A. INTRODUCTION

The IRC-160 and IRC-160ST are high performance, staring infrared imaging systems with 160 x 120 pixel resolution. The IRC-160 camera comes in two versions or basic models; both are described in this manual. Figure 1 depicts both cameras. Note that there is also a considerable difference in their appearance. The most striking technical difference in these units is the method by which the detector focal planes are cooled to their operational temperatures of about 80K or -315 degrees Fahrenheit (zero Kelvin is absolute zero; 0°C corresponds to 273 degrees Kelvin or 32 degrees Fahrenheit). The IRC-160 uses pre-liquified nitrogen gas as a cryogen. This LN_2 is poured into the sensing head dewar where it is held in contact with a detector/multiplexer focal plane array, cooling it to operational temperature. The IRC-160ST (ST stands for Stirling) uses a mechanical Stirling Cycle microcooler to provide the cooling to the detector/multiplexer array. This provides the IRC-160ST with certain convenience and portability advantages over the IRC-160. Below is a list of standard items delivered with each camera model.

IRC-160	IRC-160ST
50mm EFL Lens	50mm EFL Lens
Plug-in Pwr Supply	Plug-in Pwr Supply
Tripod	Tripod
Carrying Case	Carrying Case
LN_2 Fill Funnel	Battery w/Recharger
Evacuator Valve	Black & White Viewfinder Display
Analog Connector Cable	

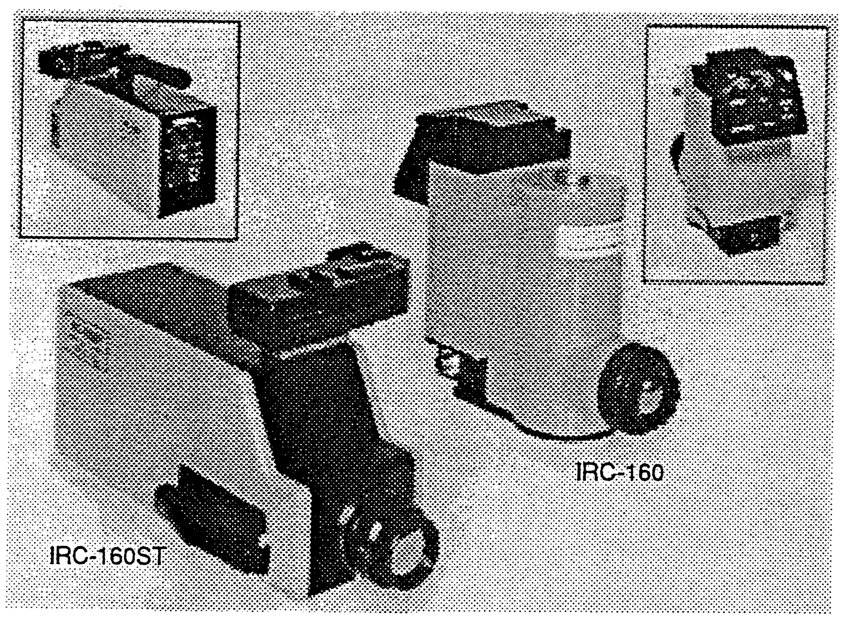

Figure 1. The IRC-160 and IRC-160ST Infrared Focal Plane Array Cameras (Rear Views Inset)

In both cameras, the standard lens or optic is 50 mm Effective Focal Length (EFL). This optic attaches to the camera via a bayonet type adaptor. They are easily removed and replaced with optional lens types that are described in a following section of this manual. The 50 mm lens provides a Field-of-View of 9.1 degrees in the azimuth direction and 6.8 degrees in the vertical or elevation direction. The pixel resolution is 1 milliradian with this standard lens. Focusing is manual and adjusted by rotating the focus ring on the lens.

Both units can be powered with their provided plug-in power supply from a wall outlet. The IRC-160ST is also provided with a battery that allows operation of the system for approximately 2 hours. This, along with the provided viewfinder display, makes the IRC-160ST completely portable and self contained. A battery recharger is also provided with the ST version.

Video outputs are provided in both the RS-170 NTSC (PAL for European Customers) and RGB formats. This allows the user more options when choosing the monitor. The RGB output is compatible with VGA monitors which are commonly used with personal computers. The composite video NTSC or PAL output can be used to record images with a Video Cassette Recorder (VCR) or display images on a variety of CRT monitors and miniature LCD graphic displays that have internal drive electronics compatible with the NTSC or PAL formats. It is up to the user to provide a monitor for the IRC-160. However, a Black and White Viewfinder Monitor is provided with the IRC-160ST. This viewfinder monitor is suitable for truly portable operation of the Stirling cooled unit. In either case, we recommend the user acquire a quality larger format color monitor for tripod or non-portable operation. Contact CE for a recommendation or see the OPTIONAL ACCESSORIES SECTION of this manual.

Several controls are mounted on the camera. These controls are all located on the panel of the IRC-160; all the controls except BRIGHTNESS and CONTRAST are located on the rear panel of the IRC-160ST. The ST BRIGHTNESS and CONTRAST controls are on the side of the camera housing above the hand strap. Electrical controls are Power ON/OFF, CONTRAST, BRIGHTNESS, COLOR SELECT, NTSC(PAL)/VGA timing selection, COLOR BAR toggle and CORR/UNCORR data selection. These controls, their meaning and application will be described in Section C of this manual titled A GUIDE TO OPERATION OF THE IRC-160 AND IRC-160ST INFRARED CAMERAS.

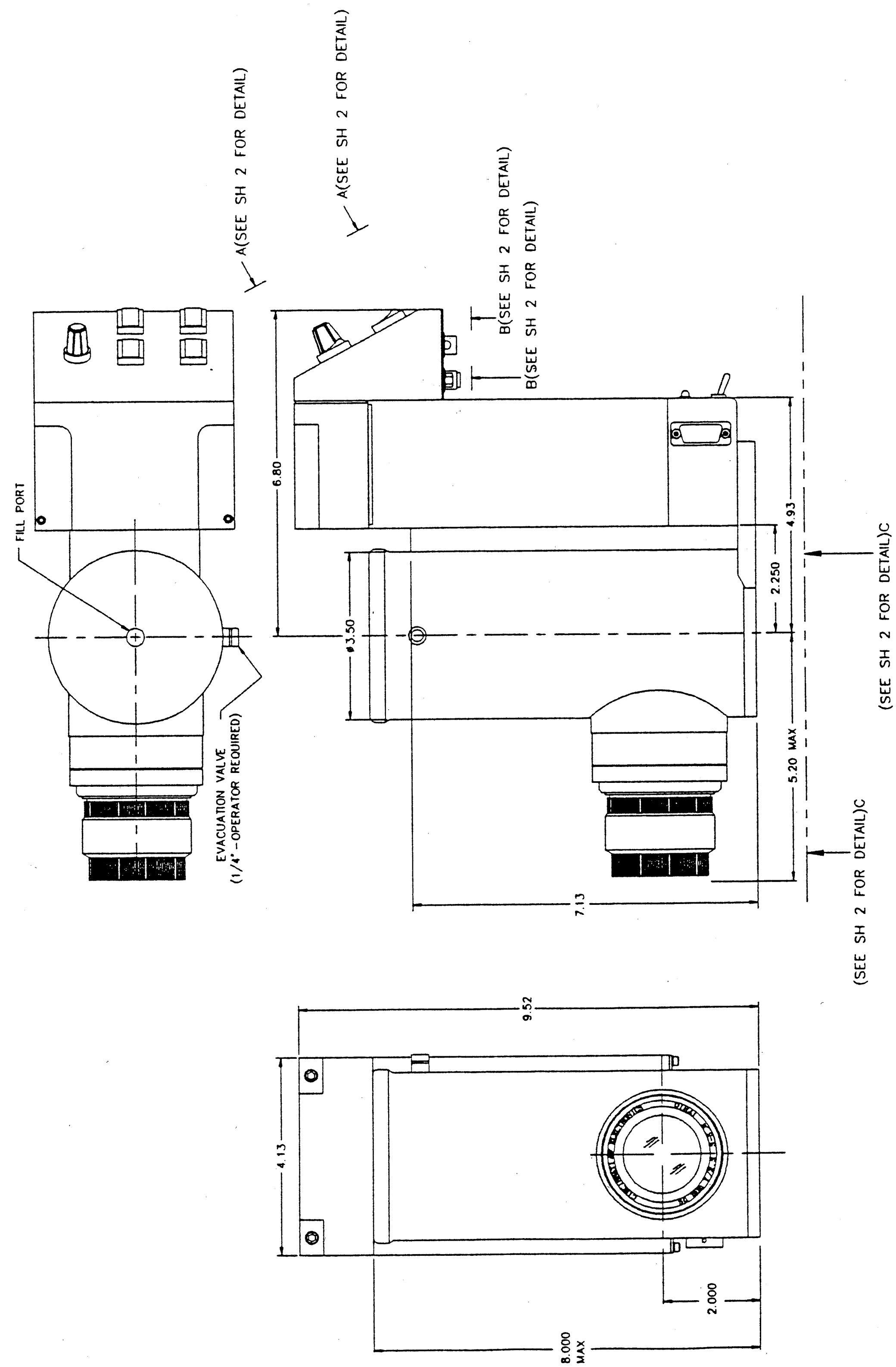

Figure 5. IRC-160 Envelope

D3. The Spectral Filter

A spectral filter is placed within the dewars of both the IRC-160 and IRC-160ST. It is the purpose of this filter to limit the spectral response of the cameras. Figure 9 details the response as measured at the appropriate cryogenic temperature. The filter is mounted between the cold shield and the IR focal plane array. In the case of the IRC-160, it is possible to exchange this filter with one of the User's choice. If this choice is selected, please review the cautions listed in Section B1. It is, of course, necessary to break the dewar vacuum and any operations or modifications within the dewar should only be made by experienced and qualified technicians. The IRC-160 filter is 1 inch in diameter and .040 inches thick; this is fairly standard for Infrared Filters fabricated by various suppliers. Thus, a reasonable stock is usually available that will fit the IRC-160 filter holder.

The situation is quite different with the IRC-160ST. Its spectral filter is not interchangeable. This dewar is permanently evacuated and cannot under any circumstances be opened or modified. Although the spectral characteristics of the IRC-160ST's filter is identical to the pour-fill dewar of the IRC-160, its mechanical characteristics are different. It is much smaller and thinner. This reduces the heat load in the Stirling cooled unit.

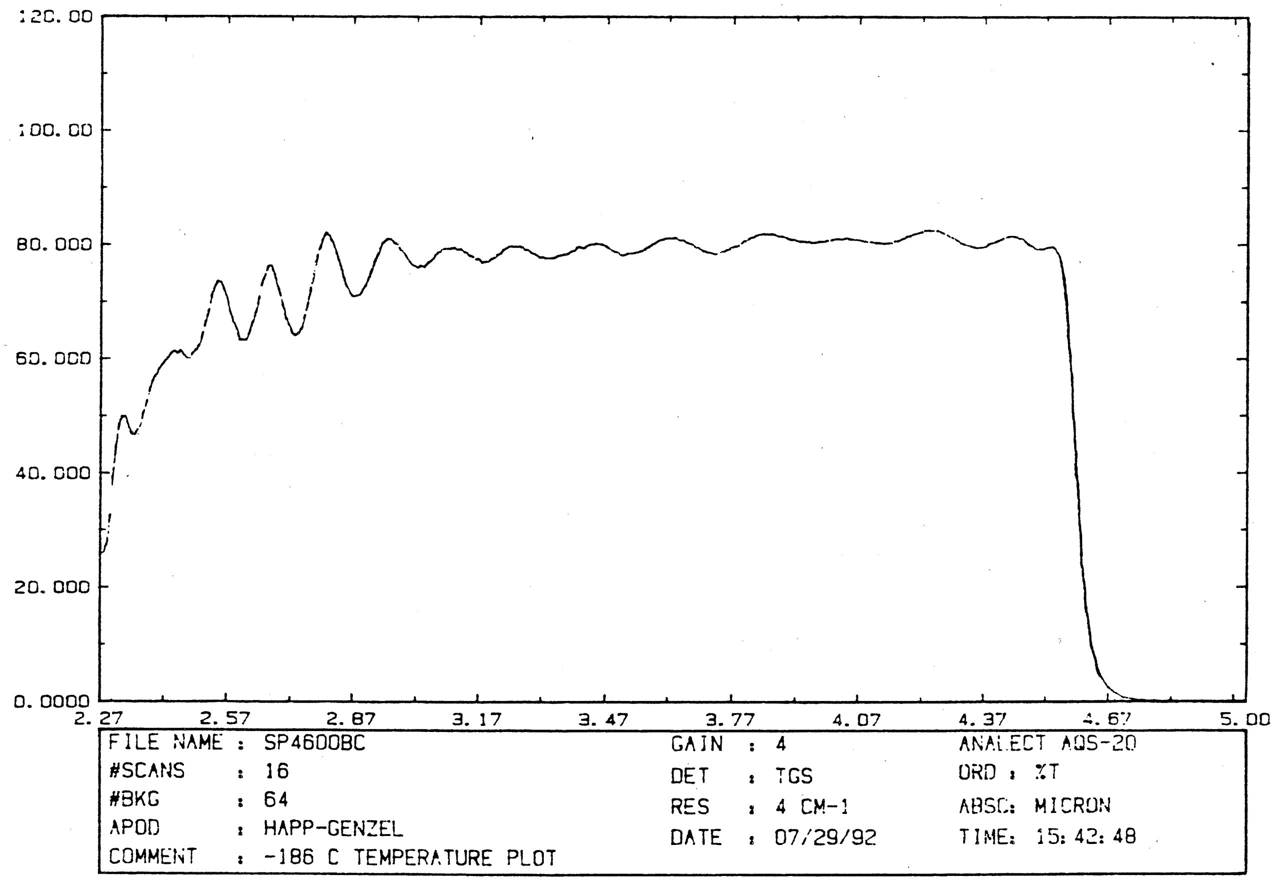

Figure 9. IRC-160 and IRC-160ST Spectral Response at Operating Temperature

The User that is considering changing the spectral filter in the IRC-160 should also consider the following:

1. The IRC-160 camera's detectors are photon detectors and at normal ambient temperatures the photon exitance (photon/sec-cm^2) of objects varies rapidly with spectral characteristics. The photon existence over the total detector spectral response of 0-5.4 micron is about 4 times the existence over the 2.2-4.6 micron response of the standard cold filter.

2. The camera is set up so that its internal well fill capability is about 1/3 full. This means that with no filter, the array would be saturated by room temperature objects. This can be compensated by reducing the integration or stare time of the camera. Please consult Cincinnati Electronics for instructions and advice.

3. Placing a warm filter (external to the camera) will not eleviate the background problem. Since an external filter is warm, it emits background photons to replace the photons it does not transmit.

4. Spatial uniformity corrections, if important for the application, will need to be reprogrammed. Even if the original filter is removed and replaced, recorrection will be likely required. This is because filters themselves are nonuniform and it would be virtually impossible to reinstall the filter in its exact original position. Users that need to change spectral filters should inquire about the available "**DOWN-LOADABLE CORRECTION DATA COLLECTION CARD**". It is a full-length PC-AT compatible board that is used to reestablish uniformity correction of the IRC-160 cameras. It is used in conjunction with a user's AT computer and the software provided with the card.

D4. The Focal Plane Array

The IRC-160 and IRC-160ST use a Focal Plane Array (FPA) as a sensing element. Actually, there are 19200 sensing elements located on a chip. The system uses internal electronics scanning similar to the CCD television cameras. This type of camera needs no scanning system; it stares at the scene through the optics that sets the total field-of-view and resolution.

The sensing element or pixels or sites are photovoltaic quantum detectors made of Indium Antimonide (InSb). They are arranged in an array of 160 columns and 120 rows for a total of 19200 pixels. These detector pixel sites are semiconductor devices sensitive to photon count over the wavelength range of 1 to 5.5 micrometers. Photons are captured by the detector and converted to an electrical current.

The following summarizes the detector array characteristics:

Detector Material	Indium Antimonide
Spectral Response	1-5.5 micrometers
Number of Elements	19200
Device Format	160 x 120
Pixel Pitch	50 micrometers
Pixel Size	28 x 28 micrometers
Fill Factor	30%
Quantum Efficiency	70%

The 19200 pixel detector array is bump bonded or attached to a matching 19200 unit cells of a CMOS multiplexer. A schematic representation of the multiplexer and detector is shown in Figure 10. The block labeled "input cell" is a unit cell and thus there is one unit cell for every element of the array. The electrical connection between the detector pixel and the multiplexer unit cell is through the bump bond connection. The multiplexer is more than the name implies. It serves as a buffer or preamp, integrates photocurrent on a storage capacitor and on command from its row and column shift registers selects sequentially each detector element.

The unit cell read-out structure of the 160 x 120 multiplexer is normally referred to as "Direct Injection". Better known to most is the term "common gate amplifier". Photocurrent is integrated on capacitor CI for a time following reset of the capacitor to the initial voltage VR. This time interval, from reset to read, is called the integration or stare time. The multiplexer provides the capability of adjusting the integration time in steps. These steps are equivalent to one line time. The 160 x 120 pixel array is read out pixel by pixel one line at a time and there are 120 lines in a frame of an image. The multiplexer has the capability of providing integration times ranging from 2/120 (2 lines) of a frame time to 120/120=1 (120 lines) frame time. One should note, however, that the camera is set up with a fixed integration time corresponding to about 34 lines.

The IRC-160 Master Clock runs at 8 MHz. It takes 8 clock cycles to read a pixel; thus the pixel rate is 1 x 10^6 pixels/sec. A frame time is made up of 162 x 120 pixels/frame (160 pixels plus 2 pixels of dead time or overhead per line). This all adds up to 51.44 frame/second or a frame time of 19.44 milliseconds. 34 out of 120 lines thus take up about 5.5 milliseconds. This 5.5 milliseconds is the nominal integration or stare time of the camera.

This is not to be confused with the frame rate of the video display device such as an image monitor. Although the IRC-160 acquires frames of data at the rate of 51.44 frames per second, it outputs video to the display device at the standard 30 frames per second for the NTSC format and 60 frames per second in the VGA mode. Digital data appears at the DIGITAL DATA PORT at the rate of 51.44 frames/sec.

D5. The IRC-160 and IRC-160ST Electronics

A block diagram of the camera electronics is illustrated in Figure 11. The main part of the electronics is made up of 3 printed wiring boards; the partition shown in the diagram properly segregates the functions.

Board 1 is the DRIVE BOARD. It provides bias voltage for the focal plane array, clock signal to control the multiplexer and an analog gain stage. It also provides an initial analog nonuniformity correction.

As mentioned previously, the camera focal plane is an array of 19200 individual picture elements or pixels. These individual sensors each have associated "unit cells" with the multiplexer that converts photocurrent generated by the detector pixel into a pixel voltage. These individual voltages are then time division multiplexed out to the camera processing electronics. It is not hard to imagine that each of the sensing cells may have a slightly different response even if the scene was uniform. If the scene were uniform, one would expect to see a uniform gray level on the display. However, different pixel responses will cause a speckled image for uniform scene and distort the image for a real scene. For this reason, the camera electronics "corrects" the data. The Primary Gain and Offset correction are accomplished on the Drive Board. Once programmed, the ROMS that provide the Correction Coefficients are permanent.

The Analog to Digital Conversion is done on Board 2 (the Converter Board). Note that a second nonuniformity correction is performed on this board and the CONTRAST and BRIGHTNESS controls are implemented. This second set of corrections is again a two point correction. The status of data at the Data Port is determined by CORR/UNCORR rocker switch. In the CORR position this second set of uniformity corrections are

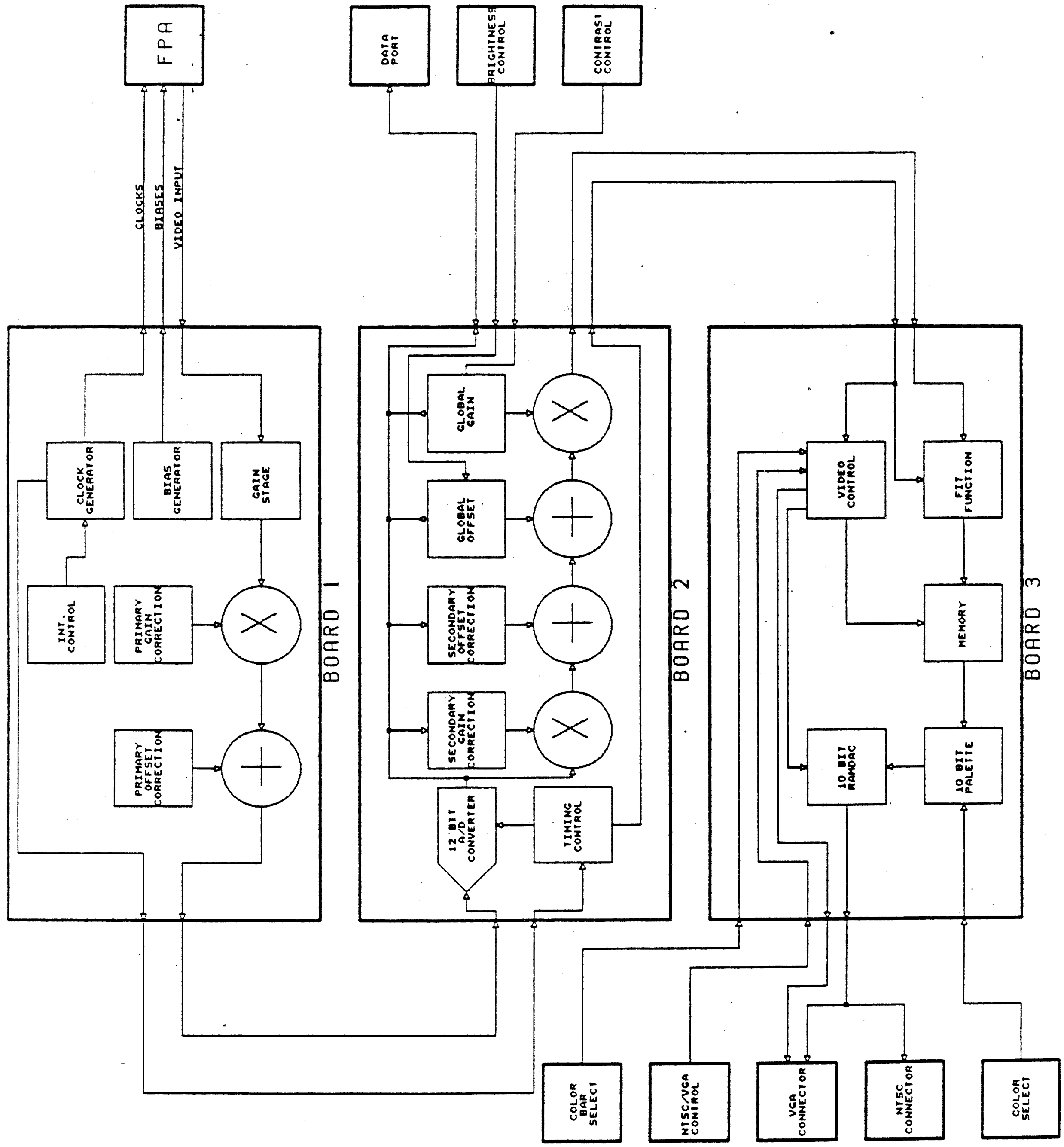

Figure 11. Block Diagram of the IR Camera Electronics