INSTRUCTION MANUAL

CVI MODEL 502 DATA CAMERA

COLORADO VIDEO, INCORPORATED

BOULDER, COLORADO

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

This instruction book is to be used as a guide to the installation, adjustment, operation, and maintenance of the CVI Model 502 Data Camera.

1.2 PURPOSE OF EQUIPMENT

The Model 502 is intended primarily as a laboratory research instrument for the conversion of visual data into standard or non-standard TV format.

1.3 DESCRIPTION OF EQUIPMENT

The CVI Model 502 Data Camera is a three-piece instrument capable of using a variety of standard 1" pickup tubes. The 502 accommodates standard vidicons of either separate or integral mesh, silicon diode target tubes, lead oxide target tubes, or other devices with appropriate mechanical and electrical characteristics.

The Model 502 is primarily intended for laboratory or industrial inspection usage, and incorporates a number of features not normally found in conventional CCTV equipment. These include:

- Externally controllable sweep circuits which allow for non-conventional scanning patterns or rapid changes in position, angle, or size, when required for pattern matching or similar applications. H and V deflection may be interchanged.

- Externally controllable beam blanking for target integration or pulsed light applications.

- Wide range sweep circuits (DC coupled) and video circuits capable of operating from one frame per second to 1000 frames per second.

- Remote, dynamic, gain control over a 4 to 1 range.

- Plug-in video low pass filters for best signal-to-noise ratio (Note: normal video bandwidth is 10 MHz).

- Remote, continuous, beam current control.

- A series of available options:

1. Video data sampler for A/D conversion for control purposes.

2. Eight video low pass filter frequencies selectable by means of a 3-bit digital code.

3. Preamplifier gain/bandwidth selection by means of an 8-bit digital code.

1.4 SPECIFICATIONS

Size:	Camera Head	4½" x 5" x 11" (w/o lens)
	Camera Control	3½" x 19" x 8"
	Power Supply	3½" x 19" x 9½"
Construction:	Solid state, silicon	
Power:	117 VAC, 25 watts	
Inputs:	Horizontal drive	TTL, positive going
	Vertical drive	TTL, positive going
	Ext. Blanking	TTL, positive going
	H. Deflection	0 to +5 V, 10K ohms
	V. Deflection	0 to +5 V, 10K ohms
	Remote beam	0 to +5 V, 10K ohms
	Remote gain	0 to +5 V, 10K ohms
Outputs:	Video	0 to +1 V, 75 ohms, DC coupled
	Video (option 1)	0 to +4 V, 500 ohms, DC coupled

Controls:

Front Panel
- Gain
- Blanking
- Video Polarity +,-
- Target
- Beam
- Focus
- Horizontal Size
- Horizontal Centering
- Vertical Size
- Vertical Centering
- Scan Centering (option #1)

Rear Panel
- #1 Alignment
- #2 Alignment
- Blanking: Int/Ext
- Sweeps: Int/Ext
- Beam: Int/Ext

Power Supply
- AC On/Off

Connectors: BNC

1.5 PERFORMANCE CHARACTERISTICS

Deflection:	Slew Rate (both axes)	Full raster in 10 us min.
	Built-in Sawtooth Generators	Rate internally changeable (1 capacitor per axis)
	Linearity	1%
Video:	Bandwidth	10 MHz @ -3 dB
	S/N	35 dB pp/rms
Remote Gain:	4:1 range in less than 7 us	
Remote Beam:	Cutoff to max. in less than 7 us	
Power Supply:	Adjustable to suit many types of 1" tubes	

SECTION 2

OPERATING INSTRUCTIONS

2.1 INTRODUCTION

This section contains the general operating procedures and instructions for the CVI Model 502 Camera.

2.2 INITIAL INSTALLATION

Unpack the equipment carefully and inspect for possible mechanical damage to the camera head, control unit, power supply, or connecting cable.

With the AC power plug disconnected, connect the camera head to the control unit by means of the multi-conductor connecting cable. Connect vertical and horizontal drive pulse inputs (see Section 1.4 for pulse requirements) and connect an appropriate TV monitor to the "real time" video output. (Note that the TV monitor must be externally synchronized, as a composite video output is not produced by the 502.)

Be sure that the sync pulse source and monitor are operating properly, then turn the "BEAM" control full counter-clockwise and apply AC power to the 502. Rotate the "GAIN" control full clockwise and slowly turn the "BLANK" control clockwise. Noise should now appear on the monitor screen indicating proper functioning of the video amplifier and blanking circuits.

Place the camera head so that it is looking at a moderately illuminated (50 to 100 foot candles) test pattern or other subject and uncap the lens. CAUTION. Do not point the lens directly at sources of strong light or damage to the vidicon target may result. Slowly bring up the "BEAM" control until an image of some sort appears on the monitor screen with the "POLARITY" switch in the + position. Some readjustment of the GAIN and BLANK controls may now be desirable for best monitor picture contrast.

Optically focus the camera lens for the clearest image as seen on the monitor screen, then adjust the electrical FOCUS control for the same purpose. Note that "whiter" portions of the scene will not be reproduced if the BEAM control is not sufficiently far advanced. Slight adjustments of the scan size and centering controls may now be made if required. CAUTION. Some vidicon tubes have relatively sensitive target structures and will "burn in" or produce a negative after-image if left focused on a stationary subject for a period of time. Similarly, do not operate the camera without proper scanning of the vidicon or target damage may result.

Connect a wide band oscilloscope across the "real time" video output for the monitoring of video signal. Levels should be set for approximately .5 to 1 volt PP with a discernible space between the video baseline and the blackest portion of the video signal (as set by the BLANK control). Switching to - polarity will invert the video signal, causing a negative image to appear on the monitor screen. An increase in the setting of the BLANK level control is usually necessary at this time to prevent negative going signal components from being lost.

The various operating and setup controls should be adjusted for optimum image quality with the particular vidicon and subject material used. Scan rates may be varied over a wide range; however, the 502 is usually shipped with the internal saw generators set for 15,750 and 60 PPS.

2.3 OPERATION

2.3.1 DESCRIPTION OF CONTROLS

<u>Power Supply</u>

POWER	On/Off

<u>Control Unit</u>

Front Panel:

VERT SIZE	Controls the size of the vertical region which is scanned on the vidicon target. Clockwise movement decreases the scanned region. This control is operational when either internal or external deflection is used. NOTE: TUBE DAMAGE MAY RESULT IF UNDERSCANNING TAKES PLACE BECAUSE OF EITHER SIZE CONTROL BEING SET TOO NEAR THE CLOCKWISE END.
VERT CENT	Controls the position of the scanned area. This control is operational when either internal or external deflection is used.
HORIZ SIZE	Performs the same function as the VERT SIZE control, except on the horizontal axis.
HORIZ CENT	Performs the same function as the VERT CENT control, except on the horizontal axis.

BEAM	Controls the amount of vidicon beam current by means of varying the G1 voltage. When BEAM switch (rear panel) is set to INT, range of the BEAM control is from tube cutoff to maximum beam current (V_{G1}=0). When external beam control is used, the BEAM control acts as a sensitivity control, i.e. the external signal may remain fixed in amplitude and the maximum beam current set with the BEAM control.
FOCUS	Controls the electrical focus of the vidicon by means of varying the G3 voltage.
TARGET	Controls the vidicon target voltage over the range of 0 to +50 V. This should not be an operational control when a fixed target voltage tube is used; a hole cover is provided for preventing inadvertent adjustment under this circumstance.
SCAN CENT (Option #1)	Controls the (horizontal) position of the line upon which data is sampled for bandwidth reduction. If this feature is not being used, the SCAN CENT control should be left fully counterclockwise.
POLARITY +/-	When switched to the "+" position, video output will be of normal polarity (white more positive than black). When the POLARITY switch is in the "-" position, the video is inverted. A readjustment of the BLANK control is necessary when the polarity is changed, since blanking remains negative going (to approximately 0 V).
GAIN	Adjusts video output level. This control is functional whether or not the remote gain feature is being used.
BLANK	Controls the amount of offset of the video output signal.

Rear Panel:

BLANK INT/EXT	When switched to INT, and drive signals are applied, blanking is internally generated. When switched to EXT, the internal blanking is disconnected and blanking must be externally provided.

BEAM INT/EXT	Selects internal or external control of the vidicon beam current.
SWEEP INT/EXT	When switched to INT, and drive signals are applied, internally generated deflection signals are routed to the yoke. These are designed to be operated at a 525-line, 30 frame/sec standard rate, and produce a standard scan pattern. If SWEEP INT/EXT is switched to EXT, external deflection signals must be provided. NOTE: TUBE DAMAGE MAY OCCUR IF SWEEP INT/EXT IS PUT IN EXT POSITION AND NO DEFLECTION SIGNAL IS APPLIED. TUBE DAMAGE MAY OCCUR IF SWEEP INT/EXT IS PUT IN INT POSITION AND VERT AND/OR HORIZ DRIVES ARE ABSENT.
ALIGN 1 & 2	Two adjustments which affect the accuracy with which the vidicon beam strikes the target. Nominally adjusted for best image quality with a specific tube. Rule of thumb is to set both pots so that image on monitor screen appears to rotate around a central axis when the FOCUS control is varied back and forth, but shading and overall resolution in picture should also be considered.

2.3.2 OTHER OPERATIONS

Remote Gain

A positive voltage applied to the REMOTE GAIN IN connector at any time will reduce the video output level from that set by the front panel GAIN control. The reduction is linear, and a +5 volt signal will reduce the output level by a factor of at least 4. Rate of change is approximately 7 microseconds for full attenuation.

Remote Beam

The beam current is variable from at or below tube cutoff to maximum by switching BEAM INT/EXT (main unit, rear panel) to EXT and connecting a 0 to +5 volt signal to the REMOTE BEAM IN connector. A +5 volt signal will increase the beam current to a level determined by the front panel BEAM control. A 0 volt signal will decrease the beam current to a level determined by an internal adjustment. This was factory set for tube cutoff and should normally not require readjustment unless the tube is replaced. For instructions regarding this adjustment, refer to CAMERA TUBE REPLACEMENT, assembly, item 6. The change in G1 voltage with respect to the input signal is linear regardless of the settings of the BEAM control and internal adjustment; full range of control is obtainable in approximately 7 microseconds. There is little or no interaction between the controls.

External Blanking

A HIGH TTL level applied to the BLANK IN connector, when BLANK INT/EXT switch is in the EXT position, will produce the following results:

1. Camera beam will be blanked.

2. The internal keyed clamp will clamp the video to the level determined by the BLANK control.

3. The video output will be held at 0 V (blanked).

The external blanking signal may be of as long a duration as desired, but a minimum width of 7 usec is required to allow the keyed clamp to function properly. Tilt may become objectionable at horizontal repetition rates much less than 120 Hz.

External Deflection

External deflection may be applied to the H DEFL IN and V DEFL IN connectors. These signals of 0 to +5 V will be applied to the deflection yoke when the SWEEP INT/EXT switch is in the EXT position. The direction of scan caused by the external deflection signals is such that if positive-going sawtooth signals are applied to both inputs, a normal raster scan (left to right, top to bottom) will be produced.

Either or both axes may be reversed in scan direction most conveniently by reversing the appropriate deflection yoke leads.

The front panel SIZE and CENT controls remain functional when external deflection is being used.

Slow Scan (Option #1)

The 502 converts a real time video signal to the equivalent of a slow scan TV signal by means of high speed sampling. An indication of the sampling process is a thin white vertical marking line appearing on the TV monitor which may be moved back and forth by means of the SCAN CENT control. The narrow band video output signal appearing at the connector on the rear panel represents the video information falling directly under this line, with the slow scan signal format being rotated 90 degrees from that of the original real time signal, and with the line rate of the slow scan video being the same as the vertical sweep rate of the real time video.

For some forms of video data analysis the marker line may be manually positioned to a location of interest, and the resultant continuously repeated line of slow scan video observed on a scope or processed by external equipment.

The slow scan video output may be checked by connecting a scope across the output connector. Scope sensitivity should be set to approximately 1 volt/cm, and sweep rate at approximately 2 milliseconds/cm. With the POLARITY switch in the + position and .5 volt of real time video output, the slow scan video level should be between 3 and 4 volts with black referenced at ground, white positive. Rotation of the SCAN CENT control should cause a faint vertical line on the TV monitor to move across the raster, and at the same time the slow scan video output signal should reflect the information falling directly under the marker line. To scan out a frame of slow scan video, the marker should be positioned at the left-hand edge of the raster and then a low frequency ramp going from ground positive applied to the SCAN position input of the multi-pin connector on the rear of the chassis. Polarity inversion of the real time signal will also invert the slow scan signal; however, blanking polarity remains constant in all cases.

The raw slow scan output consists of sampled data, and this must be taken into consideration if further sampling is to be employed, such as in A/D conversion. Either synchronous sampling may be employed by locking the line rate of the 502 to the digital clock, or a simple interpolation filter may be used between the slow scan output of the 502 and the input to the external sampling device. The last expedient works well when the 502 is used with a relatively low frequency vertical scan rate, giving an increased number of data points to interpolate. It is also important to note that a certain amount of high frequency "trash" is usually present in the raw slow scan output, and an 8 kilohertz low pass filter will cause a much cleaner waveform to be presented.

The slow scan video signal can also be scanned horizontally by application of an appropriate "deflection" signal at the connector on the rear of the control unit chassis. A low frequency sawtooth signal starting at ground potential and rising to a value of +4 volts will cause the sampling line to scan from left to right. Alternately, a signal starting at ground and going negative will cause scanning from right to left. The SCAN CENT control is used in either instance to determine the starting location of the scan.

The external scanning signal need be neither linear nor continuous if special scanning patterns are desired. Slow scan output levels will be essentially constant regardless of the scan pattern used, although reproduction of the slow scan images via a CRT may be made more complex. In implementing unique scan patterns, the key factor to remember is that the instantaneous voltage/time relationship of the external scanning signal will determine at what point along an individual TV line a sample is taken.

SECTION 3

UNCONVENTIONAL OPERATION OF VIDICON TUBES

3.1 INTRODUCTION

Standard television cameras, both CCTV and broadcast, operate with the following parameters:

- A constant light input to the target.
- Rectilinear scanning.
- Constant velocity scanning.
- Three-by-four image aspect ratio.
- A horizontal scanning rate of 15,750 lines per second. A vertical scan rate of 60 fields per second. A frame rate of 30 per second. Lines are interlaced on a field-to-field basis as illustrated below.*

```
_______________  1st Field
---------------  2nd Field
_______________
---------------
_______________
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Other modes of operation are sometimes desirable in scientific and industrial applications, and a number of special techniques and the considerations involved are described in the following material.

3.2 SPECIAL OPERATIONS

3.2.1 PULSED LIGHT SOURCE

The target of the vidicon tube integrates light much as a piece of photographic film and thus averages the optical input data. The scanning electron beam erases the charge pattern on the target, giving the effect of a 1/30 second shutter speed. Consequently, if rapidly moving objects are to be clearly reproduced, a pulsed light source may be used, a form of "shutter" employed, or some form of rotating prism or mirror used to stabilize the image on the tube target. The simplest technique is the pulsed light source. This may have a duration of 40 microseconds or less depending upon possible reciprocity effects produced by the vidicon target structure.

It is important to note, however, that the best video output data will be obtained only during the field immediately following the application of the light source, even though interlaced scanning might be used. This is because of the fact that the finite size of the scanning beam will tend to partially erase the charge image that is to be scanned during the second field. The simplest procedure is to trigger the pulsed light source during the TV camera vertical blanking interval which then produces a field of good data

*U.S. standards; may vary in other countries.

immediately following. This may not always be practical, as the pulsed light may need to be triggered asynchronously. Two expedients may be used in this case. First, line counting will identify information in a quasi-field which will usually be interrupted by the vertical blanking period, causing the requirement for some form of image reassembly. Second, if some kind of prediction is possible, the camera scanning beam may be blanked off prior to the light pulse and then turned on at the field succeeding the pulse.

Depending upon the type of vidicon target, the charge image may be held for a short length of time before read-out. Thus the target may be used as a short term buffer, varying from several fields to perhaps several seconds.

3.2.2 TARGET INTEGRATION

The sensitivity of a particular tube may usually be greatly increased by allowing a stationary image to fall upon the target for an appreciable amount of time before scanning. In some instances, several orders of magnitude increase in sensitivity may be achieved by this process, but it is important to remember again that once the scanning beam is turned on, the best data will be obtained from the first field of information.

3.2.3 SWEEP REVERSAL

With rectilinear scanning, it is a simple matter to reverse the direction of scanning either horizontally or vertically. Note, however, that slight changes in image quality may result in terms of shading characteristics and linearity.

3.2.4 INTERMITTENT SCANNING

The beam blanking and turn-on techniques previously mentioned may also be applied during the course of scanning a single field. This can be a very useful expedient in some operations, as the image may be scanned only to the point where certain identifying features are located, then the beam turned off and changes made in the scanning pattern to affect registration or other operations, and the target subsequently rescanned.

3.2.5 REDUCED VELOCITY SCANNING

In some instances it is necessary to reduce the camera scanning rate so that the resulting data may be directly digitized or otherwise processed. If a pulsed light source is used, it is important to note that the signal output from the vidicon target will drop linearly as the beam velocity is reduced. Compensation for this effect can be made by increasing the video preamplifier gain, and by lowering the amplifier bandwidth, the last to eliminate noise which would fall above the useful video response.

Frame rates between 5 and 30 per second can give quite good tube performance while lower rates may introduce some additional problems in terms of dark current build-up, microphonics, and leakage of the target charge image.

3.2.6 VARIABLE RATE SCANNING

Rectilinear Scanning

Vidicon target scanning rates may be rapidly switched for special applications, for example between 30 and 5 frames per second, if corresponding compensation is made relating to the factors influencing vidicon signal output. It should be noted that when changing scan rates, the new raster may not exactly match the old, making it necessary to provide for a one-frame erase cycle to eliminate remnants of an earlier charge pattern.

Certain forms of rectilinear scanning may involve variable velocity, e.g. scanning the left-hand side of the picture more rapidly than the right. Because the signal output of the vidicon is proportional to scanning velocity, such a pattern would cause the right-hand side of the image to be reproduced darker. This factor must be considered or compensated for when variable velocity scanning is used.

Trapezoidal Scanning

In some instances it is desirable to change the scanning geometry to correct for optical distortions or for other reasons. Primary considerations in this case are: (1) video amplitude compensation for changes in beam velocity and (2) taking care that the scanning beam does not overlap its previous pattern, as this will also result in changes in output level.

Circular Scanning

The vidicon target may be scanned in a circular manner within the limitations of beam velocity ratio. In practice this means the central part of the image should be ignored, as beam velocity will normally become too low to produce a usable output.

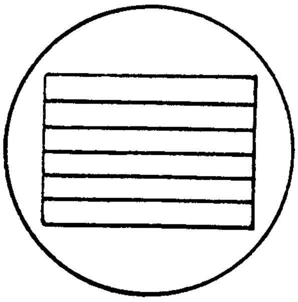
Radial Scanning

The vidicon target may be scanned from center outward in a series of lines similar to that used in radar. However, the output from the center of the tube may be reduced in amplitude because of scanning beam overlap.

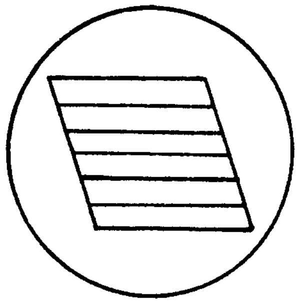
Pseudo-random Scanning

Depending upon the slewing rate of the vidicon deflection system, the scanning beam may be blanked and then positioned over a portion of the target and unblanked for read-out.

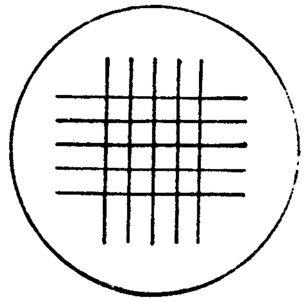
3.2.7 TYPES OF VIDICON TARGET SCANNING



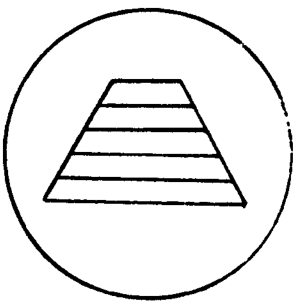
Rectilinear



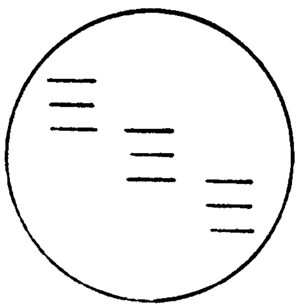
Trapezoidal



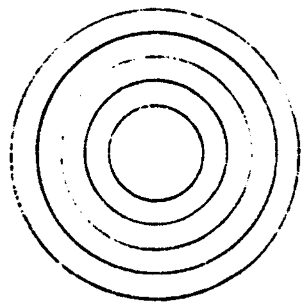
Axis Reversal



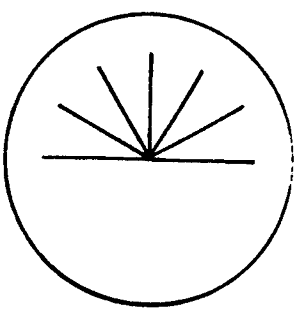
Keystoning



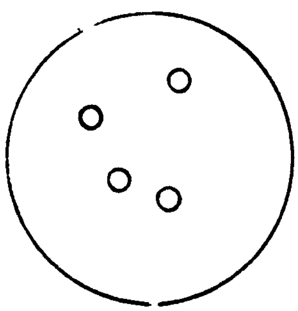
Sub-raster Linear



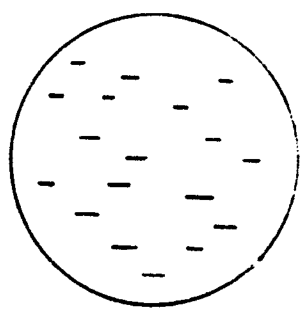
Circular



Radial



Sub-raster Circular



Pseudo-random

SECTION 4

MAINTENANCE

4.1 INTRODUCTION

This section contains instructions for vidicon tube replacement and the electrical schematics and assembly drawings for the CVI Model 502 Data Camera.

4.2 CAMERA TUBE REPLACEMENT

4.2.1 REMOVAL

1. Remove power from the camera. Allow several minutes for capacitors to discharge before proceeding.
2. Remove the side cover plates of the camera head assembly. Remove the four screws holding the small plate into which the lens is screwed. Remove this plate and the lens.
3. Unplug the socket (and associated board) from the tube.
4. Loosen the two screws on the tube support which clamp the tube.
5. Carefully push the tube out the front of the head assembly.

4.2.2 ADJUSTMENT

If the replacement tube is of a different type than that which was removed, readjustment of electrode voltages must be done prior to insertion of the replacement tube.

CAUTION: POTENTIALLY LETHAL VOLTAGES EXIST IN THE POWER SUPPLY AND ON THE TUBE SOCKET PINS.

1. Remove the power supply top cover plate.
2. Turn the BEAM control (main control unit, front panel) fully CCW.
3. Using a VTVM, adjust the electrode voltages according to the tube manufacturer's "typical operation" specifications as follows:

Tube Element	VTVM Test Point Tube Pin #	Adjust	Location
G2	5	G2	Power supply
G3	6	FOCUS	Main control unit, front panel
G4*	3	G4	Power supply

*Prior to adjusting G4, switch G4 ON/OFF (on the socket-mounted board) to ON if the tube is equipped with a fourth grid, anode, or mesh connected to pin 3. If the tube is not so equipped, turn the G4 ON/OFF switch to OFF and disregard the G4 adjustment.

4. Adjust target voltage as follows:

   If the tube is not a silicon-target type, or any other that requires a fixed target voltage, turn the TARGET control (main control unit, front panel) fully CCW and adjust after the tube is reinserted and the camera energized. If the tube is one which requires a fixed target voltage, locate the test point:

   From the left side (as viewed from the rear) of the camera head assembly may be seen a label marked "TARGET V" which points toward a feed-through capacitor to which a brown wire is attached. This is the test point.

   Connect the VTVM to this point and adjust the TARGET control for the correct target voltage.

5. Although most tubes are designed for operation in a 40 gauss field, occasionally a manufacturer specifies a different field intensity. The field has been adjusted to 40 gauss (satisfactory for types 8484 and 4532A) at the factory. If, however, a tube is used which requires a different field, the intensity may be adjusted between approximately 35-50 gauss as follows:

   NOTE: THIS ADJUSTMENT SHOULD ONLY BE MADE WITH THE TUBE REMOVED, OR WITH THE BEAM CONTROL FULLY CCW.

   Remove the top cover plate of the main control unit. Locate, near the right front of the board, a terminal identified by the letter "F" adjacent to it. Remove the wire connected to it and insert a milliammeter between the wire and terminal (positive current flow is out of the terminal). With power applied, adjust the trimpot which is identified by the letter "F" for the correct value of current, based on 1 mA/gauss. Reconnect the wire and replace the cover.

4.2.3 ASSEMBLY

1. Remove power from the camera.

2. Insert the replacement tube from the front of the camera, with the short index pin on the left (as viewed from the rear). Tighten the clamp screws and connect socket. Replace the lens plate and lens.

3. Point camera at a distant object, and set lens focus to infinity. Energize camera.

4. Adjust TARGET (if applicable) and BEAM controls until a picture is visible on the monitor. Adjust FOCUS for approximately the best electrical focus.

5. Slightly loosen the clamp screws and, USING AN INSULATED TOOL, move the tube slightly forward until the best optical focus is obtained. Tighten the clamp screws.

6. If desired, the sensitivity of the BEAM control and remote beam control may be reduced to make more precise adjustment possible. This is accomplished as follows:

   a. Remove the top cover plate of the camera head assembly. Locate the green trimpot on the copper board.

   b. Switch BEAM INT/EXT (main unit, rear panel) to INT and turn BEAM control fully CCW or switch BEAM INT/EXT to EXT and apply 0 V at the REMOTE BEAM IN connector.

   c. Energize camera and adjust the trimpot labeled "Cutoff" until the beam is just cut off.

7. Replace all covers.

4.2.4 ELECTRODE ADJUSTMENT RANGES

HEATER	FIXED, 6.3 VAC, 600 mA max.
TARGET	0 to +50 V (front panel adjustable, TARGET)
G1	0 to -150 V (front panel adjustable, BEAM) Maximum negative excursion with EXT or INT beam control may be limited with an internal adjustment.
G2	+250 to +350 V
G3	+200 to +550 V (front panel adjustable, FOCUS)
G4	+200 to +650 V. May be disconnected from tube by means of G4 ON/OFF switch.
CATHODE	FIXED, normally at ground; +20 V during blanking.

A wide variety of vidicon tubes may be used in the 502 Camera, but manufacturer's literature should be consulted to insure that the proper potentials are applied to the tube elements. Typical tubes are the types 7038, 7735, and 8484 for visible spectral response with a gamma of approximately .65. The type 7290 may be used when a gamma approaching unity is required, and special tubes may be obtained with targets sensitive to the infra-red or ultraviolet portions of the spectrum. Silicon target tubes are recommended for ruggedness.

NOTE

BECAUSE OF PARTS AVAILABILITY AND OTHER CONSIDERATIONS, 74XX SERIES LOGIC DEVICES SHOWN ON DRAWINGS AS LS MAY ACTUALLY BE NON-LS DEVICES. WHEN THIS IS DONE, OTHER COMPONENTS SUCH AS TIMING COMPONENTS MAY CHANGE VALUE.

THEREFORE, WHEN REPLACING ANY ON-BOARD DEVICES, THEY MUST BE REPLACED WITH LIKE KIND.