CHAPTER # III

MECHANICAL ASSEMBLY AND INTERFACE

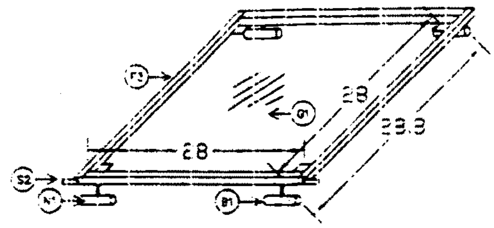
(Design Consideration)

This section describes the design of the mechanical stage to move the x - ray film, (25.4 cm X 25.4 Cm), to be scanned and digitized. The mechanism is similar to scan in system, but in this case instead of deflecting the beam, the film is moved systematically.

In most of the film digitizing systems reported, either the assembly of source and detector is moved in X-Y coordinates to capture the pixel information or the beam of light is made to deflecte using mirrors, with the film, collector lens and detector kept stationary.

As we are proposing the film to be moved, we shall need a three frame movement system. Out of the three stages, two stages are moving stages in X and Y directions respectively, and the third stage is fixed. Components used for the movement of these stages are standard practice of the subject content robotics (18) (2). Basically the movement mechanisms are either dc/ac servo or controlled by a step motor and lead servo arrangement.

In this design, as shown in the Figure. 3.1 a,b,c we are using the PM-DC motor for X-movement and a stepper motor for the Y-movement of the film. As the servo and stepper are the two possible mechanisms of movement, we have carried out our design with both these types, included so the design becomes a most versatile one. It is to be noted that the abscissa and ordinate could be selected conveniently. Before going into the details of the mechanical design, let us discuss fundamentals of these two types of motors and mechanism of



FIG(a)

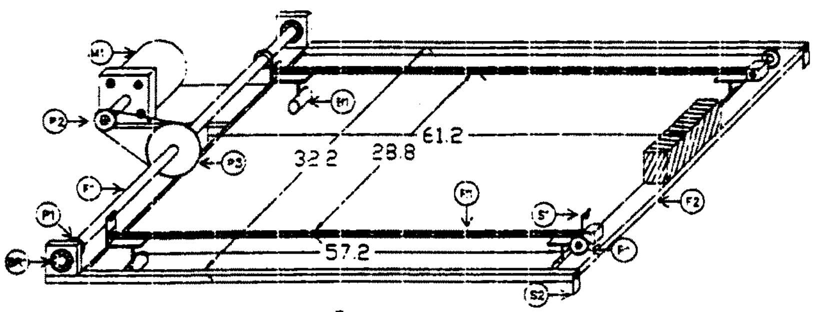
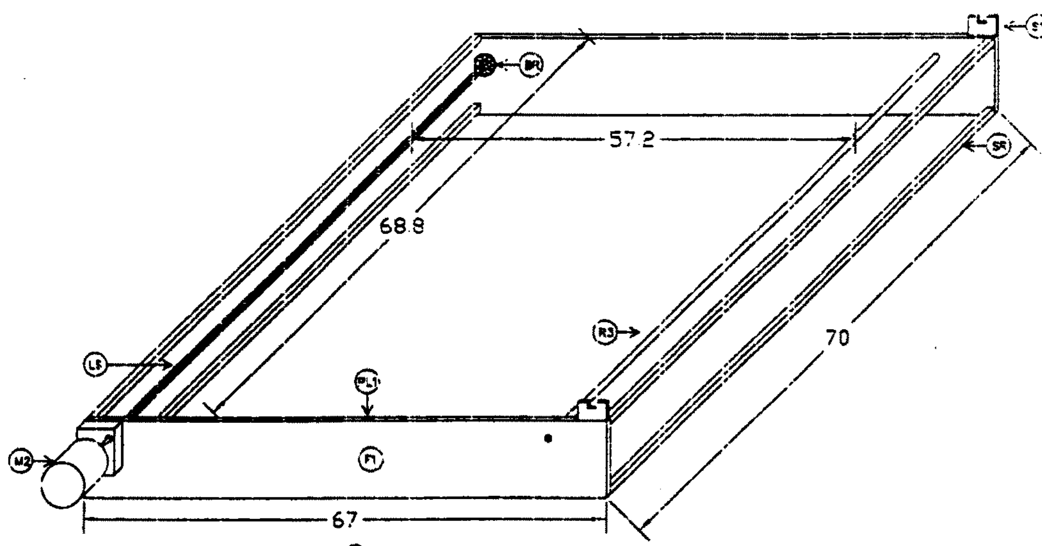
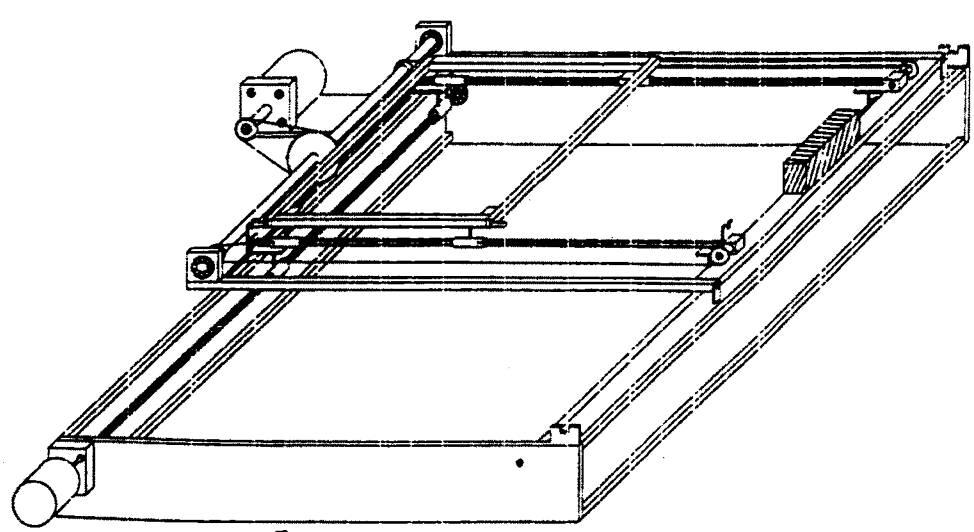


FIG.(b)



FIG(c)



FIG(D)

3.1 Mechanical Assembly

control.

3.1 PM - DC MOTOR

An electric rotating machine energized by DC and used to convert electrical energy to mechanical energy is the DC motor . It is characterized by its relative ease of speed control and in the case of series connected motor, by an ability, to produce large torque under load without taking excessive current. Further the servo mechanism refers to a feed back controlled system especially for the mechanical motion (17).

The PM -DC motor is the most common actuator used in low and moderate servos. It must be large enough to move the load over the required range of velocities and accelerations. The load may mean inertia, friction, or external torque or any combination thereoff. Nevertheless special designs have been developed with superior characteristics.

3.1.1 Digital DC Motor Speed Ccontrol System

Now we shall attempt to discuss the digital DC - motor speed control system. We have adopted this design to control the speed of the DC - motor which moves one of the stages of our mechanical assembly. As shown in figure 3.1. the 3rd frame holds the film to be digitized. And the frame has to be moved to and fro with uniform speed. For this purpose PM - DC motor is chosen. To drive and control the PM - DC servo motor, we have fabricated and tested the circuit (7). The figure 3.2 shows the block diagram of the circuit that has been wired and tested. It is a closeloop DC-motor speed control system.

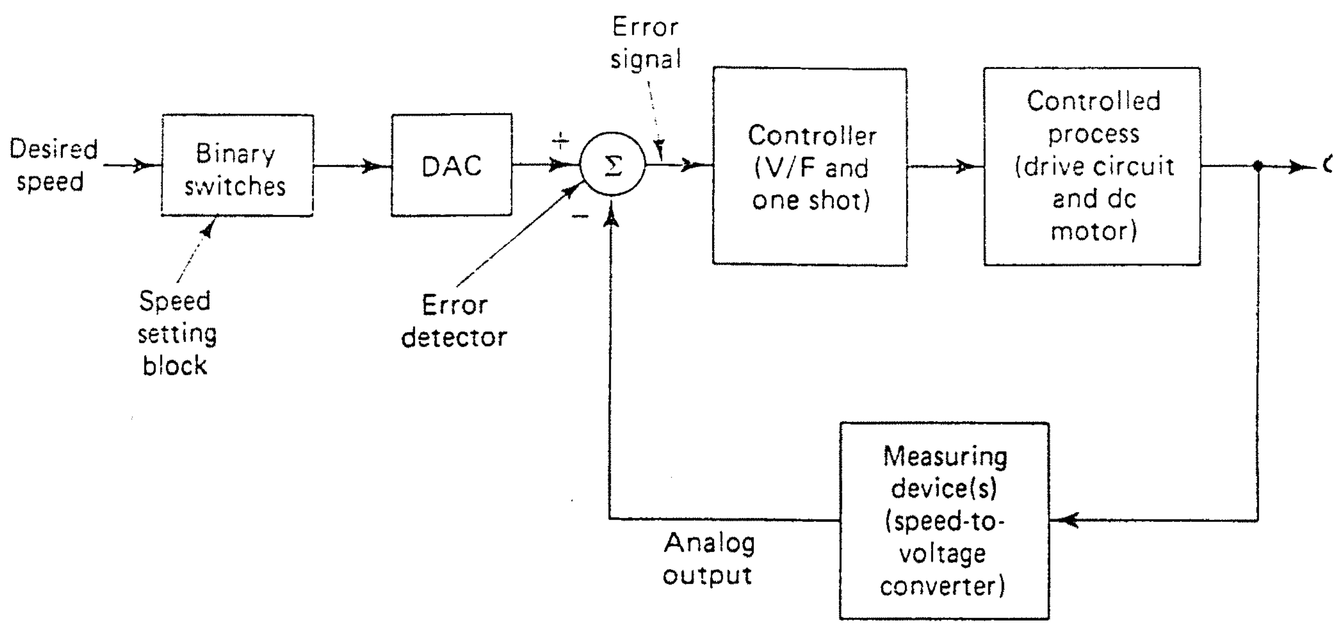
The speciality of this circuit is that it allows the user to select any speed, from maximum to minimum rpm, simply by selecting the appropriate switch position or the digital input.

The binary speed setting is converted into an analog I/P using DAC. This analog signal is then compared to the actual motor speed signal using an error detector. The error detector circuit is a O/P amplifier in comparator mode as shown in fig 3.2.a.

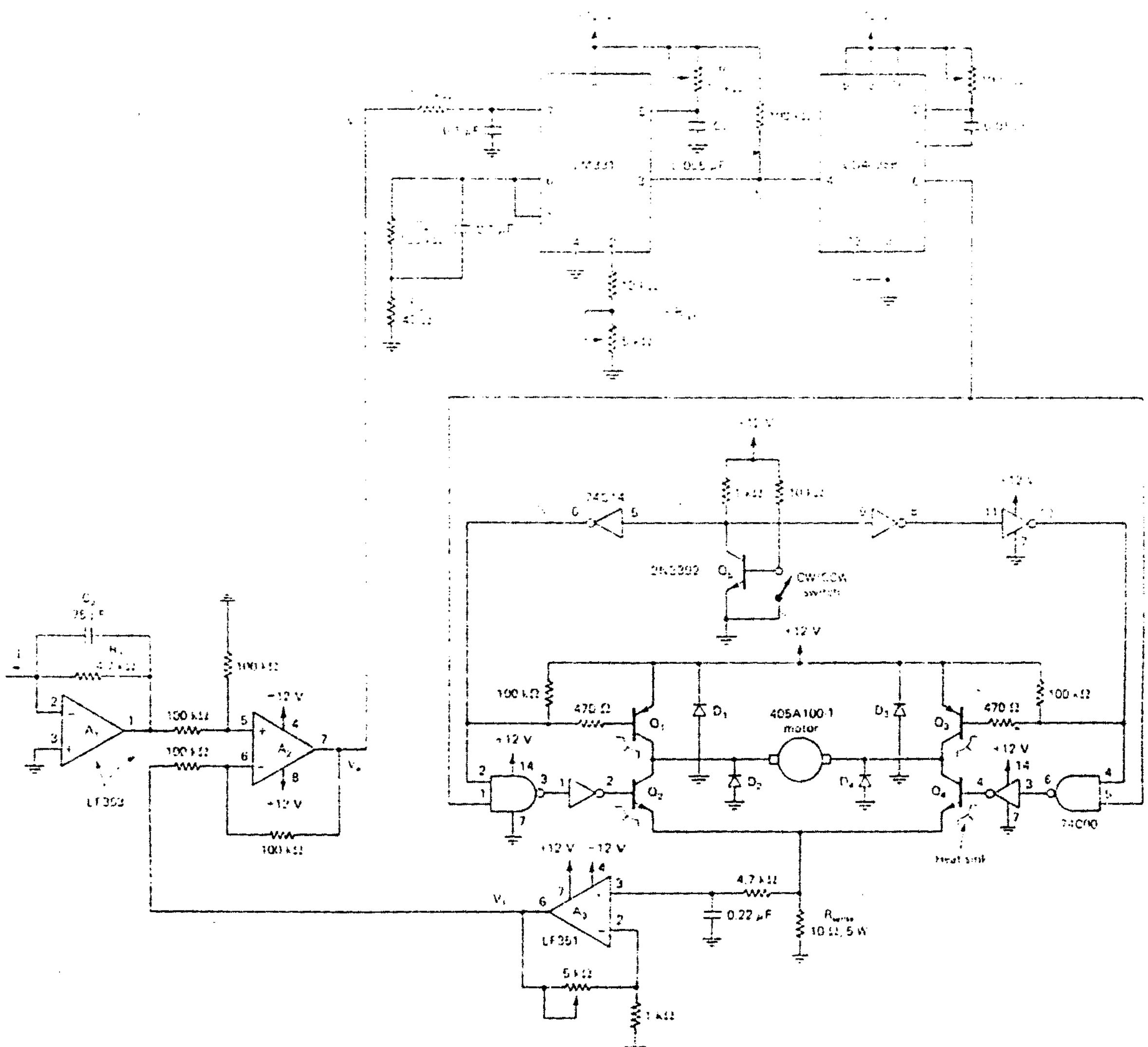
As discussed a desired speed is converted into a voltage by DAC. Similarly, an actual speed will be converted into voltage by a speed - to- voltage converter. To maintain the speed of a DC-motor, these two voltages are compared and the difference is used to drive the VFC and monostable circuit.

For VFC, LM311 is used , where the O/P duty cycle increases with an increase in the O/P voltage. These pulses are further feed to the one shot circuit., constructed using timer IC 555 which will drive the motor in on-condition as to the duty cycle of its wave form.

Output of mono-stable circuit drives either of the two transistors set, which further will drive the DC motor. The direction of the motor rotation depends upon the base bias of transistor switch. The



3.2 Block Diagram of PM DC Motor Control



3.2a Circuit Diagram of PM DC Motor

measurement circuit samples the armature current which is proportional to the speed of the motor. Another circuit converts the speed of the motor to its proportional o/p voltage, which is further feed to the error detector circuit.

Thus the digital DC motor speed control system controls the speed of motor by using the speed setting as a digital I/P. This is the set point, SP, in the conventional control system theory. The speed is controlled by a variable duty cycle output, where the speed it self occurs a feed back, i.e. Process Variable N., to the variable duty cycle circuit, composed of the VFC and the mono-stable multiviabrator's

3.2 STEPPER MOTOR CONTROL

As known, the DC motors operate in continuous manner, while the shaft of a stepper motor moves in discrete angular increment or steps. To drive the stepper motor, stator electromagnets are energized in a specific sequence. The electromagnets are energized by actuating currents in the stator windings, where the actuation could be controlled by a digital word/ byte output of a micro computer. The size of the step depends on the stepper motor design . Usually, 0.90 half step or 1.80 full step. For details about the SM and mechanism of its control we refer to the text (7,16).

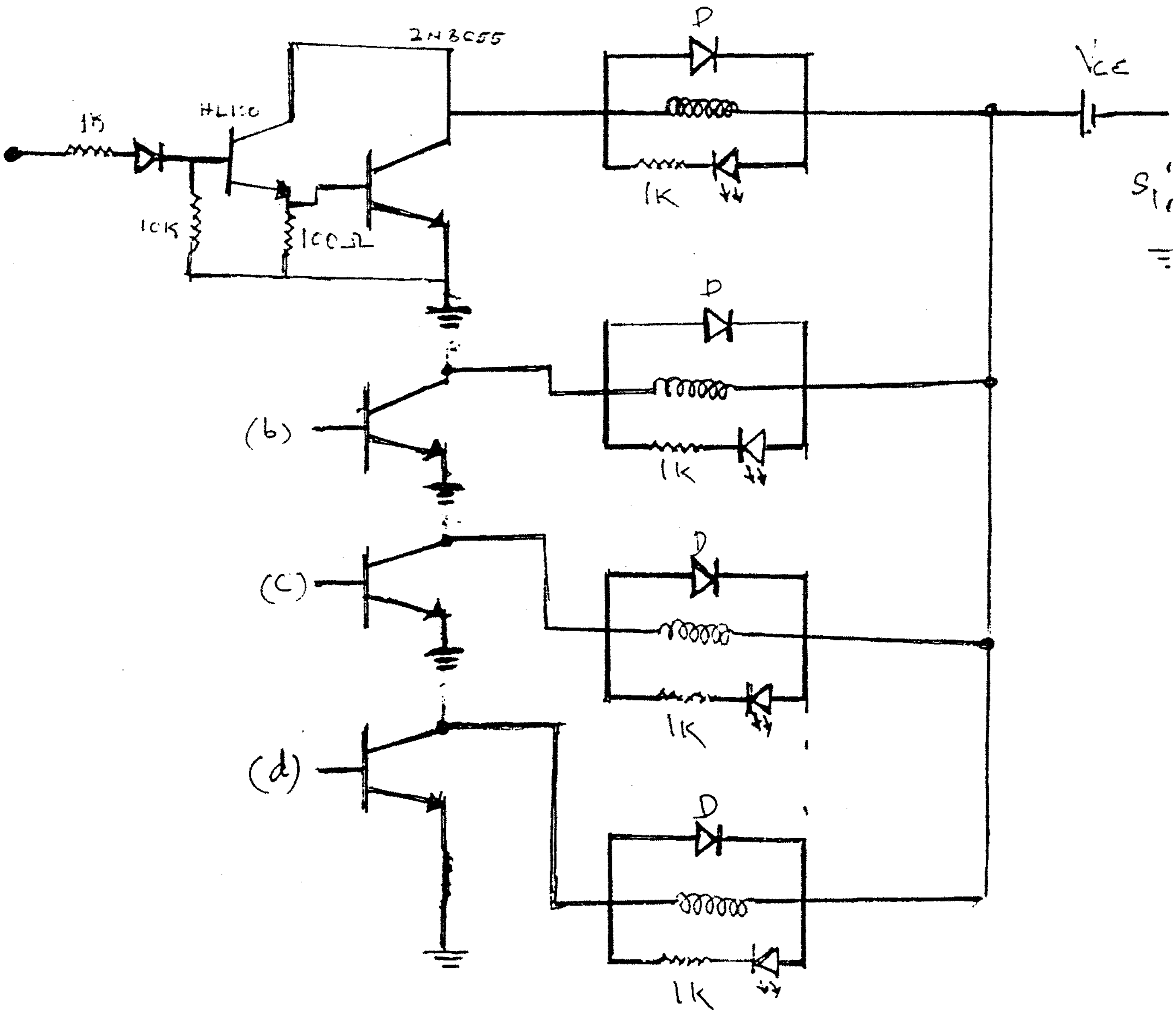
The significant characteristics of the SM is that the controller structure may be directly interfaced to a microprocessor or computer. It is also clear that a stepper motor can position a load very accurately, as each control output causes the SM to advance precisely one angular increment. The figure 3.3. shows the circuit diagram for driving the SM whcih is directly interfacable to the PC..

3.3 DESIGN OF MECHANICAL ASSEMBLY

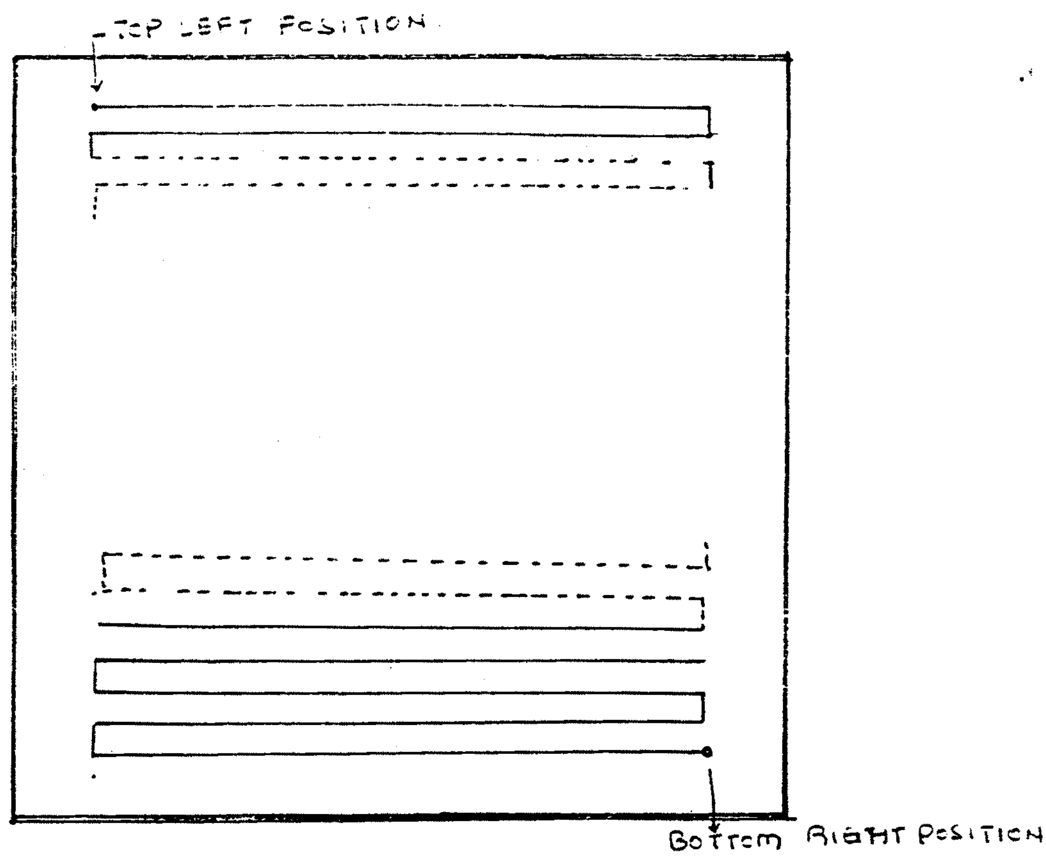
Uptill now we have elaborated upon various aspects of the subassemblies of the mechanical stage, that moved the X - ray film in X and Y directions. This section is devoted to the details of the design of this movement stage.

We shall start in the bottom up fashion to describe the design. The largest size of the X - ray film to be moved is considered 10 " X 10 ", i.e. 25.4 Cm X 25.4 Cm. The procedure of scanning is shown in figure 3.5. The scanning starts at the bottom right corner and continues in the X and Y directions as shown in the figure 3.4.

The scanning ends at the top left corner. Referring to the figure 3.1 of the mechanical assembly, the starting point of scanning occurs at approximate centre of the first frame, whcih holds frame 2 and frame 3. The optical beam is to be projected at this point with respect to the mechanical assembly. The optical source and detector arrangement is being explained in Section 3.5.



3.3 Circuit Diagram of Stepper Motor Drive



3.4 Scan Mode

3.3.1 Frame-3

As we are adopting the scan - in philosophy of digitization, the optical source and the detector shall remain stationary and the film shall travel such that the desired scan is obtained.

As the frame - 3 has to hold the X-ray film, the size of the film is selected to be 28 Cm X 28 Cm internal dimension. The frame is to be fabricated out of a square aluminium rods of 8 mm x 8 mm . Three considerations have been given at this points.

i) Total weight of the frame - 3

ii) Mechanical rigidity of frame - 3 holding the X - ray film and a glass plate of 2 mm underneath.

iii) Possibility of screwing the bushes or wheels, to two sides of the frame, as indicated by symbols 'B' in the figure 3.1. It is important to note that the film slides over these bushes/ whells. In the actual design ,we propose two wheels and two bushes to be accommodate, though the figure3.1 c marks all these components as DSB.

Another important feature of frame - 3 and the glass plate support is as follows. The glass plate is engraved from bottom right to the top right, to identify the pixel (y,0) for the scans in the X - directions. The film will be mounted in a fashion i.e. justified at bottom right corner. It will be evident from the forthcoming discussion, that, film of any size would be placed on the frame - m3 and scanned only in the area of interest. Further, its arrangement allo scanning the film from its top left corner as per the normal conversion

The frame - 3 also has the shutters mounted on it for opto-slotted coupler (7) mounted on frame - 2. The opto - slotted coupler (MOC 7811) is used as initial and end position sensor. The accuracy of the positiön sense of the slotted opto-coupler is limited by its aperture size 1 mm for Moc 7811. The opto slotted coupler will sense the position with 1 mm accuracy and the engraving are the glass may provide an accuracy in the range of 100 micrometer. For this purpose the micro lithographic/ photographic technique are to be made use of , which are not accessible to us at present.

The frame - 3 also has an outgrowth to attach the scope required for its movement. The rope is being driven by the PM-DC motor with a reduction system and rope and pulley arrangement.

3.3.2 Frame - 2

The frame - 2 holds the frame-3, PM-DC motor and the required pulleys as shown in figure 3.1b. The frame is a rectangle formed using 10mm.10mm mild steel steel rod. As the frame-2 has to hold the fast moving frame-3, we require the frame-2 to be sufficiently rigid. Therefore, the rods used are of stainless steel.

The frame -2 also supports to two 6 mm high polished stainless steel rods to hold the frame -3. The movement of bushes of frame -3 is guided by these stainless steel rods, 28.8 cms apart from each other.

The frame-2 is mounted with the DC motor, reduction gear of ratio 1:10, 4 pulleys on the corners to hold the rope , moving frame-3 and a load 'L' to balance weight distribution of the frame -2 . The frame - 2 also has two slotted opto-coupler mounted on it (MOC 7811) at the appropriate position. These are the initial and end point sensors of Y - axis. The reduction system has been used purposely to reduce the mechanical movement of frame - 3 after the stop signal is outputted by the micro computer.

3.3.3 Frame - 1

This happens to be the master frame, which holds frame - 2 mounted with frame 3 and movement mechanism for frame - 3 . This frame is to be fabricated using mild steel sheets and mild steel rods.

The overall dimensions of this frame are 67 Cm X 70 Cm. As shown in figure 3.1 a, front plate and back plate houses bearings for the lead screw. A fixed rod is also housed in the same plate. The centre to centre distance between these two rods is 57.2 Cms diameter of the rod and screw is 1 Cms. And the screw has tapping of 20 TPI. The stepper motor (M2) is attached to one end of the lead screw.

The initial and end point position sensors for Y - movement are mounted on frame -1 in the appropriate position. These are also slotted opto-coupler of type (MOC - 7811).

3.4 SYNCHRONIZATION OF MECHANICAL MOVEMENT AND ELECTRONICS

3.4.1 Movement of Y - axis

Initially we start with Y - movement. The threads used for lead screw are 20 TPI, therefore, the pitch becomes 0.05". As the lead screw is being moved by stepper motor in the half step mode, each step of the motor corresponds to 3.175 micrometer movement in the Y - direction. Whenever we ditigize the film, the movement in Y - direction should correspond to the physical pixel size on the screen, its least count becomes an important parameter. At present the least count of Y- movement is 0.492 micrometer.

Various types of monitors have been described in chapter - 2 , for the 14 inch monitor, the physical pixel size in X and Y direction shall vary with each mode and monitor type. We propose to digitize the film in a matrix of 1000 X 1000 pixels. Therefore, the physical size proposed for acquisition in 251 micrometer in X as well as Y direction. The 251 micrometer movement in Y direction corresponds to nearly 79 steps in the half step mode. It is proposed to display the image by using the monitor specific software routine. The stepper motor is proposed to move 1185 steps/min. this speed of rotation corresponds to 10 mSec/ Y step.

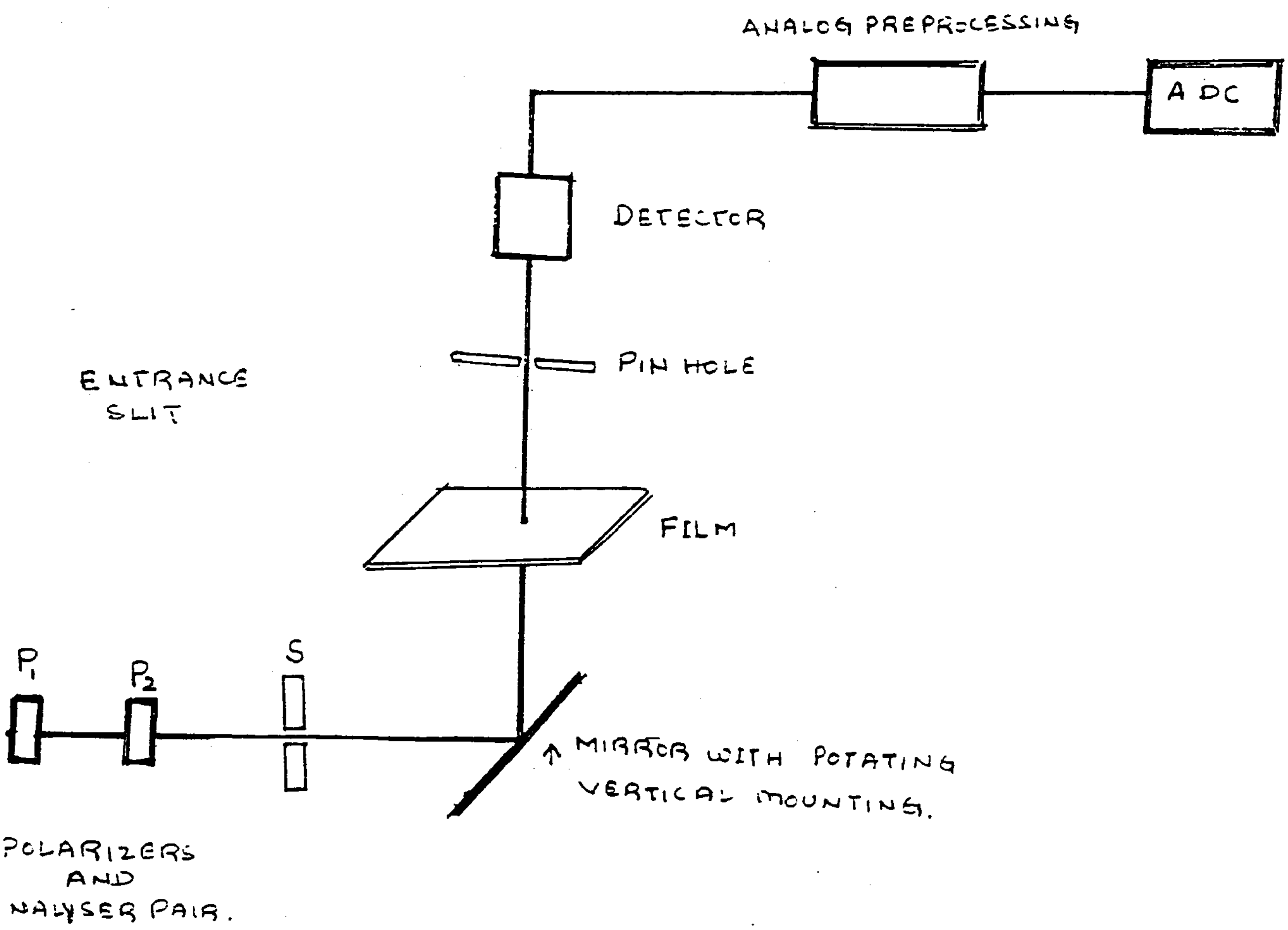
3.4.2 Movement in X - axis

In this case, the speed of movement will be limitted by the speed of the DC motor. It has already been mentioned that, we are going to arrange 1000 pixel in X direction also. Therefore, the pixel width corresponds to 251 micrometer. We propose to move the DC - motor at 1100 rpm. The movement of the frame - 3 is 11 " - in instead of 10 - inch, which corresponds to physical size of the film. This assures the data aquization at a constant rate of the physical movement of frame -3.

The mechanical assembly is so designed that, the 110 rpm of the DC motor make the frame-3 to travers 11 -inch linear length. Therefore, data acquisition in X direction need 100 mSec. This requires the size of the pulley on the motor shaft at nearly 8 mm in diameter. Finer adjustment of the X movement are achievable through the speed control and the ratio of reduction system.

3.5 OPTICAL SYSTEM

The figure 3.5 shows the optical arrangement to be used for the image digitizer. A monocramatic light beam of He-Ne laser at λ = , P = , will be employed as the source of light. P1 and P2 are polarizers. The polariser is mounted on a stand to rotate the axis of polarisation and it is available commercially. In this case we adopt the optical components from M/S Jain Lasertech Pvt. Ltd, Bombay. A polariser /analyser pair is used to control the intensity of the laser beam falling on the X-ray film. 'S' is the entrance slit and form a beam of 1 mm in diameter. The mirror 'M suitable for the required precision ,is to be used to change the direction of the optical beam and align it in the direction of the pin hole. The pin hole , between 200 to 300 micrometer, is to be used to transmit light proportional to the optical density of the film to the detector 'D'. The instrumentation part which includes the analog preprocessing and the ADC has been discussed in section 4.1.1. The instrumentation involved in this case resembles that of the densitometer, used for the experimental work. Being a standard instrumentation system, it has been discussed briefly in section 4.1.1.



3.5 Optical Arrangement for Image Digitizer