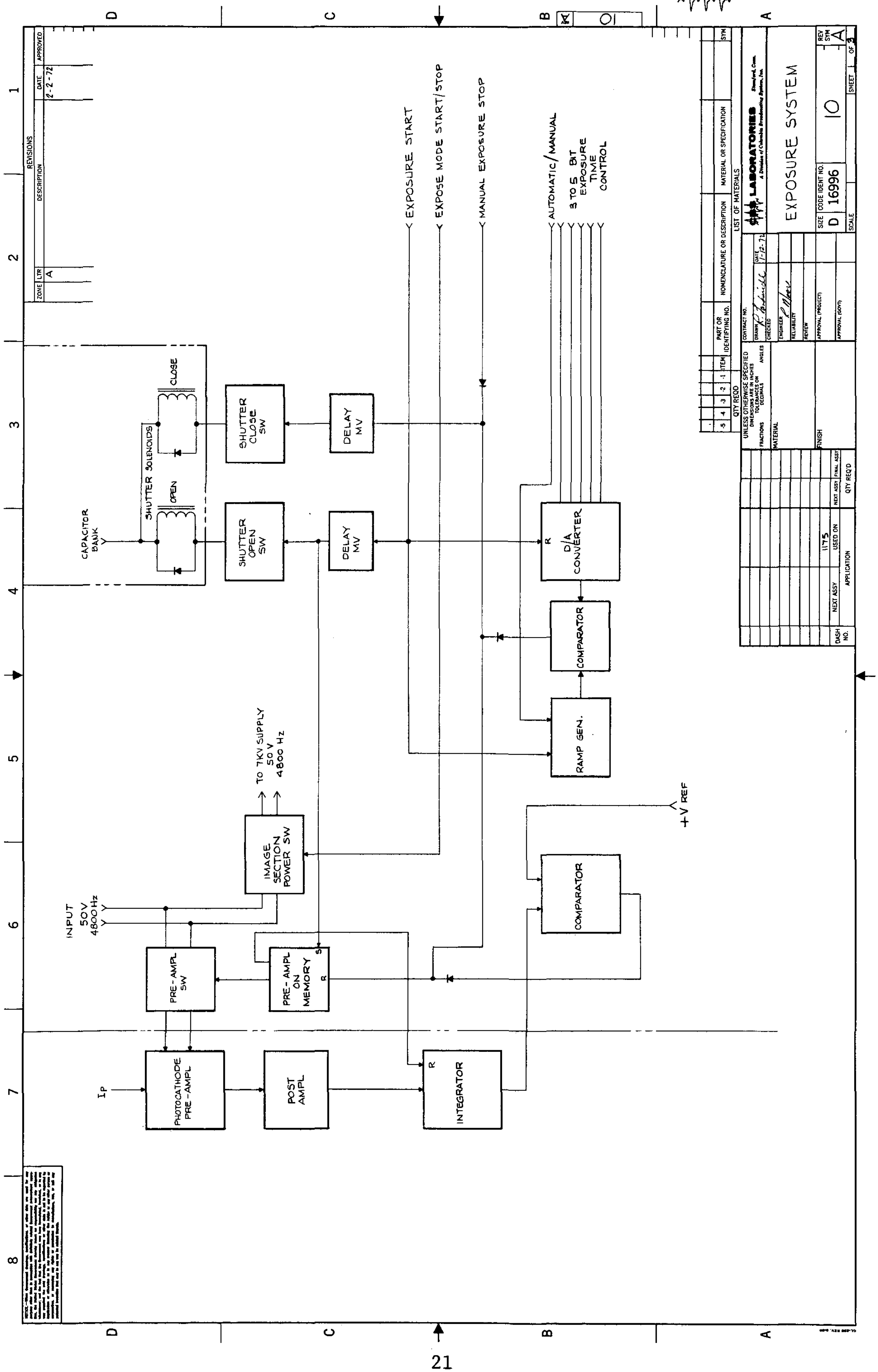
7.0 EXPOSURE SYSTEM

The exposure system in drawing #10 provides two separate modes of operation. In the automatic mode, the photocathode current of the image section is amplified and integrated. The output of the integrator is then compared to a reference signal and when they are equal, the shutter is closed. Since the integrated photocathode current is proportional to light exposing the photocathode, an automatic exposure level is established. The reference would be precalibrated to match the average charge density required to record an image on the storage tape during exposure. In the manual operating mode, the exposure system receives a digital command which is coded in accordance to pre-selected exposure times. When the shutter exposure time is complete, the shutter closes automatically. An over-riding shutter close command is available to permit ground control of exposure time in the event that there is a malfunction of the other systems.

The exposure mode start/stop command energizes the image section power supply. In the automatic mode, the ramp generator is held off so that the manual comparator is not operational. Where the exposure start command is received, it is converted into a pulse by the delay multivibrator of proper width to energize the shutter solenoid. Simultaneously, this pulse energizes the photocathode preamplifier by setting the preamp memory circuit and also energizes the current integrator. The photocathode pre-amplifier is essentially identical to the video preamp in that it operates at the photocathode potential (-7KV) and employs optical H.V. isolation. It does not require any gain control. The post ampliifer provides enough gain to drive the integrator. The intergrator output and the exposure reference are compared.

When the exposure reaches the reference level, the comparator output causes the delay multivibrator in the shutter close circuit to develop a pulse closing the shutter. The comparator output also resets the preamp memory which de-energizes the preamp and resets the integrator. A signal from the shutter close operation goes to the CCLM to reset the expose latch so the system is ready for the next expose command.

In the manual expose mode, the shutter open and close operation is identical to the automatic, the difference being in how the shutter close pulse is derived. When the manual mode is selected, the ramp generator is set to operate and the preamp memory is held in the off setting. The exposure start pulse causes the ramp generator to start the ramp. The period of the ramp is longer than the longest exposure time. The digital exposure time command has been converted by the D/A converter into a DC reference level. When the ramp voltage reaches the reference level, the shutter close command is obtained and the shutter closes as before.



REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
A
2-2-72
EXPOSURE START
EXPOSE MODE START/STOP
MANUAL EXPOSURE STOP
AUTOMATIC/MANUAL
3 TO 5 BIT EXPOSURE TIME CONTROL
CAPACITOR BANK
SHUTTER SOLENOIDS
OPEN
CLOSE
SHUTTER CLOSE SW
SHUTTER OPEN SW
DELAY MV
DELAY MV
D/A CONVERTER
COMPARATOR
RAMP GEN.
TO 7KV SUPPLY 50 V 4800 Hz
IMAGE SECTION POWER SW
+V REF
COMPARATOR
INPUT 50V 4800Hz
PRE-AMPL SW
PRE-AMPL ON MEMORY
S
R
R
PHOTOCATHODE PRE-AMPL
POST AMPL
INTEGRATOR
Ip
LIST OF MATERIALS
QTY REQD
ITEM
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR SPECIFICATION
UNLESS OTHERWISE SPECIFIED
CBS LABORATORIES
EXPOSURE SYSTEM
SIZE
D
CODE IDENT NO.
16996
10
REV
A
SHEET 1 OF 3
NEXT ASSY
USED ON
1175
APPLICATION

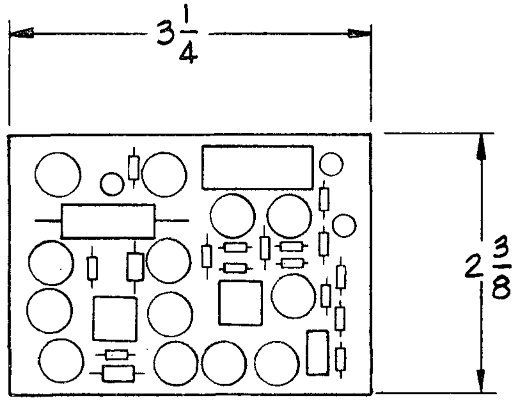
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY

COMPONENTS	11.5
CARD	9.0
TOTAL GRAMS	20.5

POWER SUMMARY

+5V	140 MW
+15V	1025 MW
−15V	125 MW



LOGIC COMPLIMENT

54L73	1
54L122	1

LINEAR COMPLIMENT

μA741	4
μA722	1
2N3904	1
2N2219	5
FET	2

COMPONENTS

TO-5 RELAY	3
CAPACITORS	4
DIODES	5
RESISTOR ARRAY	1
1/8 W RESISTORS	9

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.
DRAWN RL DATE 1-28-72
CHECKED
ENGR. R. Moore
REVIEW
APPROVAL (PROJ)
APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn.
A Division of Columbia Broadcasting System, Inc.

EXPOSURE SYSTEM ELECTRONICS

SIZE B | CODE IDENT NO. 16996 | 10 | REV SYM
SCALE | SHEET 2 OF 3

CL-283 REV. 6-60
GRAPHIC CONTROLS CORP.

6

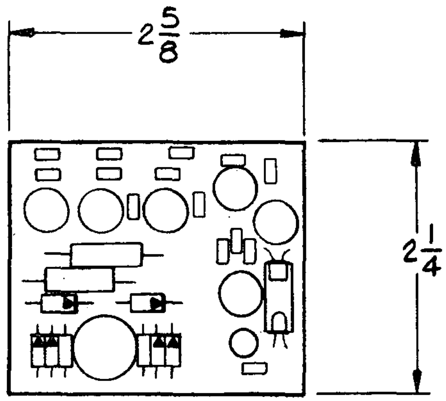
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY

COMPONENTS	20.8
CARD	5.5
TOTAL GRAMS	26.3

POWER SUMMARY

+15V	25MW
-15V	25 MW
50V 4800 Hz	550 MW



LINEAR COMPLIMENT

FET	1
TRANSISTOR	3
PHOTOTRANSISTOR	1
µA741	3
LED	1

COMPONENTS

DIODES	4
ZENER DIODES	3
CAPACITORS	4
1/8W RESISTORS	12
1/4W RESISTORS	2

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.
DRAWN RI DATE 1-26-72
CHECKED
ENGR. R. Moore
REVIEW
APPROVAL (PROJ)
APPROVAL (GOVT)

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PHOTOCATHODE PRE-AMPL & POST AMPL

SIZE B | CODE IDENT NO. 16996 | 10 | REV SYM

SCALE | SHEET 3 OF 3

CL-253 REV. 6-66

GRAPHIC CONTROLS CORP.

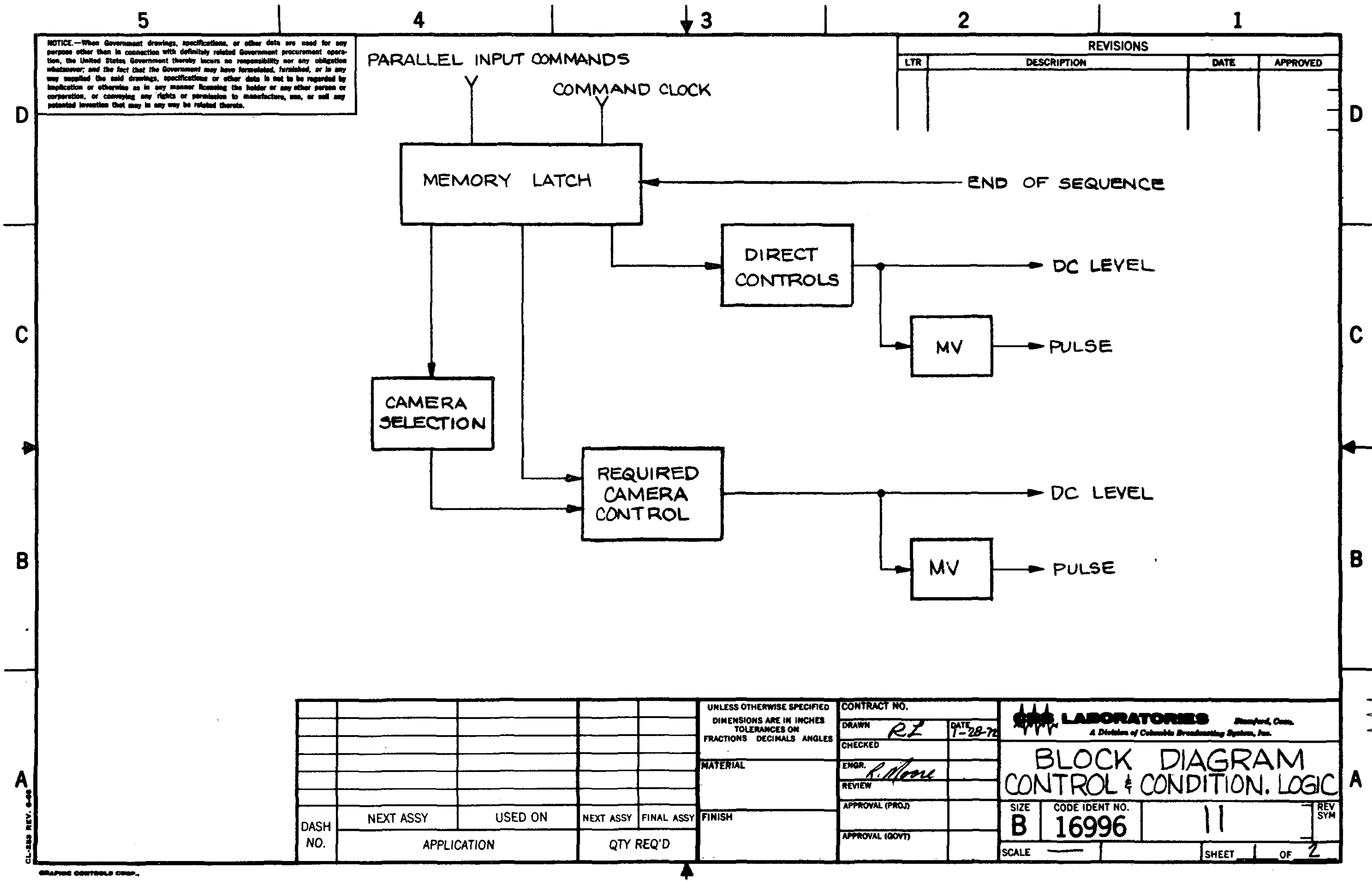
8.0 CONTROL AND CONDITIONING LOGIC MATRIX

Since the parameters of the spacecraft command system are undefined, as well as the number of command bits available for the camera system, the input commands have been selected to provide for the most flexible operation of the Electrostatic Camera. Design of the Control and Conditioning Logic Matrix (CCLM), drawing #11, provides independent control of the image section and readout section power supplies for mode control and power conservation. The CCLM allows consecutive single camera operation, alternating two camera operation, and simultaneous operation of the cameras. All combinations of camera mode operation are possible with the exception of simultaneous readout from both cameras. A thorough analysis of the mission profile may preclude the necessity of some of these optional operating modes, and therefore, permit specification of the control system.

For the design of the CCLM, it has been assumed that parallel data will be provided at intermittant or low data rates. Therefore, all data is fed into latches for temporary memory between data updates. The data could be provided in coded serial format. This would require the addition of decoding and serial to parallel conversion in the CCLM. Overall system considerations will dictate the actual command interface and is beyond the scope of this study.

The CCLM will receive and decode all of the camera commands and direct them to the appropriate circuit. The command system as designed requires a maximum of 42 bits. Some of these commands are redundant in that they could be made automatic. A listing of camera system commands and the number of bits required follows:

TV Power, ON-OFF	1-bit
Lens Cover, Open-Close	2
Camera A/B, Exposure mode	2
Exposure Start	1
Manual Exposure ON-OFF	1
Exposure Reference	3-5
Manual Exposure Stop	1
Camera A Drum Advance	1
Drum Position Reference	5
Camera B Drum Advance	1
Drum Position Reference	5
Camera A Filter Advance	1
Filter Position Reference	3-4
Camera A/B Readout Mode	2
Readout Start	1
Data Rate Selection	2
Camera A/B Prime Erase Mode	2
Erase-Prime Start	1
	42 bits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REVISIONS
LTR
DESCRIPTION
DATE
APPROVED
PARALLEL INPUT COMMANDS
COMMAND CLOCK
MEMORY LATCH
END OF SEQUENCE
DIRECT CONTROLS
DC LEVEL
MV
PULSE
CAMERA SELECTION
REQUIRED CAMERA CONTROL
DC LEVEL
MV
PULSE
DASH NO.
NEXT ASSY
USED ON
APPLICATION
NEXT ASSY
FINAL ASSY
QTY REQ'D
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES
MATERIAL
FINISH
CONTRACT NO.
DRAWN R.L.
DATE 7-28-72
CHECKED
ENGR. R. Moore
REVIEW
APPROVAL (PROJ)
APPROVAL (GOVT)
CBS LABORATORIES Stamford, Conn.
A Division of Columbia Broadcasting System, Inc.
BLOCK DIAGRAM
CONTROL & CONDITION. LOGIC
SIZE B
CODE IDENT NO. 16996
11
REV SYM
SCALE
SHEET 1 OF 2
CL-283 REV. 6-68
GRAPHIC CONTROLS CORP.

REVISIONS

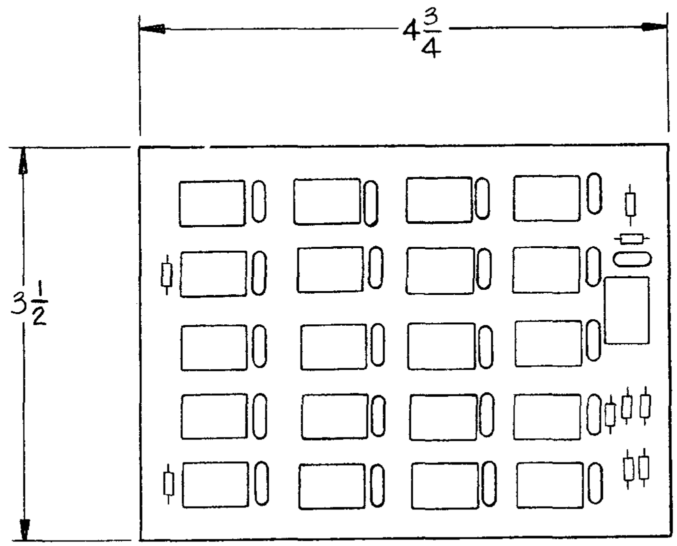
LTR	DESCRIPTION	DATE	APPROVED
A		2-2-72	

WEIGHT SUMMARY

COMPONENTS	38.50
CARD	33.22
TOTAL GRAMS	71.72

POWER SUMMARY

+5V	1580MW



LOGIC COMPLIMENT

93L14	10
5408	4
9602	3
54L00	4

COMPONENTS

RESISTORS	9
CAPACITORS	12

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.

DRAWN R. Lonbrudel DATE 1-24-72

CHECKED

ENGR. R. Moore

REVIEW

APPROVAL (PROJ)

APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn. A Division of Columbia Broadcasting System, Inc.

CONTROL & CONDITIONING LOGIC MATRIX

SIZE B | CODE IDENT NO. 16996 | 11 | REV SYM A

SCALE 1/1 | SHEET 2 OF 2

CL-283 REV. 6-66

GRAPHIC CONTROLS CORP.

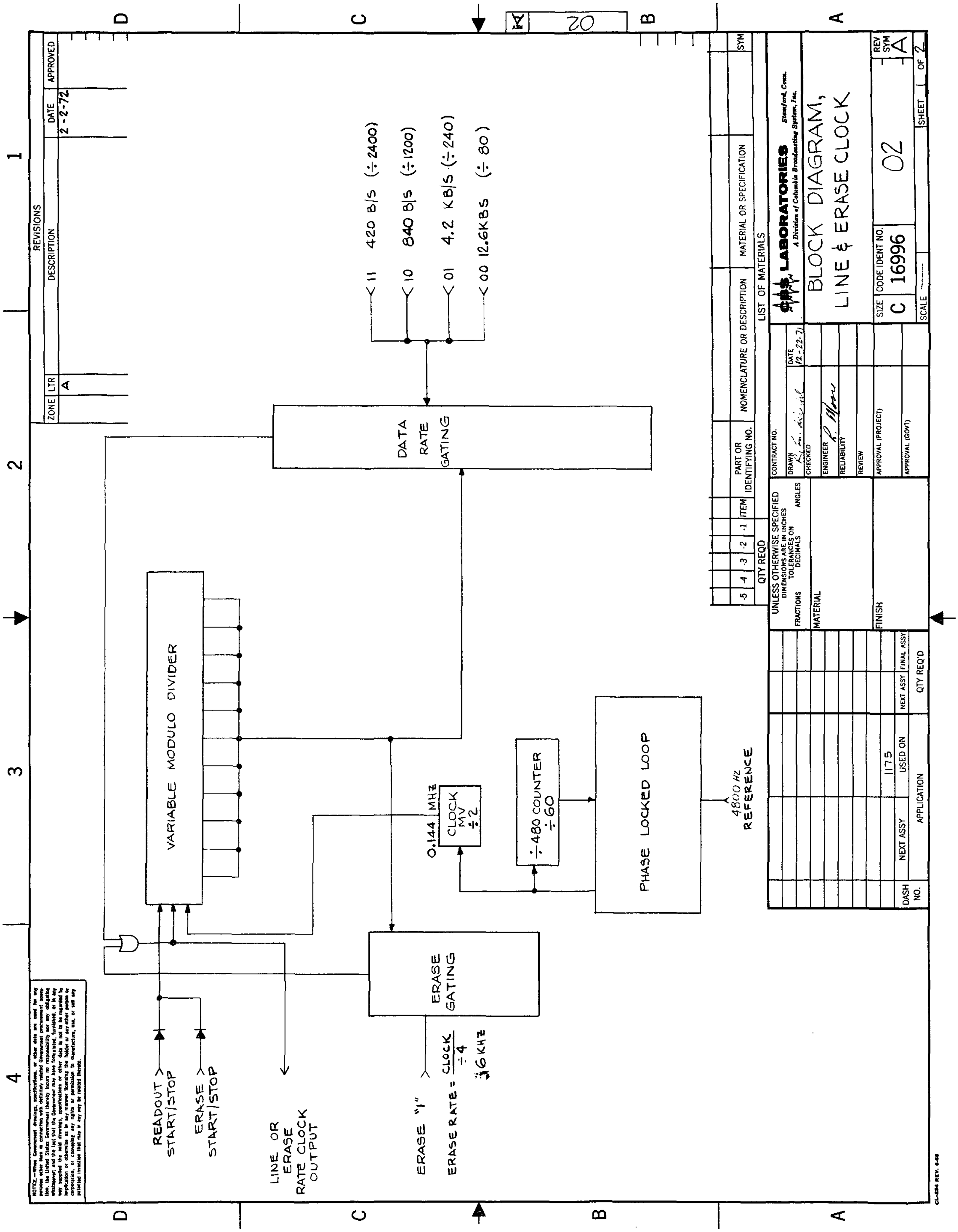
CBS LABORATORIES

9.0 LINE AND ERASE CLOCK

The primary consideration in the design of the Line and Erase Clock was to provide a clock that could be digitally programmed to operate at different frequencies with the output occurring at the required data or erase rate line frequencies. Another concern was in selection of a frequency reference to use to control the system. Drawing #2 shows the Line and Erase Clock Block Diagram.

The power supply frequency of 4800 Hz was selected as the reference frequency so that any power related glitches that might occur in the video would be "locked" to the scanning rate and therefore could be easily identified and removed in ground video processing. The selection of the 4800 Hz reference dictated changes in the data rates so that all rates are evenly divisible into the master oscillator frequency. Other choices for the reference frequency are possible. For example, the clock rate of the video A/D converter would be another excellent possibility or a VCO type oscillator could be employed to obtain variations of data rates about the pre-selected rate.

The phase-locked loop and the ÷60 counter multiply the reference frequency by 60. The multiplying is obtained with the phase-locked loop which has a VCO oscillator operating at 288KHz. The oscillator output is divided by the counter to obtain a 4800Hz signal which is compared to the reference frequency by a phase comparator. The output of the phase comparator is filtered and applied to the VCO so that the X60 relationship is maintained. The output of the VCO is ÷2 to obtain the system clock of 144KHz.


BLOCK DIAGRAM,
LINE & ERASE CLOCK
CBS LABORATORIES A Division of Columbia Broadcasting System, Inc. Stamford, Conn.
DATA RATE GATING
11 420 B/S (÷ 2400)
10 840 B/S (÷ 1200)
01 4.2 KB/S (÷ 240)
00 12.6KBS (÷ 80)
VARIABLE MODULO DIVIDER
PHASE LOCKED LOOP
÷ 480 COUNTER ÷ 60
CLOCK MV ÷ 2
0.144 MHZ
4800 Hz REFERENCE
ERASE GATING
READOUT START/STOP
ERASE START/STOP
LINE OR ERASE RATE CLOCK OUTPUT
ERASE "1"
ERASE RATE = CLOCK ÷ 4
36 KHZ
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
A 2-2-72
LIST OF MATERIALS
SIZE C CODE IDENT NO. 16996 02
REV SYM A
SHEET 1 OF 2
DATE 12-22-71
1175 USED ON

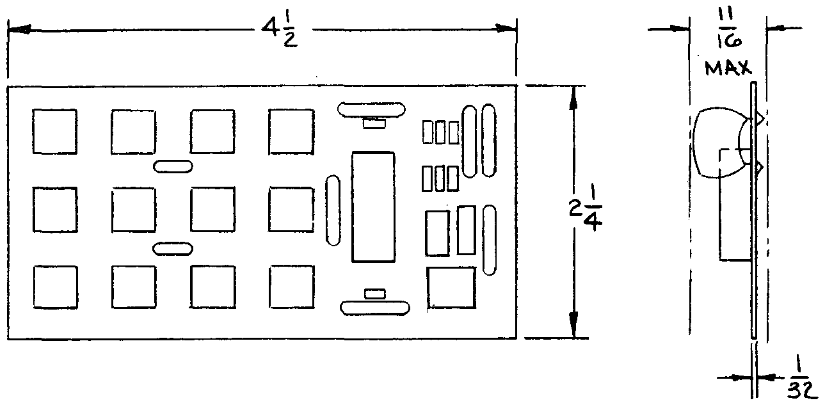
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY

COMPONENTS	10.73
CARD	11.70
TOTAL	22.43 GRAMS

POWER SUMMARY

+5	245
+15	150
TOTAL	395 MW



LOGIC COMPLIMENT:	QTY
SN54L93	5
SN54121	1
SN54L10	3
SN54L00	2
SN54L04	1
SN54L20	1
LINEAR COMPLIMENT:	
NE562B	1
COMPONENTS:	
1/8 W RESISTORS	8
CAPACITORS	10

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
		1175		
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.

DRAWN J. Tgeville DATE 1-6-72

CHECKED

ENGR. R. Moore

REVIEW

APPROVAL (PROJ)

APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn. A Division of Columbia Broadcasting System, Inc.

COMPONENT BOARD, LINE & ERASE CLOCK

SIZE B | CODE IDENT NO. 16996 | 02 | REV SYM

SCALE 1/1 | SHEET 2 OF 2

CL-253 REV. 6-69

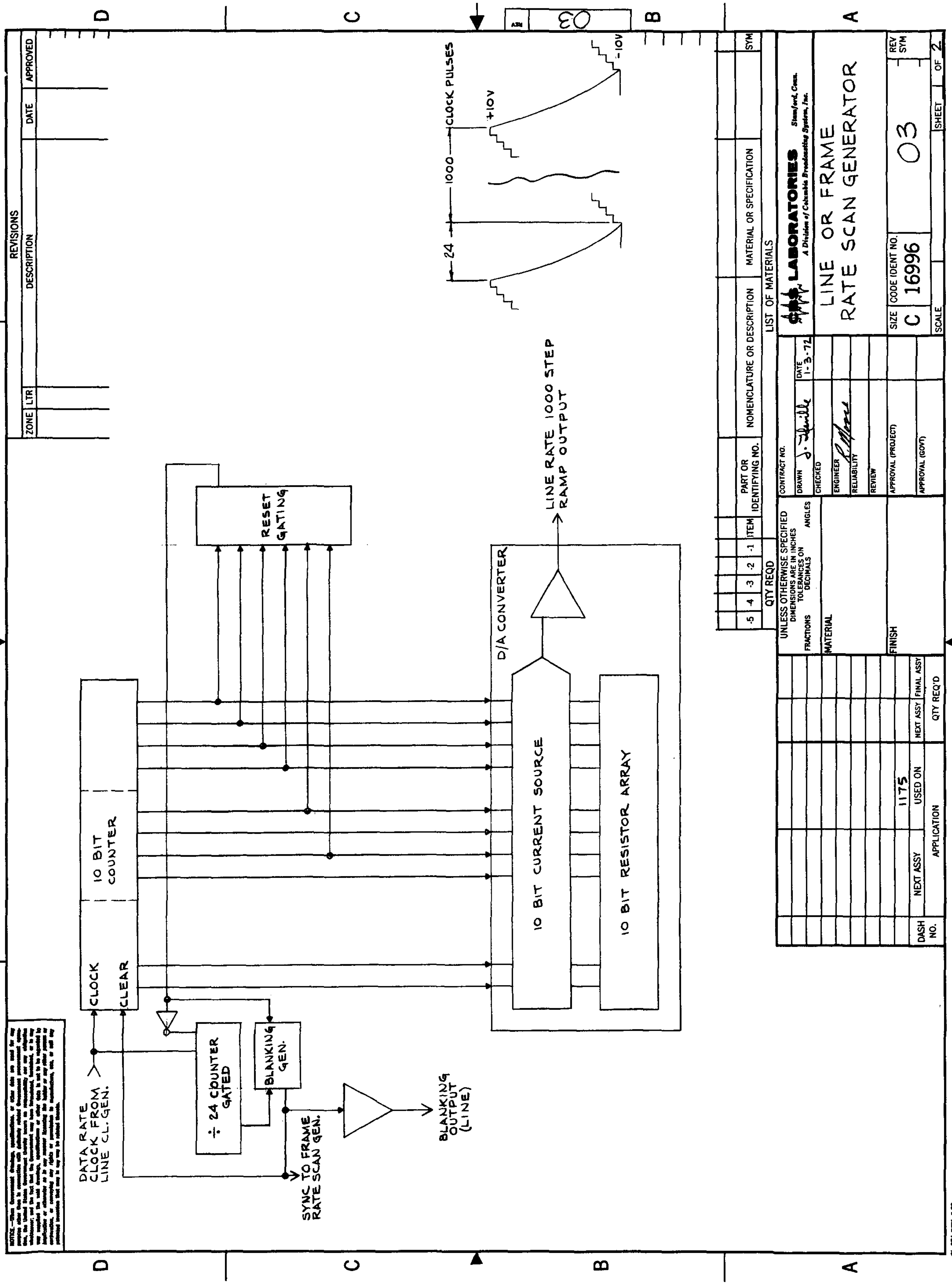
GRAPHIC CONTROLS CORP.

The data rate code or erase command output of the variable modulo divider are gated in such a manner as to reset the counter when the desired division has been performed. This produces an output line pulse at the desired rate which is used to drive the line scan generator directly.

10.0 LINE OR FRAME RATE SCAN GENERATOR

Operation of the Scan Generator shown in drawing #3 is identical whether used in the frame or line rate position. The function of the scan generator is to provide the low voltage ramp signals to drive the deflection amplifiers. Because of the low frequencies involved in the system, a digital method of generating the ramp voltage was employed instead of some form of RC generator. Even though the output of the digital system is a stairstep voltage rather than a ramp voltage, it will produce a more accurate output than could be obtained with an analog system.

The line generator is driven from the line clock. The 10-bit counter is gated to count to 1000 with each count being converted by the digital to analog converter to produce a voltage step of 20 millivolts at the output. At the one thousandth count, an output from the reset gating starts the ÷24 counter and the blanking generator. At the end of the ÷24 period, the counter resets the blanking generator. The output of the blanking generator has cleared the main counter and holds it in the cleared condition until the 1024 count is completed. The line blanking is amplified to provide cathode blanking and the sync (low amplitude blanking) is used to



REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
10 BIT COUNTER
CLOCK
CLEAR
RESET GATING
D/A CONVERTER
10 BIT CURRENT SOURCE
10 BIT RESISTOR ARRAY
LINE RATE 1000 STEP RAMP OUTPUT
DATA RATE CLOCK FROM LINE CL. GEN.
÷ 24 COUNTER GATED
BLANKING GEN.
SYNC TO FRAME RATE SCAN GEN.
BLANKING OUTPUT (LINE)
24
1000
CLOCK PULSES
+10V
-10V
LIST OF MATERIALS
CBS LABORATORIES
A Division of Columbia Broadcasting System, Inc.
Stamford, Conn.
LINE OR FRAME RATE SCAN GENERATOR
DATE 1-3-72
SIZE C
CODE IDENT NO. 16996
03
SHEET 1 OF 2
NEXT ASSY
USED ON 1175
APPLICATION

CBS LABORATORIES

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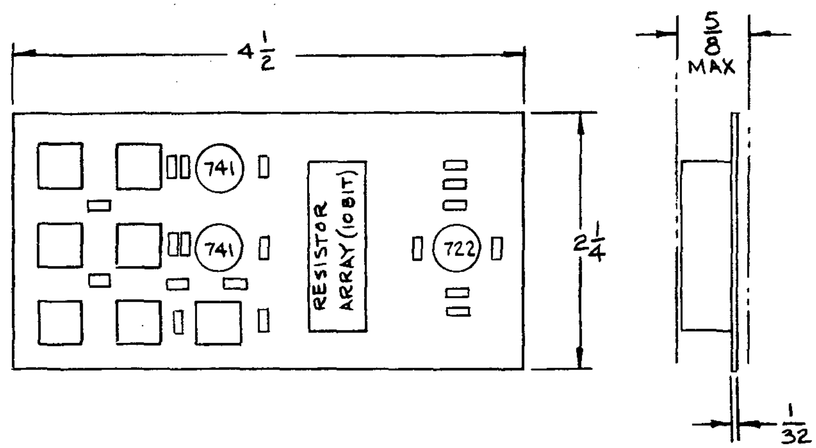
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY

COMPONENTS	11.04
CARD	11.70
TOTAL	22.74 GRAMS

POWER SUMMARY

+15	215
-15	50
+5	83
TOTAL	348 MW



	QTY
LOGIC COMPLIMENT:	
SN54L93	3
SN54L73	2
SN54L10	1
SN54L00	1
LINEAR COMPLIMENT:	
μA741	2
μA722	1
COMPONENTS:	
1/8 W RESISTORS	12
RESISTOR ARRAY	1
CAPACITORS	7

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
		1175		
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.
DRAWN J. Heville DATE 1-6-72
CHECKED
ENGR. R. Moore
REVIEW
APPROVAL (PROJ)
APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn.
A Division of Columbia Broadcasting System, Inc.

COMPONENT BOARD,
LINE OR FRAME RATE SCAN GEN.

SIZE B | CODE IDENT NO. 16996 | 03 | REV SYM
SCALE 1/1 | SHEET 2 OF 2

CL-323 REV. 6-68
GRAPHIC CONTROLS CORP.

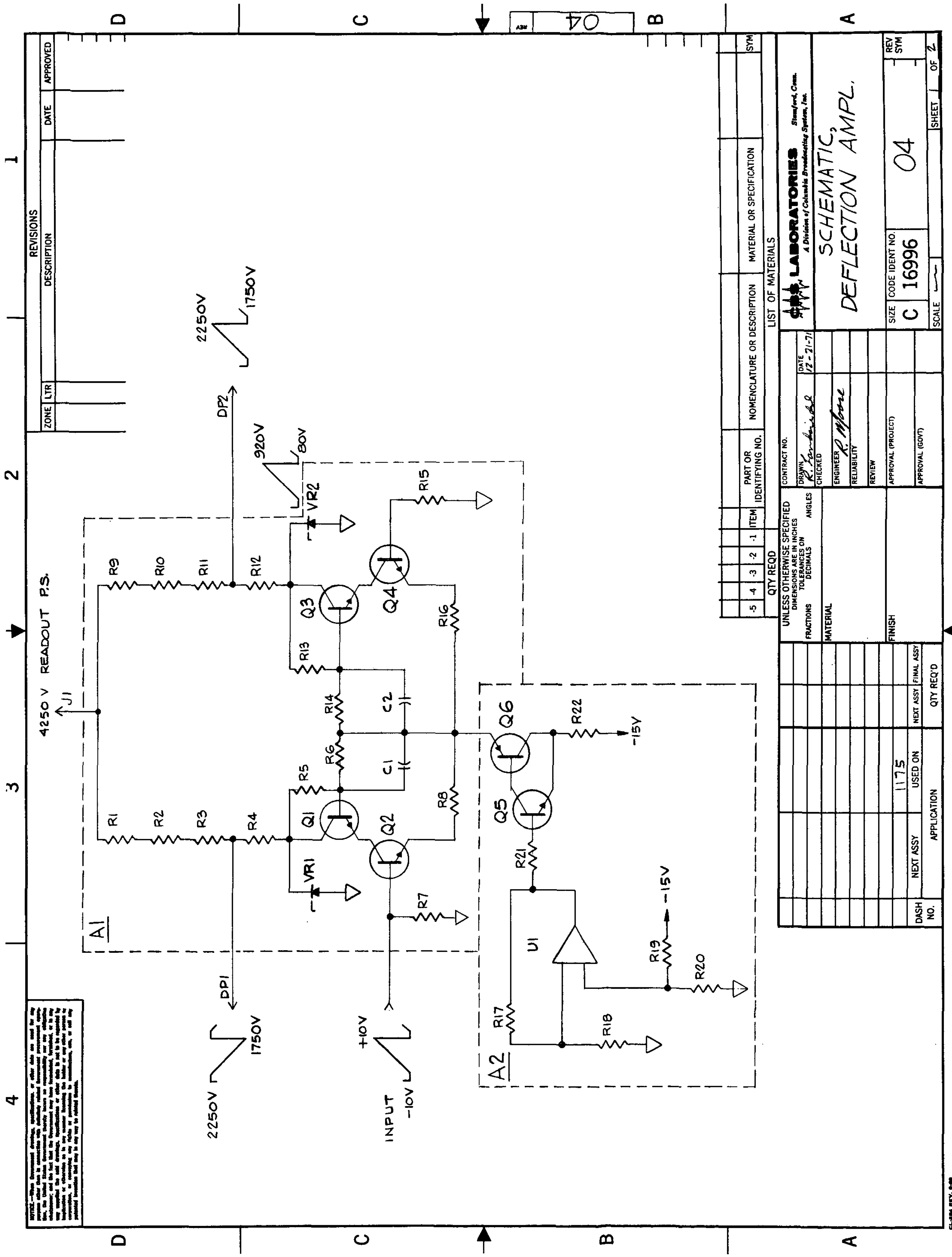
drive the frame scan generator. Sync from the frame scan provides the reset command to complete the readout or erase mode.

11.0 DEFLECTION AMPLIFIER

One requirement of the deflection system, drawing #4, is that the deflection plates of the readout section be operated at an average DC potential of 2000V. To accomplish this, the deflection amplifier is directly coupled to the plates. Direct coupling is necessary because the low frequency scanning rates involved would require coupling capacitors of prohibitive size and weight.

The deflection amplifier is a differential amplifier to insure equal and opposite polarity ramps to the deflection plates. Q2 and Q4 are a common emitter differential pair driving Q1 and Q3 as common base amplifiers. Q1 and Q 3 are high voltage transistors to provide the high collector breakdown voltage necessary for circuit operation. It is possible to replace Q1 and Q3 with several transistors of lower breakdown voltage connected in series to achieve the high voltage requirement of the ciruit. Negative feedback that is now provided by R5 and R13 must be provided to the base of each series transistor to insure equal division of the signal. U1, Q5, and Q6 form a stable constant current source for the differential pair.

The power dissipation of the amplifier is determined by the collector current and the supply voltage necessary to provide the 2000 volt focus voltage. For our system, a collector current of 0.25 milliamperes was selected. This, in turn, requires R1, R2, and R3 to be 9 megaohms and R4 to be 5 megaohms. These resistors and the capacitance

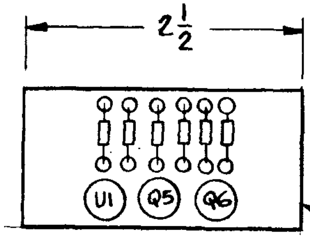


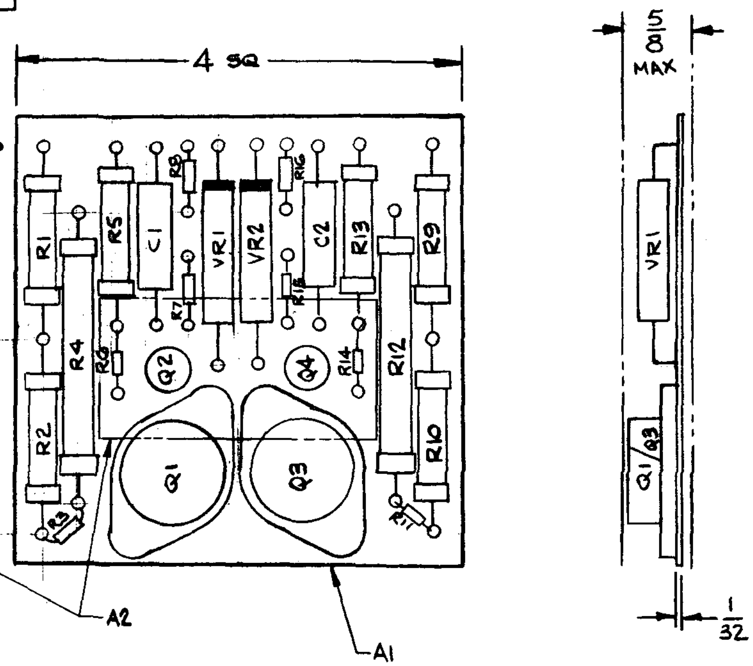
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
4250 V READOUT P.S.
J1
2250V
1750V
920V
80V
DP1
DP2
INPUT
-10V
+10V
-15V
A1
A2
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R17
R18
R19
R20
R21
R22
C1
C2
Q1
Q2
Q3
Q4
Q5
Q6
VR1
VR2
U1
QTY REQD
ITEM
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR SPECIFICATION
LIST OF MATERIALS
SYM
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS
FRACTIONS
ANGLES
MATERIAL
FINISH
CONTRACT NO.
DRAWN
DATE
12-21-71
CHECKED
ENGINEER
RELIABILITY
REVIEW
APPROVAL (PROJECT)
APPROVAL (GOVT)
CBS LABORATORIES
Stamford, Conn.
A Division of Columbia Broadcasting System, Inc.
SCHEMATIC,
DEFLECTION AMPL.
SIZE
C
CODE IDENT NO.
16996
04
REV SYM
SCALE
SHEET 1 OF 2
NEXT ASSY
USED ON
1175
APPLICATION
FINAL ASSY
QTY REQ'D
DASH NO.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY

COMPONENTS	101.76
CARDS	20.10
TOTAL	121.86 GRAMS





LINEAR COMPLIMENT:

	QTY
DTS 702	2
2N2219	2
2N3440	2
μA741	1
COMPONENTS:	
H.V. RESISTORS	4
VITROREEN MOX-1 RESISTOR	2
VITROREEN MOX-2 RESISTOR	2
1/2 W, 1% RESISTOR	2
1/4 W, 1% RESISTORS	6
H.V. ZENER	2
AL. ELECTROLYTIC CAP	2
1/2 W, 1% RESISTOR	1
1/8 W, 1% RESISTORS	5

POWER SUMMARY

+15V	25
-15V	33
READOUT PWR SUPPLY	2120
TOTAL	2178 MW

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
		1175		
	APPLICATION		QTY REQ'D	

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

MATERIAL

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CONTRACT NO.

DRAWN J. Tenille DATE 1-7-72

CHECKED

ENGR. R. Moore

REVIEW

APPROVAL (PROJ)

APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn. A Division of Columbia Broadcasting System, Inc.

COMPONENT BOARDS

DEFLECTION AMPL

SIZE B | CODE IDENT NO. 16996 | 04 | REV SYM

SCALE 1/1 | SHEET 2 OF 2

CL-283 REV. 6-66

GRAPHIC CONTROLS CORP.

of the deflection plates limit the risetime of the ampliifer. Worst case is when the ramp peak approaches the supply voltage during retrace. Calculations indicate that the amplifier should have no problem in retracing at the fastest rate encountered during the erase mode of operation.

12.0 VIDEO AMPLIFIER SIGNAL CHAIN

The design of the video portion of the camera is complicated by the fact that the output of the solid state multiplier/analyzer is operated at about 4KV. This requires that the video preamplifier input be operated at 4KV or high voltage input isolation capacitors must be employed. Because of the low frequency requirements of a base band system, capacitive coupling is not practical as high capacitance, high voltage capacitors are not available. Therefore, the preamplifier is operated at the high voltage potential with optical coupling employed to provide the high voltage interface. The fact that the preamp operates at high voltage is the only difference between this preamp and any standard camera preamp and the design parameters that effect performance apply directly. This includes the use of capacitive coupling within the amplifier to circumvent the stability problems connected with DC coupled amplifiers. By operating at high voltage, the voltage requirement on the input capacitor is reduced to that of an ordinary solid state circuit type capacitor.

The proposed system is a baseband system which requires a maximum bandwidth of 1800hz. Since the multiplier analyzer is essentially a current, rather than a voltage source, a load resistor is used which is deliberately made large in order to minimize its noise contribution, and a high input impedance voltage amplifier is employed to amplify the signal. Normally, the main drawback to this type of system is the problem of high frequency compensation. However, with the low frequency bandwidth requirements, the poor high frequency performance of the uncompensated amplifier should permit the amplifier bandwidth to be adjusted to meet the system requirements. The cascode input stage as shown is normally used to minimize the effect of the feedback capacitance and may not be required due to the modest bandwidth requirements. Feedback is included to stabilize the amplifier gain. The calculated transresistance of the preamp is 1.5×10^7 which is in the order required of standard vidicon preamps. Since the real criterion of preamp performance is signal-to-noise, careful design of the input stages are required to achieve optimum signal-to-noise performance and this will determine the exact input configuration.

The signal output level of the multiplier/analyzer varies in proportion to the readout scan rates. Therefore, data rate dependent amplifier gain adjustment is necessary. Four LED-phototransistor optical couplers are employed as attenuator switches to adjust the amplifier gain so that a constant level signal is applied to the optical HV isolator. Some bandpass filtering is possible with the addition of capacitors to the attenuator.

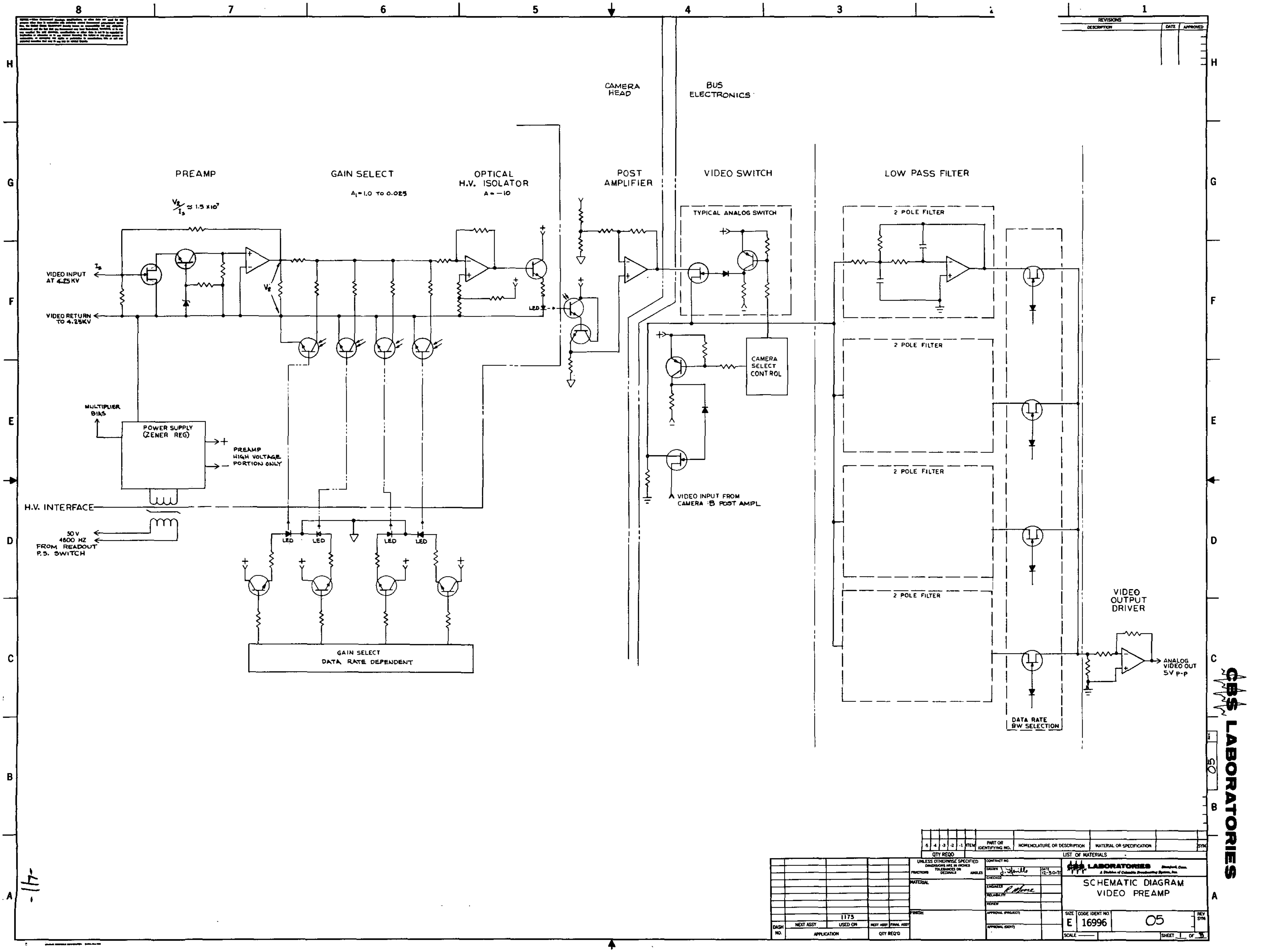
Video output high voltage isolation is obtained using a LED phototransistor coupler. An offset voltage is used with the operational amplifier feeding the LED driver transistor to bias the LED into its linear operating range with no video signal applied. The LED is a gallium arsenide type which exhibits a linear light output versus forward current drive. The light output of this diode then varies linearly with the driving video signal provided the operating range is correctly maintained and the phototransistor is matched to the diode. Again, the low frequency requirements of the baseband system impose no stringent frequency requirements on the coupling system. The post amplifier amplifies the video signal and provides a relatively low impedance drive for the video cable connecting the camera head to the bus electronics portion of the system. The gain of this amplifier in conjunction with the video output driver gain are set to provide a 5.0 volt video output signal.

To power the high voltage portion of the video ampliifer, a simple zener regulated, transformer coupled power supply is necessary. This power supply also provides the 6-10 volt negative bias necessary for operation of the solid state multiplier analyzer.

The remainder of the video system is incorporated into the bus electronics. FET analog gates are employed for all video switching applications because of their excellent isolation and low power requirements. The first set of switches selects which camera video is applied to the input. The other set of switches select the output of the low pass filter in accordance with the data rate requirement. The low pass filters are of the conventional two pole active filter type. Their use provides improved signal-to-noise performance of the video system. The video output driver is the final gain stage and provides a 5.0 volt p-p video signal to drive the A/D converter which directly converts the video information for transmission back to earth. With the polarities as shown, the video amplifier produces a white positive signal. Either the post amplifier or video output driver could be made non-inverting if a white negative video signal is desirable.

12.1 RF VIDEO SYSTEM

An alternative video system to the proposed baseband system would be an RF System very similar to the Mariner Mars 1971 video system. The readout tube beam current would be modulated and this would provide higher signal levels at the preamp input during the on period. The other change afforded by the RF System would be the possibility of transformer coupling of the video signal from the preamp operating at high voltage to the post amplifier rather than using the light coupling method. The transformer could be designed as a bandpass device to alleviate the need for a filter between the preamp and post amplifier. The higher operating frequency would impose more stringent requirements on the preamplifier design.


CAMERA HEAD
BUS ELECTRONICS
PREAMP
$\frac{V_E}{I_S} \approx 1.5 \times 10^7$
GAIN SELECT
$A_1 = 1.0$ TO 0.025
OPTICAL H.V. ISOLATOR
A = −10
POST AMPLIFIER
VIDEO SWITCH
TYPICAL ANALOG SWITCH
LOW PASS FILTER
2 POLE FILTER
2 POLE FILTER
2 POLE FILTER
2 POLE FILTER
VIDEO INPUT AT 4.25KV
VIDEO RETURN TO 4.25KV
LED
MULTIPLIER BIAS
POWER SUPPLY (ZENER REG)
PREAMP HIGH VOLTAGE PORTION ONLY
H.V. INTERFACE
50V 4800 HZ FROM READOUT P.S. SWITCH
LED
LED
LED
LED
GAIN SELECT DATA RATE DEPENDENT
CAMERA SELECT CONTROL
VIDEO INPUT FROM CAMERA B POST AMPL
DATA RATE BW SELECTION
VIDEO OUTPUT DRIVER
ANALOG VIDEO OUT 5V P-P
REVISIONS
DESCRIPTION
DATE
APPROVED
QTY REQD
ITEM
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR SPECIFICATION
LIST OF MATERIALS
CBS LABORATORIES
SCHEMATIC DIAGRAM
VIDEO PREAMP
SIZE E
CODE IDENT NO 16996
05
1175
NEXT ASSY
USED ON
APPLICATION
QTY REQ'D
SHEET 1 OF 5

-41-

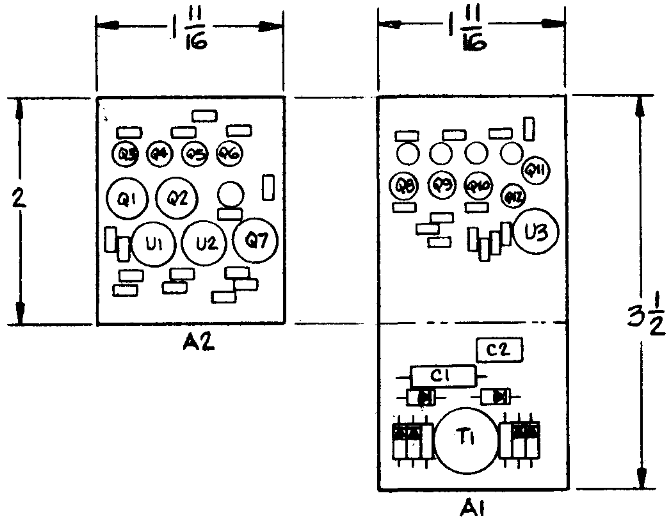
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT SUMMARY

COMPONENTS	24.43
A1 CARD	6.77
A2 CARD	4.07
TOTAL GRAMS	35.27

POWER SUMMARY

+15V	25 MW
−15V	25 MW
50V 4800 Hz	550 MW



LINEAR COMPLIMENT

FET	1
TRANSISTOR	2
PHOTOTRANSISTOR	5
μA741	3
2N2219	1
2N3904	4
LED	5

COMPONENTS

DIODES	4
ZENER DIODE	3
CAPACITORS	6
TRANSFORMER	1
1/8 W RESISTORS	24
1/4 W RESISTORS	2

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.

DRAWN R. [illegible] — DATE 1-24-72

CHECKED

ENGR. R. Moore

REVIEW

APPROVAL (PROJ)

APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn. A Division of Columbia Broadcasting System, Inc.

VIDEO PRE-AMPL.

SIZE B | CODE IDENT NO. 16996 | 05 | REV SYM

SCALE | SHEET 2 OF 3

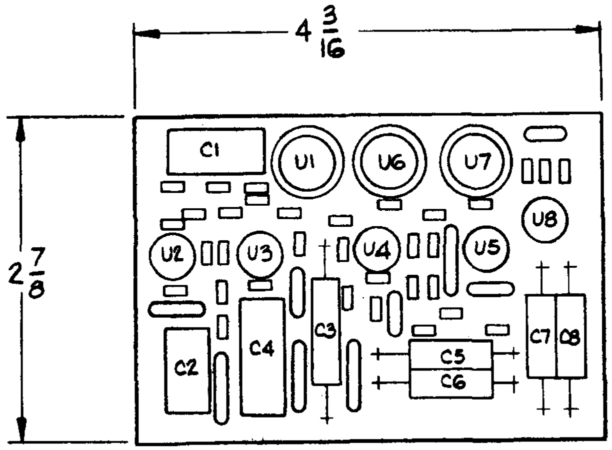
CL-659 REV. 6-68

GRAPHIC CONTROLS CORP.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

WEIGHT	SUMMARY
COMPONENTS	69.45
CARD	13.57
TOTAL GRAMS	83.02

POWER	SUMMARY
+15V	173
-15V	173
TOTAL	346 MW



LINEAR COMPLIMENT	QTY
μA741	5
2141 BF ANAL. GATE	3

COMPONENTS	
CAPACITORS	17
1/8W RESISTORS	33

DASH NO.	NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
	APPLICATION		QTY REQ'D	

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

MATERIAL

FINISH

CONTRACT NO.

DRAWN R. Lockhill DATE 7-24-72

CHECKED

ENGR. R. Moore

REVIEW

APPROVAL (PROJ)

APPROVAL (GOVT)

CBS LABORATORIES Stamford, Conn.
A Division of Columbia Broadcasting System, Inc.

LOW PASS FILTER & VIDEO OUT.

SIZE B | CODE IDENT NO. 16996 | 05 | REV SYM

SCALE 1/1 | SHEET 3 OF 3

CL-223 REV. 6-66

GRAPHIC CONTROLS CORP.

CBS LABORATORIES

13.0 ELECTROSTATIC CAMERA SYSTEM SPECIFICATIONS

ELECTROSTATIC CAMERA SPECIFICATIONS & CHARACTERISTICS						
		TRANSMISSION BIT RATE				
CHARACTERISTIC	SPECIFICATION	12,600 B/S	4,200 B/S	840 B/S	420 B/S	ERASE
Active Target Raster	16mm x 16mm					
Aspect Ratio	1:1					
Active Scan Lines Per Frame	1,000					
Kell Factor	1					
Active Picture Elements Per Line	1,000					
Frame Time		569s	$1.707x10^3$s	$8.54x10^3$s	$16.67x10^3$s	
Total Line Time		.569s	1.707s	8.54s	17.07s	
Active Line Time		.556s	1.667s	8.34s	16.67s	
Line Retrace Time		.013s	.040s	.200s	.400s	
Erase Time Per Picture						29.16 s
Video Base Band		900Hz	300Hz	60Hz	30Hz	
Video Sampling Frequency		1,800Hz	600Hz	120Hz	60Hz	
Picture Elements Per Frame	10^6					
Bits per Picture Element	7					
Readout Beam Current		$5x10^{-10}$a			$1.5x10^{-11}$a	
Analyzer Current	1/10 to 9/10 I_b					
Multiplier Gain					2,500	

13.0 ELECTROSTATIC CAMERA SYSTEM SPECIFICATIONS, Continued

ELECTROSTATIC CAMERA SPECIFICATIONS & CHARACTERISTICS		TRANSMISSION BIT RATE				
CHARACTERISTIC	SPECIFICATION	12,600 B/S	4,200 B/S	840 B/S	420 B/S	ERASE
Exposure	4.2×10^{-2} erg/cm^2 for SNR = 50					
Storage	30 Frames					
Storage Time	>1 week					
Dynamic Range	>64:1					
Erase Rate	36 KHz					
Readout Rates	12.6KB/S, 4.2KB/S, 840B/S, 420B/S					
Maximum Frame Time (Expose/Record)	5 sec.					
Analog Video Output Impedance	50 Ohms					
Transfer Characteristic of Readout	0.13A/A/Volt					
Area of Scan Beam	2.8×10^{-6} cm^2					
Unit Area Capacitance of Dielectric	5.4×10^{-9} Farad/cm^2					
Photocathode Sensitivity	150μA/Lumcn					
Gain of Dielectric (Readin)		225				
Quantum Eff. of Photocathode	8.7% at 6000°K					

13.0 ELECTROSTATIC CAMERA SYSTEM SPECIFICATIONS, Continued

ELECTROSTATIC CAMERA SPECIFICATIONS & CHARACTERISTICS						
		TRANSMISSION BIT RATE				
CHARACTERISTIC	SPECIFICATION	12,600 B/S	4,200 B/S	840 B/S	420 B/S	ERASE
MTF of Image Section	30% @ 30 lp/mm					
MTF of Storage Section	95% @ 30 lp/mm					
MTF of Readout	67% @ 30 lp/mm					
Exposure Time Range	5ms to 10 sec.					