A TELEVISION/COMPUTER SYSTEM FOR HUMAN LOCOMOTION ANALYSIS

Thesis presented for the degree of Doctor of Philosophy

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To my Parents and Mary

Summary

The literature review, Chapter One, is in three parts. The first part concerns the development of locomotion analysis, placing particular emphasis on the methods of measurement used. The second part is a review of kinematic measurement systems in which the attributes and limitations of each method are fully discussed. The final part of the review describes other television/computer systems that have been used or developed for locomotion measurement and discusses the limitations of these systems.

Chapter Two discusses methods of detecting the spatial position of body segments using a television camera and justifies the use of a passive marker system to indicate anatomical landmarks. A suitable material for markers and its response is described. Methods of identifying the signals produced by the markers in the camera video output are suggested, and the circuits for the marker detectors used are presented.

The principles of operation of a television/computer interface designed to generate the spatial co-ordinates of markers are described in Chapter Three. A simple scheme to obtain these co-ordinates is first of all presented and the limitations of this method are shown and used to justify the development of a more complex digital system. A description is presented of the functional elements of this system, which generates the co-ordinates of markers detected in the video signals from up to six television cameras. The basic principles of television referred to in this chapter will be found in Appendix Al; similarly those aspects of the PDP 12 computer system which directly concern the interface are described in Appendix A2.

Chapter Four presents the logic of the interface in the form of a description and a set of logic drawings. The nomenclature used to describe the logic is first of all discussed and then a detailed description with the aid of timing diagrams and tables is presented for each drawing.

Computer programming of the interface is described in Chapter Five The instruction set created to control the interface is listed, and two programming examples are provided to show how the instruction set may be used. A method of decoding the interface data, to relate the co-ordinates to the camera which generated them, is also presented. A summary of the computer software written and listed in Appendix A3 is given.

Chapter Six describes how the system was tested in all aspects of its design and in its suitability for human locomotion measurement. Errors and methods of calibrating the data are discussed. The co-ordinates generated by the interface for the trajectories of markers placed on a walking subject are presented and a means of identifying markers from co-ordinate data is described. Some modifications to the basic design are suggested to give improved performance. The performance of the system is summarised and comparisons are made with other methods. Clinical and other applications of the system are discussed and recommendations for future work are given.

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CHAPTER I

REVIEW OF THE LITERATURE

1.1 Introduction

- 1.2 Development of Locomotion Analysis
- 1.3 Kinematic Measuring Systems
 - 1.3.1 Photographic Systems
 - 1.3.2 Non Photographic Optical Methods
 - 1.3.3 Contacting Methods
 - 1.3.4 Other Techniques
- 1.4 Television Systems

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1.1 Introduction

It is the purpose of this chapter to review the literature concerning the development of locomotion analysis, the different types of kinematic measurement systems and television/computer systems.

1.2 Development of Locomotion Analysis

Scientific enquiry into the nature of human locomation has a history extending back to the time of Ancient Greece. Aristotle (384-322 BC) described the actions of muscles and subjected them to a geometrical analysis. Leonardo da Vinci (1452-1519) described the mechanics of the body in standing, walking up and down hill, rising from sitting, and jumping. William Harvey, in his notes "De Motu Locali Animalium" (Harvey (1627)), frequently refers to the work of Aristotle when discussing the relative motions of body segments. In these notes Harvey also stresses the function of the antagonistic action of muscles in modulating movement. Typical of these philosophers was the great range of their studies. Harvey was no exception, and his reference to the kinds of gait in man resembling that of a duck, a crane, a crow etc. were not facetious comments but typical of the way in which he drew his illustrations from every kind of animal life which he had studied. Borelli (1680) described forward motion as the projection of the centre of gravity of the body and consequent loss of stability which was regained by swinging the limb through. Borelli considered the skeleton as a system of levers and again did not confine his studies to humans, as Figure 1.1 shows.

The Weber brothers (1836) were perhaps the first to attempt some quantitative measurement of locomotion. They used measuring lines and evolved a theory which considered the swing phase of gait as a pure pendulum. This theory was later repudiated by Fischer (1895-1904). Carlet (1872) investigated human walking using a pneumatic system of recording displacements of parts of the body, foot pressure and periods of muscular activity. The test subjects were constrained to walk in a circle around the recording equipment.

It was not until the advant of photography that significant advances in quantifying locomotion were made. Muybridge (1882), in America, demonstrated

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Figure 1.1. Plate from Borelli (1680).

the ability of the photographic system to arrest motion. He used 24 fixed cameras and two portable batteries of 12 cameras each to photograph animals and people in action. Investigations were performed on human subjects walking, running, rising from the sitting position and various other activities. The serial photographs were combined and used to show a slow motion moving picture of the recorded event. In some of the studies the background was divided into squares to allow a quantitative estimation to be made of the displacements of various parts of the body. The photographic technique was further adapted and improved by Marey (1895). His technique was to use a single plate camera which had a rotating disc with slits mounted in front of the lens. The subject was dressed in black and the limbs and joints were marked with shiny strips and bright buttons. The tests were carried out in bright sublight and a "stick" diagram of the subjects motion was recorded on the plate, Figures 1.2 and 1.3. This technique, known as chronophotography, is still in use in various forms today.

Fischer (1895-1904) was the first to perform a comprehensive analysis of three dimensional movements of parts of the human body. In these investigations the subject was dressed in black and carried incandescent light tubes strapped to the various segments of the body. The subject walked in a darkened room in the view of four plate cameras; the plates being exposed at a constant cyclic rate. The exposed images of the tubes on the plate gove stick diagrams representing the successive positions of body segments. Measurements from these plates were corrected to eliminate errors due to perspective, which was complicated by the layout of the cameras. Two of the cameras were perpendicular to the axis of progression (one on each side) and the other two were positioned obliquely at 30° to the line of progression to obtain the frontal view. The information was analysed to obtain displacement, velocity and acceleration curves against time in three dimensions. This data together with data collected by Fischer on the mass properties of the body segments was used to calculate resultant forces acting on the centres of gravity of the segments. Fischer's work has been referred to by all subsequent investigators and his findings largely conditioned the mechanical design of external prostheses for the first half of this century.



Figure 1.2. One of Marey's subjects dressed for photography (From Bernstein (1967)).



Figure 1.3. Stick diagram produced by Marey's technique (From Bernstein (1967)).

Amar (1916) extended Fischer's work by developing an instrument which measured three components of ground to foot force. This "force plate" was of purely mechanical design, spring deflections indicating the applied forces. Investigations into the gait of subjects wearing external prostheses were made, and the results were used to suggest improvements in prosthetic design. Elftman (1938) also designed a mechanical force plate, in which the spring deflections were recorded by a high speed cine camera, which also recorded the position of the foot in one plane. Elftman (1939) extended his work to study the planar kinetics of the leg, using the force plate to measure stance phase forces and cine photography to measure displacements. As recording techniques improved investigators attempted to look for finer details in the recorded patterns of locomotion. Bernstein (1940) used chronophotography with repeated exposure rates from 60 to 190/sec and claimed that small details in the patterns of motion, in the derived curves of force etc., were common to all normals in locomotion. In the waveforms of the horizontal component of force acting on the centre of gravity of the thigh he claimed to observe, consistently, 10 distinct features in one cycle - Figure 1.4. Studies were made of the development of running technique in children using chronophotography, as well as many other types of movement. Data on the segment mass parameters of the body was also collected by Bernstein (1934) from studies of 150 live subjects. Most of Bernstein's work was carried out in two dimensions, but he did some tests in 3 dimensions by means of stereo photography (using a mirror to provide the second Image)

A major landmark in locomotion analysis was the research carried out by the College of Engineering and the Medical School of the University of California, Berkeley. Their report, University of California (1947), covers a wide range of work, and provides much original information about the characteristics of human locomotion in the normal and in the amputee. Their studies provided data on the rotations of the lower limb segments about their long axes, Levens (1948). This data was obtained by making measurements of the spatial position of stainless steel pins which were inserted into bony prominences of the limb, from the recordings of three 35 mm cine cameras. Two dimensional



Figure 1.4. Force curves at the centre of gravity of the thigh in normal walking used by Bernstein to illustrate distinctive features during the walking cycle. Above: vertical components. Below: horizontal components. (From Bernstein (1967)).

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studies of motion were made using interrupted light techniques, and three dimensional measurements were made with cine cameras. One of the principal advances made by the California group was the development of a force plate which could measure the six quantities necessary to define the resultant force actions transmitted between ground and foot during walking. The objectives of these studies were "I) to gain an accurate knowledge of the functions of components (of the body), so that repair techniques could be improved, 2) to form the basis of physiotherapy treatment, 3) to provide design parameters for external support devices and limb replacements". Figure 1.5 shows a part of the experimental set up.

Details of the labour involved in the University of California studies are contained in Bresler and Frankel (1950). In this paper it is revealed that to calculate the external forces and moments in the leg during normal level walking some 14,000 numerical calculations were made, 72 curves were plotted, and 24 curves were subjected to graphical differentiation for only one strict. The calculations were performed on desk calculators and the data processing for the first subject took 500 man hours, this was reduced to 250 man hours for the fourth (last) subject.

In a historical review of gait analysis Steindler (1953) claimed that "kinetic analysis of gait reveals and enlightens many situations concerning the practising physician...,", also that it had "....become apparent that the kinetic analysis of gait has developed into a guide for clinical practice and an effective adviser in difficult and controversial situations....". The colossal manual effort involved in a proper kinetic analysis of gait certainly precluded its use in a clinical situation, and restricted the number of tests that could be made for research studies; hence the results of such studies needed to be treated with caution if they were to be applied to other subjects.

Saunders et al (1953) proposed, on the basis of the University of California's research, that locomotion is fundamentally the translation of the centre of gravity of the body through space along a pathway requiring the least expenditure of energy. Six factors which had a major influence on this motion were identified:- rotation, tilt and lateral displacement of the pelvis together with knee and hip flexion and knee/ankle interaction. Loss of any of these motions lead to



Figure 1.5. Part of the University of California's experimental set up the glass walkway. (From University of California (1947)).



Figure 1.6. Photographic recording of locomotion as used by Murray (1964).

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compensation by the others, which was reasonably effective if only one determinant was lost but the loss of two determinants lead to an increase in energy requirements of three times. The force plate and interrupted light photography were used in these particular studies, and the energies referred to were the mechanical energy requirements not the physiological energy requirements. The cadence of normal gait was compared with that of various pathological gaits by Drillis (1958). The cadence for normals was found from a sample of 936 pedestrians on a New York city street. Measurements of pathological gait were made in the laboratory using foot contact switches to record the times of the various phases of gait, and a tachograph was used to record the horizontal velocity of the trunk. More detailed studies were made using interrupted light photography at frequencies from 25 exposures/sec to 100 exposures/sec. Mention is also made in this paper of the use of 3 accelerometers to determine the acceleration of the subjects' centre of gravity, but no results are quoted.

Use was made of a stroboscope to obtain interrupted light stick diagrams by Murray (1964). 60 male subjects were analysed, measurements being made of 1) duration of the walk cycle and its phases, 2) length and width of steps and strides and foot angles, 3) saggital rotations of pelvis, hip, knee and ankle, 4) vertical, forward and lateral excursions of the head and neck, 5) transverse rotation of the pelvis and thorax, and 6) saggital excursions of the upper extremities. 14 markers were used and the subject was filmed in semi-darkness in one plane, but with an overhead mirror to provide the view of lateral movements. Figure 1.6 shows one of the photographs from which measurements were made, obviously a considerable amount of manual effort was required. Murray suggested that the results of these investigations showed the wolking patterns of normal men, however although a fairly large sample was taken compared with other work the size of sample was still relatively small. The 60 subjects were split into 5 age groups, and the sample for each age group was split into three further groups by height.

The resultant force action at the human hip joint was studied by Hunt (1965) using cine cameras and a force plate similar in design to that at the University of California. During this work accelerometers were used, mounted

on the shank, to check the differentiation procedures used to obtain acceleration from the cine displacement/time data. The results showed that, generally, the differentiation procedure was satisfactory and that the use of accelerometers available at that time would involve excessive complications and constriction of the test subject. Paul (1967) determined the forces transmitted by the hip joint using cine photography, force plate and EMG recordings, during normal level walking. The displacement data was obtained in three dimensions by using two cine cameras, and measurements were made over a complete gait cycle. The manual measurement of the film and force plate records, and preparation for input to a digital computer took 23 man hours. A considerable improvement over the time required for the University of California studies but still a major obstacle for this sort of study. Paul was able to compare his results with an in vivo test made by Rydell (1966) who used an instrumented femoral head prosthesis. Paul's results showed some agreement with those of Rydell, when compared on a basis of body weight and stride length. Morrison (1967) used the same experimental techniques as Paul to evaluate the forces transmitted by the knee joint. The reasons for these studies were similar to those given by the University of California group.

Grieve (1968) introduced the concept of angle/angle diagrams, in which the angles of rotation about one joint were plotted against those of another joint. This method produced closed loops which Grieve suggested provided consistent and recognisable patterns, illustrating this by showing the changes produced by different walking speeds. Data for these studies was obtained using cine film and because of this time consuming method only 13 subjects were studied. Peizer (1969) used a variety of the available techniques to measure locomotion and also measured oxygen consumption and CO₂ production to assess the physiological energy cost of particular activities. An instrumented pylon, similar to that first used by the University of California (1947), was developed to measure directly the axial load, knee moment, anterior-posterior shear, medial-lateral shear and torque.

movement for normal subjects were presented and qualitative observations of departure from the "normal" patterns were noted in certain pathological cases. Measurements from the recordings were made manually. Kettalkamp et al (1970) followed up Johnston's work with a similar study of the knee using the same goniometer apparatus. In both studies errors arose due to the geometrical offset of the goniometer with respect to the joint centre, and due to the mobility of the soft tissues to which the goniometer was strapped.

Wirta (1970) uses a variety of techniques for his analysis - electrogoniometers, foot switches, myoelectric detectors and twin force plates, together with specialist instrumentation to measure the spatial displacement of the hips. The significant aspect of Wirta's system is his data collection method. The system records the data on magnetic tape which is then processed automatically to provide data in punched card form, suitable for input to a digital computer. However this system still involves many physical attachments to the subject and hence constrains completely free movement, as Figure 1.7 shows. Extensive use is made of a computer, as the key to a data handling system, by Lamoreux (1971). In this system an exoskeleton, Figure 1.8, is used to measure skeletal motion. This apparatus is instrumented with potentiometers as in the more normal electrogonicmeter. Information from instrumentation which measured pelvic displacement and heel contact was also recorded. The collected data was digitised and stored by a computer system and the data was subsequently processed to produce parameters such as flexion-extension at the joints, relative rotation etc. which were presented graphically. All the experiments reported in this paper were based on one test subject.

Assessment of locomotion performance after total joint replacement has been made using a quantitative measuring system by Charnley (1968) and Murray (1972). The system used by Charnley is discussed in a paper by Jacobs et al (1972) in which the waveforms of the vertical components of force, as measured by force plates, are subjected to further analysis. Comparisons are made between normal and pathological gait, and waveforms are classified according to shape. It was claimed that certain mathematical parameters help distinguish one wave from another and also bear a distinct correlation to the diagnostic state of the hip joint. Murray (1972) carried out an analysis on 30 patients



Figure 1.7. Wirta's apparatus to measure hip position during walking. (From Wirta (1970)).



Figure 1.8. Lamoreux's "exoskeleton" in use. (From Lamoreux (1971)).

before and after hip joint replacement. The same measuring system was used as in Murray (1964) for the locomotion studies. The paper concludes by saying "The quantitative values presented in this study provide a basis for comparing the functional performance following major reconstructive procedures on the hip". However it is difficult to see how true comparisons can be made because of the number of variables – the ages of the subjects ranged from 36 to 85, there were large variations in the extent of the pathology, the degree to which other joints were affected, a lack of information about weight and height etc. The improved performance was clearly shown in the results, but a large amount of manual effort was required to obtain the data.

A strain gauged force plate and cine cameras were used by Poulson (1973) to perform a biomechanical analysis of the leg during fast and slow walking, walking up and down a ramp, and up and down stairs. In his studies on the biomechanics of the leg in normal level walking he considered I) muscle force, 2) internal joint force, 3) muscle tension versus length, 4) segment energy levels, 5) joint power and 6) muscle power. The cine film and force plate record were transcribed into a form suitable for input to a digital computer by using an X-Y analyser. This device produces coordinates in punched tape form of the position of a pointer which is placed over the point on the recording to be measured. Even using this labour saving device l_2^1 to 2 hours were still required to transcribe the data for one stride.

A statistical study of the kinematics of normal locomotion was presented in a paper by Winter et al (1974). The data for this two dimensional analysis was collected by a television-computer system. Three walking speeds were analysed over at least 3 strides for each test. Ranges of linear and angular measurements of displacements, velocities and accelerations are shown, and comparisons are made with the studies of Murray (1964) and Lamoreux (1971). These comparisons show agreement between the studies where comparable measurements were made; except in the case of the angular accelerations of the ankle reported by Lamoreux. Winter et al suggest that this difference might be attributed to the different types of footwear used, the instrumentation

worn by Lamoreux' subject and the fact that a treadmill was used. However the last two factors would certainly have affected the other parameters also. Lamoreux used a sampling rate of 200/sec compared with Winters 60/sec; this could also account for the difference in the accelerations measured because Winters' results would have been subjected to a much higher degree of smoothing and hence loss of the high frequency components which would produce the higher accelerations.

1.3 Kinematic Measuring Systems

For the purpose of this review these systems will be grouped under the following general titles: - Photographic, Non-Photographic Optical, Contacting, and Other Techniques.

1.3.1 Photographic Systems

Interrupted Light. This method was introduced by Marcy (1895) and is still in use today. The use made of the technique by Marey and Fischer has already been discussed. Bernstein (1934) made refinements to the technique and used the system extensively, he referred to it as cyclography. Tiny gas filled electric light bulbs were used to mark positions on the test subject, the light from these bulbs to the camera was interrupted by means of a rotating shutter. Bernstein claimed that he could achieve exposure rates of up to 600/sec, although to avoid the recorded light dots from merging with one another, such high exposure rates could only be used when observing purely fast movements. Most of his experiments were made at exposure rates of between 60 and 190/sec., the measurement of shutter speed being accomplished by the determination of a tone emitted by a siren located on the shutter and rotating with it. Later an electromagnetic tuning-fork was used to switch a neon bulb and the speed of the shutter was adjusted until a circle of astericks marked on the shutter appeared motionless when illuminated by the neon. Enlargements were made of the exposed film and during this process a grid of $\frac{1}{2}$ or 1 mm squares was superimposed on the recording. Measurements of the displacements of the recorded points were then taken and used for the analysis. Cyclography is not suitable for the recording of overlapping movements, and to overcome this

deficiency Bernstein introduced kymocyclography i.e. cyclographical exposures on slowly and evenly moving photographic film. A further extension of the technique was the three dimensional recording of movement by placing a mirror at 45° to the main optical axis of the objective and so effectively making a stereoscopic recording. The manual labour involved in obtaining quantitative data from these methods must have been colossal, although Bernstein refers to this part of the procedure as being "easy".

The University of California used the interrupted light technique in their fundamental studies of locomotion as reported by Bresler (1950) and Eberhart (1951). Opthalmic electric bulbs were attached to the subject at estimated joint centres of the leg, on the iliac crest, and on the heel and toe of the shoe. The lights were continuously lit and the subject walked in a darkened room, the field of view of the open camera lens being interrupted 30 times/sec by a rotating disc with an 18° opening. The speed of the disc was made uniform by using a mains synchronised motor to drive it. A Kodatron speed lamp was synchronised with the shutter and fired to catch the subject in midfield for identification. The data was measured from the resulting photograph using a toolmakers' microscope (30X magnification) or d a scale factor. Only data in one plane was obtained using this method and Eberhart stated that the interrupted light technique was "not particularly useful in evaluation of gait".

More recent use of the method has been reported, by Murray (1964, 1967, 1972). Instead of using light sources as markers and a rotating shutter Murray uses reflective markers and a stroboscope flashing at 20 times/sec. Fourteen markers are used to identify various anatomical landmarks on the subject, and an overhead mirror in the field of view of the camera provides a view of lateral displacements of markers on the head, neck, thorax and pelvis. Although only sampling the positions of the points every 0.05 sec Murray (1964), p.294). All interrupted light measurement systems suffer from the problem of manual data reduction. The technique can be quite accurate for movements in one plane, but there are identification problems if movements overlap, and if a point remains more or less stationary (as in the foot during stance phase). Also

if the subject moves out of the defined plane of motion then parallax will occur. The recording of movement in 3 dimensions is not impossible, as Bernstein demonstrated, but it is difficult. Another disadvantage is that subjects are generally required to walk in a darkened room.

Muybridge's serial photographs of human and animal movement Cine. can be said to have pioneered cine photography. Elftman (1939) was one of the earliest users of cine photography to obtain displacement-time data of locomotion, although he only made two-dimensional measurements. The University of California made extensive use of the method and an evaluation of its use is given in Eberhart (1951). In these studies two cameras were used, set up to provide front and side views of a glass walkway (Figure 1.5). The side view camera was also used to provide a bottom view by means of a mirror placed at 45° to the vertical underneath the glass walkway; by this means it was possible to obtain an estimation of the transverse rotation of the leg. An adjustable contact brace was strapped to the pelvis locating on the posterior and anterior iliac spines; anterior and posterior projections were attached to this brace to magnify angular displacements and allow the transverse rotations of the pelvis to be measured. To measure transverse rotations at the ankle, targets were fixed to a "U" shaped bracket holding two small pins. The pins entered the cortices of the bone of the medial and lateral malleoli, after a local anaesthetic had been administered. These projections on the ankle and the pelvis could be seen via the mirror and hence it was possible to measure the transverse rotations. Saggital and lateral displacements were measured from 1" diameter black dots on a white background placed over the joint centres of the limb. To minimise errors due to parallax the cameras were placed forty feet away. Measurements of the target displacements, to an accuracy of $\frac{1}{2}$ ", were taken from each frame of the exposed film; as the cameras were running at a film speed of 48 frames/sec. the manual measurement process took a considerable time. High speed cine, with film speeds of up to 700 frames/sec, was also used during these studies. Filming had to be done outdoors in bright sunlight. No quantitative results are quoted from the high speed cine tests and it appears that only qualitative use was made of the technique.

A much higher degree of accuracy was obtained by Paul (1967) who used cine photography in his studies of the forces at the hip joint. Two Paillard Bolex HI6 reflex 16 mm cameras were used running at a film speed of 50 frames/sec. Synchronous electric motors provided the drive to the cameras and the frame speed was shown to be constant within 0.4% by filming a crystal controlled timing unit. After a test run the film was rewound and than re-exposed to a grid of 5" squares placed in a known position in the field of view. Subsequent measurements were taken from the film using the grid as a reference, optical errors thereby being restricted to those occurring within a 5" square. A high level of illumination was required (8 KW total giving an illumination of 260 foot candles over the measurement area) as the markers used to identify the anatomical landmarks were small $\left(\frac{1}{4}\right)^{n}$ diameter) white paper spots, and exposure times were relatively short for indoor high speed filming (1/125 sec). The camera records were synchronised by firing a flash bulb which was in the field of view of both cameras. Firing of the flash bulb also triggered an event marker which was recorded on a U.V. recorder along with ground reaction forces provided by a force plate. A worst possible phasing error of 18 m S was quoted, and the measurement accuracy of the displacements of the markers was stated to be 0.05" (~1 mm). The measurement of film and force plate records for one test on one subject occupied two operators for approximately 9 hours; preparation and checking of the data for input to a computer took a further 5 hours. Corrections for parallax were made in the subsequent analysis.

In an attempt to remove the manual effort required to analyse cine film Kasvand (1971 & 1972) developed a computer-based system to do the processing. A flying spotscanner under computer control was used to intermigate each frame of the test film. Two digital to analogue converters provided the deflection voltages, from digital x, y coordinates, to position the scanner beam. Once the deflection voltages had been set up the scanner beam was turned on and the autput of the photomultiplier was read with an analogue to digital converter to provide a measurement of the transparency of the film at the point x, y. It was stated that a 35 mm frame can be resolved into 4,000 x 3,000 elements

with this system. During filming the camera was moved along parallel to the subject and to provide the necessary spatial reference 5 parallel digital encoded bars contained between two continuous bars were visible in the background. Anatomical landmarks were indicated by 1" diameter black spots on a white background, the spatial reference bars being 1" wide and also black on a white background, as seen in Figure 1.9. The computer programs used to obtain the displacements from the film provided for operator intervention at any stage. Initially a coarse scan of the first frame was done and the results displayed, the operator then marked off the area of the spatial reference code and selected the spots to be analysed, defining a neighbourhood for each spot, Figure 1.10. Having set up the initial conditions the computer program then reads the reference code and locates the specified spots from frame to frame, providing a continuous on-line display as shown in Figure 1.11. Processing speed for 5 spots in one frame was about 15 sec if no operator interaction was required. EMG signals from 4 major muscle masses were recorded simultaneously on a FM tape recorder together with signals from foot switches which were used to synchronise EMG data and displacement data. No details of the measurement accuracy of this system were given and the difficulties of expanding the system to three dimensional measurement were not discussed. Synchronisation of EMG records and displacement data, by using the foot switch signals, could not be particularly accurate because of difficulties in estimating the corresponding times of heel contact etc. from the displacement data.

An automatic system for transcribing data from cine film has also been developed in the Biomechanics Facility of the Childrens Hospital in Iowa City, U.S.A. (Pepoe (1970)). This system utilises fibre optics to provide a line scan of cine film, and is interfaced to a PDP 12 computer. Three sheets of fibres are used, with 1024 fibres in each sheet. The fibres are arranged in bundles in such a way as to digitally encode the position of a light spot falling on the fibre ends by illuminating an array of phototransistors. The sheets are clamped together and cine film is projected onto the fibre ends. The illuminated phototransistors provide a digital x co-ordinate (to 1 part in 1024) of any light



Figure 1.9. Marker and spatial reference system used by Kasvand (1971).



Figure 1.10. Coarse computer scan with local search areas marked. (Kasvand (1971)).



Figure 1.11. On line computer display of marker trajectories produced by Kasvand's system (Kasvand (1971)).

spots in the film. The y co-ordinate is provided by a shaft encoder which is rotated by the moving film. The shaft encoder increments a counter in the PDP 12 which is reset at the beginning of each cine film frame, providing 750 counts/frame. If two light spots fall in line then the co-ordinates generated by the system will be erroneous. This would prove to be a limitation when markers are placed close together, such as on the foot, or at the pelvis. The film is processed at the rate of 2 frames/sec., which is faster than the flying spot scanner method of Kasvand (1971), but further processing would be required to identify co-ordinates belonging to particular markers.

In a more conventional cine system Sutherland (1972) discusses the discrepancies that can be made in manual measurements of cine film. Comparisons were made of the differences in values computed from measurements, made by two observers, of the same piece of film. The parameters compared were rotation of the pelvis, femur and foot; flexion-extension of the knee; and plantar flexion and dorsiflexion of the ankle. The discrepancies in values were most serious where the total range in the value of the parameter was small. The worst case was pelvic rotation in which there was an average discrepancy of 2.6° (20% of total range) and a maximum discrepancy of 6.3° (48% of total range). The best agreement obtained by two observers was in the measurement of flexion-extension of the knee. Here the average discrepancy was only 5% of the total range and the maximum was 13%. Repeatability of measurements by a single observer was found to be better and resulted in variations of computed parameters of 0° to 2.5°. Sutherland used a Vanguard motion analyser to obtain the displacement measurements from the film; even so it took 2 hours to digitise the data.

Cine systems have played a major part in the most important locomotion studies. However the manual effort required to obtain data from film has been a great obstacle. The number of subjects studied and the number of tests carried out for each subject has been severely limited by this constraint. Semi-automatic systems of film analysis have reduced the data collection time substantially, fully automatic systems are still in the development stage and present problems of synchronisation of film data and other data. If a fully automated system were developed to the point where three dimensional studies

of movement together with data from other sources could be achieved there would still be disadvantages in using cine. Firstly the recorded movement is not immediately available, the film must be developed; secondly in addition to the cost of computer processing time (which will be required for any comprehensive analysis) there will be an appreciable cost in film and film processing; thirdly flying spot scanners for this purpose are not commercially available; and lastly an appreciable amount of computer time would be required for data collection.

The technique of obtaining three dimensional measure-Photogrammetry. ments from two planar recordings of an object has been used extensively in surveying (Halbert (1960)). The method requires that two simultaneous recordings are made of the spatial position of the object. Providing the distance (base) separating the recording devices is known and the focal length (principal distance) of the optical system is also known then the third dimension (usually called depth) can be derived from the two planar measurements. Bernstein (1934) made the first use of the method for studies of human movement; no details of the accuracy obtained were given and his general method has already been discussed. More recently Ayoub (1970) has developed a stereometric system for measuring human motion. A measurement accuracy of 2% was claimed, although to obtain this it was stated that it was necessary to measure the differences in the spatial positions of common points in stereo-pairs (the two planar recordings) to within 0.0004 inch. Stereocomparators can certainly measure to very high accuracies, but it must be remembered that when photographing movements; because of the relatively long exposure times used, there is certain to be a degree of blurring of the image. To use the limits of accuracy of a stereocomparator sharp edges are required. The other measurements involved, base and principal distance, must also be known to a high degree of accuracy, as any errors in these measurements will affect the overall accuracy considerably. Ayoub studied hand and arm movements using stereo-photography and the interrupted light technique to produce multiple exposure stereo-pairs. The type of movement studied is limited for the same reasons as with interrupted light photography and again manual measurement of the results is necessary.

Lippert (1973) used a photogrammetric system to study the mobility of fracture fragments of the tibia. Lippert rejected conventional methods of movement measurement, such as cine photography, because of the "artificial restrictions imposed on the subjects' movement by the measuring apparatus". In Lippert's tests targets were attached above and below the fracture site by stainless steel pins inserted into the bone (through both cortices). A Zeis SMK-40 stereocamera was used and a measurement resolution of 1.0 - 1.5 mm was claimed. The patient was photographed, on the same film, in four positions - one "no load" and three other positions which put various loads on the limb. The tests had to be carried out in a darkened room which, with patients whose movements were restricted by their plaster casts, was inconvenient and occasionally led to targets being knocked. Measurements from the exposures were made manually and 6 personnel were required to run the tests.

Photogrammetric methods can be used to obtain three dimensional displacement-time data for human movement, but very precise alignment of the photographic system is required. Measurements must be made manually using a stereocomparator, which is very costly and could not be justified for exclusive use in these sort of studies. The clinical use suggested by Lippert is not acceptable in terms of the effort required, and the insertion of pins into the bones of patients.

1.3.2 Non Photographic Optical Methods

Methods of this type did not become available until the late 1960's. Obviously television/computer systems could be included under this heading but discussion of such systems will be deferred. Limited studies using non photographic optical systems have been carried out, but so far the studies have been restricted to kinematics (and kinetics where no external forces are involved) and no comprehensive analysis of locomotion has yet been presented. In some cases the systems have only been available for a short time and no doubt the inclusion of other measurements will soon be attempted; in other cases the additional facilities required for measuring other aspects of locomotion have not been available.

Systems using polarised light have been developed by Reed and Reynolds (1969), Grieve (1969) and the University of Loughborough (1973 and Mitchelson (1975)). The techniques used are essentially identical and so a description will be limited to that of the University of Loughborough system. A schematic diagram of the system is shown in Figure 1.12. Light from a D.C. powered light source is polarised by a linearly polarised filter which is rotated. This has the effect of rotating the plane of polarisation through 180°, which happens twice for every revolution of the polarising filter. The polarised light is received by a matched pair of photodiodes connected in opposition to each other. A window of polarising filter is placed over each photodiode with the planes of polarisation at right angles to each other. The effect of this arrangement is that any non-polarised light incident on the photodiode pair is received in equal amounts by each and thus the resulting signals cancel each other. On the other hand polarised light incident to the photocells is first transmitted to one cell and extinguished at the other, and then vice versa as the plane of polarisation of the light source rotates. A sinusoidal voltage is thus produced by this receiver. A reference mark on the rotating filter of the light source is detected by a photocell, a reference pulse being produced every time the mark passes the photocell. The logic of the electronic circuitry is arranged so that a linear voltage ramp is initiated on receipt of the reference pulse, and the ramp is stopped when the sinusoidal signal from the receiver passes through its zero reference voltage in a negative going sense. The final value reached by the voltage ramp is stored in a sample and hold circuit. This voltage represents the angular displacement of the receiver with respect to the light source. Any orientation of the receiver to the light source can be chosen as zero angular displacement by delaying the reference puise by an appropriate time. The output voltage is updated once for every revolution of the light source filter, in the case described 150 times a second. The measured noise level of the angular displacement output was stated to be in the region of 0.3 degrees (in a total range of 180°), and the linearity of the system was quoted as $\stackrel{+}{=}$ 0.1° over the total range. Measurement errors can arise when the receivers undergo two rotations with respect to the plane of polarisation of the



Figure 1.12. Schematic diagram of the Polarised Light Goniometer. (From Mitchelson (1975)).





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light source, in addition to the rotation which is being measured. Mitchelson shows that this can amount to a measurement error of 7^o for two additional rotations of 20^o in planes mutually perpendicular to the plane in which the measured rotation is taking place. Obviously careful positioning of the receivers can keep such errors low for locomotion studies. Analogue outputs of angular velocity can be obtained by appropriate analogue processing of the angular displacement voltage; although the effects of noise must be carefully considered, and preclude the derivation of acceleration in this way.

This technique provides a relatively inexpensive means of obtaining angular displacement data. The disadvantage of the technique is the need to attach the receivers to the body and provide a power source and connecting leads to them. Also only relative measurements are made, the technique does not provide absolute measurements.

A continuous light spot position sensor forms the basis of the commercial SELSPOT system, Lindholm (1974), Selcom (1975). The sensor is basically a large area silicon photo-diode of the Schottky barrier type manufactured by United Detector Technology Inc.. An equivalent circuit of a single axis sensor of this type is shown in Figure 1.14 (from Woltring (1973)). The average position of a light spot imaged on the sensor surface at any instant varies the current in the load resistances. A dual axis version of the sensor provides the two dimensional co-ordinates of the incident light spot. In order to monitor the position of more than one light source time division multiplexing must be used. In the SELSPOT system small light emitting diodes (LED's) are used as the light sources and are placed over anatomical landmarks. The LED's are switched on in turn to give a short pulse of light; the x, y co-ordinates from the detector for each LED being processed by special noise suppressing and linearizing circuits (noise is suppressed by 60 dB and non-linearity is decreased from 60% to 0.5%). The co-ordinates for each LED are then made available as analogue signals on individual output channels. The resolution of the system depends to a large extent on signal to noise ratio in the signal processor and detector, and hence on the incident power of the light source on the detector. For sufficiently large incident power (~ 1 mW) a resolution of 10⁻⁴ (1 in 10,000) is quoted



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Figure 1.14. Equivalent electrical circuit for a single axis continuous light spot position sensor (From Woltring (1973)).

(Woltring (1973)), however currently available LED's cannot produce this sort of incident power at the ranges of interest in locomotion studies. The duration of the incident light pulse also affects the signal to noise ratio due to the time constant of the sensor, so that Laser LED's of high power but rather short duration (200 nS - 1μ S) are not particularly suitable. However a resolution of better than 10^{-3} is claimed with currently available LED's over a range of 6 m within a cube of 3 m sides, at a sampling frequency of over 200 Hz for up to 30 LED's (Selcom (1975)). Three dimensional measurements can be obtained by using two sensors, and there is also the possibility of using extra sensors positioned so as to pick up light sources that may occasionally be obscured to the main sensor. The SELSPOT system has the advantage that output signals are obtained for individual markers and there are therefore no co-ordinate/marker identification problems; also the resolution and sampling frequency specifications of the system are good, provided LED's of sufficient power are available. The disadvantages of this type of system are the necessity for active light sources to be mounted on the body, the need for switching circuits, and the consequent requirement of power supply all of which would have to be attached to the subject if trailing leads are to be avoided. The light sources used only have a narrow solid angle of radiation and hence some kind of lens has to be used with a consequent reduction in radiant power. The mounting of the light sources could prove difficult on some anatomical landmarks (particularly over joints if the light source is strapped onto the subject).

A similar system to SELSPOT, using the same detector, has been reported by Woltring (1974). The positions of three LED's can be sampled at 300 Hzwith this system. However at present the resolution is rather poor - 1 in 400 with the LED I m from the camera, becoming less as the LED is moved further away. This system is still in the experimental stage and it is hoped to improve the resolution by a factor of four for distances up to 3 m.

Another opto-electronic measurement system is being developed by Mitchelson (1974, 1975). This system, called CODA (Cartesian Optoelectronic Dynamic Anthropometer) uses an array of silicon photodetectors in front of which is placed an encoded optical mask, Figure 1.15. Cylindrical optics are used to focus point sources of light into a line image onto this array. The component



Figure 1.15. Optical mask used in "CODA" system. (From Mitchelson (1975)).

of movement of the point source that is at right angles to the orientation of the line image causes a corresponding shift of the line image across the focal plane. The first seven rows of detectors are behind the digitally encoded portion of the optical mask, and a direct digital readout of the position of the line image is thus obtained (7 bits). Further resolution of the position is obtained by using the analogue vernier part of the optical mask. The analogue vernier consists of 4 rows of 64 transparent wedges, the pattern of wedges being advanced by 1/4 of the interval between wedges for each row. As the line image moves across the wedge the amount of light falling onto the photodetectors is linearly proportionate to the position of the image on the wedge. However, the width of the line image may be as much as $\frac{1}{2}$ the base width of a wedge so the linear relationship only holds good in the central half of the wedge. Due to the staggered arrangement of the 4 rows the line image can only fall in the linear part of a wedge on one row at a time. The system can select the row in which there is a linear response, which therefore provides 2 further bits of resolution (I out of 4 rows). The analogue output of the selected row is then digitised and a further 6 bits of resolution is claimed. The seven bits from the digitally encoded portion of the mask together with the two bits from the row selection and the remaining 6 bits obtained from the analogue output gives a total of 15 bits resolution. One bit is lost in order to avoid ambiguous or erroneous matching of the outputs from the digital and analogue parts of the system. Two more bits are lost in the arithmetic processing necessary to derive parallax free three dimensional co-ordinates. A final output resolution for the instrument of 12 bits or 1 part in 40% is the design specification. The broad transparent portion of the optical mask provides a reference signal which allows corrections to be made for fluctuations in the intensity of the light sources.

Three dimensional co-ordinates are obtained by using three cameras. One of the cameras is oriented so that it is sensitive only to the vertical components of displacement; the other two cameras are both oriented to be sensitive to the horizontal components of movement. These two cameras are separated by a known base length and therefore stereo-photography principles can be applied to derive the "depth" component of position. Corrections for the effects of parallax can also be made. As in the SELSPOT system LED's are used to provide the light source, but due to the faster response of the sensors used it has been possible to use the higher power Lazer LED's. Each light source is switched on in turn to give a light flash of approximately 200 nS duration, 90 μ S is then required to derive the co-ordinates of the light source; and so with a total of 10 light sources (morkers) a sampling frequency or repetition rate of 1 KHz can be attained (although Mitchelson appears to be limiting the system to 8 sources).

Mitchelson states that the resolution of the system is limited by the signal to noise ratio at the sensors. With the laser light source 2 m from the camera this is stated to be 33 to 1; which gives an overall resolution of better than 1 in 4,000 (when the resolution of the digital part of the system is also considered). The signal level from the LED at the sensor follows the inverse square law so there is a corresponding decrease in resolution with increasing distance from the camera. Table 1.1 shows the effect of this on the resolving power of the system. The "width of overlap" columns give the amount by which the fields of view of the outside cameras overlap and hence the working dimensions of the system. With this system the subject would walk towards the cameras, so the minimum overlap required to ensure that lateral movements would be observed would be 0.75 m. If the recording of motion is started when the subject is 7 m from the camera then two and possibly three strides would be accommodated, and the resolution would vary from 10 mm to 0.5 mm. At the present stage of development of this system there is a systematic error of I part in 400 due to the imprecision of the vernier (wedge) part of the optical mask. This error is compounded when calculating the parallax free co-ordinates of the light source and Mitchelson (1974) quotes errors in horizontal and vertical co-ordinates of I part in 130, and of I part in 200 for the depth co-ordinate.

The overall accuracy of this system must also depend on the accuracy with which the constants of I) base length between the outside cameras, 2) focal length and 3) width of the focal plane can be set up. These constants are used in the analogue computation of the parallax free co-ordinates and are represented by preset constant voltages or currents. Any inaccuracy in

Distance from camera	Resolution	Field of view of I camera	Overlap for base = .5 m	Overlap for base = m	Resolving power
m		m	m	m	mm
2.0	1:4000	I	0.5	0	0.25
2.5	1:2500	1.25	0.75	0.25	0.5
3.0	1:1800	1.5	1.0	0.5	0.85
3.5	1:1300	1.75	1.25	0.75	1.3
4.0	1:1000	2.0	1.5	1.0	2.0
5.0	1:640	2.5	2.0	1.5	4.0
6.0	1:450	3.0	2.5	2.0	7.0
7.0	1:330	3.5	3.0	2.5	10.0

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setting up these constants will affect the overall accuracy. Pracise alignment of the sensor with the optical system is required, and also the camera must be oriented precisely to the external measurement axis. Mitchelson suggests that improvements in the precision of the optical mask and more efficient diffusion of the light from the laser landmarks will allow the design specification of a resolution of 1 part in 4,000 to be reached.

These optoelectronic methods are mostly still at the development stage. If the design specification of some of them are attained then they will provide powerful measuring systems. However it seems most likely that the range over which movement can be monitored will be restricted by the power and angle of radiation of available light sources. To monitor the movement of more than one light source it is necessary to use active light sources which will obviously require a power supply. Switching of the light sources will require control cables to be attached to the subject, or a telemetry link.

1.3.3 Contacting Methods

The electrogoniometer as used by Karpovich (1959) is Goniometers. a very simple and cheap instrument; basically it consists of a precision potentiometer fixed to a support bracket with the spindle of the potentiometer fixed to another support bracket. Relative motion between the support brackets rotates the potentiometer spindle and hence varies the resistance in direct propertion to the angle between the brackets. By suitably attaching the brackets on either side of a joint relative motion can be measured. Johnston (1969) used goniometers to measure saggital, coronal and transverse rotations about the hip joint; the same device was used by Kettelkamp (1970) to obtain similar measurements about the knee joint. The device consisted simply of a linkage in which the three rotations were individually transmitted to three goniometers; obviously, the measurements obtained were of the rotations of the linkage which is not the exact centre of the joint. Corrections were made for this but errors arising from movement of the goniometer assembly due to relative motion of the soft tissues with respect to the skeleton could not be accounted for.

Lamoreux (1971) designed an exoskeleton which was attached to the lower limb, Figure 1.16. The exoskeleton at the hip provided an external analogue



Figure 1.16. Front and side view of Lamoreux's "exoskeleton". (From Lamoreux (1971)).

of the hip joint which, after careful alignment, could have its effective centre at the centre of the hip joint. The three joints of this analogue were instrumented with potentiometers to measure the relative rotations. Parallelogram linkages were used to measure the relative rotations at the knee and ankle. These linkages will transmit two of the three components of an arbitrary rotation in three dimensions and absorb the third. Lamoreux states that precise alignment of these linkages is not necessary and that the axes of measurement are the axes of the exoskeletal joint between which the parallelogram linkages are attached. To measure the three components of rotation two linkages are required; with Lamoreux's system simultaneous measurement of the three components can be made at the ankle but not at the Measurements obtained via the exoskeleton were made while the subject knee. walked on a treadmill. The physical attachment of the exoskeleton (total weight approx. 6 lbs) and the use of the treadmill, must condition the subject's gait.

A potentiometer instrumented linkage system was used by Kinzel (1972a, 1972b) to measure the total motion between two body segments. His linkage had six degrees of freedom and he could therefore measure the three rotations and three translations which completely describe the motion at a joint. By making separate measurements of the joint surfaces Kinzel was able to study the relative motion between the joint surfaces. The end points of the linkage system were securely mounted on pins which had been inserted into the bone. This system was used to study the scapula-humerus joint in Alsatian dogs, walking on a treadmill. The measurements obtained were able to show the path by which the scapula moves over the humeral head, the percentage of the time spent by the scapula at different locations on the humeral head, and the apparent areas of contact. To apply the system to measurement of human joint motion would require a non-invasive method of attaching the linkage to the subject, and a non-invasive method of measuring the joint surfaces. Both of these requirements would limit the accuracy of measurement considerably.

Tachograph. This is another inexpensive form of instrumentation, which, in its simplest form, consists of a D.C. generator which is driven by a string

attached to the subject. The output voltage of the generator varies with the velocity of the attachment point of the string on the body. Drillis (1958) used the method to record the horizontal velocity of the trunk. Ganguli (1973) claimed that the system was suitable for use in a clinical situation. With his system the string was located in horizontal pulleys which were mounted on shafts extending between floor and ceiling, a bearing being provided at each end of the shaft. Four such pulleys were arranged at the corners of a rectangle with the string in a loop around them. The drive to the D.C. generator was taken from another pulley on one of the shafts. The string was attached to the side of the subject in the region of the iliac crest of the pelvis; the height of the string being adjusted by the position of the pulleys on the shafts. This arrangement would mean that the recorded velocities would be affected by transverse rotations of the pelvis, and would therefore not be a true measure of the motion of the centre of gravity of the subject. Ganguli evaluated the data by taking the ratio of the first period to the second period of the "centre of gravity" curve (the fundamental frequency of this curve being twice that of the gait cycle frequency). He claimed that this ratio would be independent of all factors except the symmetry of gait.

Molen (1972) used similar principles to measure the instantaneous velocity of the centre of gravity of the body. Magnetic tape prerecorded with pulses at a fixed frequency and constant tape speed was attached to the subject at front and rear at the level of the centre of gravity. The tape was then looped round guides and passed over a tape read head; vibration damping was incorporated into this path and the height of the tape read head was adjustable to suit the subject. As the subject moved the output frequency of the prerecorded pulses was proportional to the instantaneous velocity of the tape passing over the read head. A frequency to D.C. converter was used to give a proportional output voltage.

These methods are inexpensive, but the information that they give is very limited. They may show, for instance, an assymmetry in the gait, but it is most unlikely that they will indicate the cause of the assymmetry.

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Accelerometers. The technique of measuring acceleration directly with accelerometers was used during the University of Colifornia's fundamental studies of locomotion. (University of California (1947)). In the report by Eberhart (1951) on the experimental procedures used in these studies, the data provided by accelerometers was stated to be "inferior" to that obtained by using cine film techniques, but this was most likely due to the type of device available at the time. The vertical and fore- and - aft accelerations of the trunk together with the angular accelerations of the shank were measured directly using accelerometers by Gage (1964). Harmonic analyses were made of the resulting data and comparisons were made between normal and amputee gait. The degree of symmetry of gait in the normal was clearly shown by the dominance of the even harmonics; the odd harmonic values in the amputee gait being consistently higher, showing the more pronounced assymmetry of their gait. Gage stated that certain gait defects showed up as specific abnormalities in the harmonic analysis, although combinations of defects were difficult to interpret from the frequency spectra. No attempts to derive velocity and displacement data from the accelerometer recordings were reported by Gage. Accelerometers were used to verify the procedures by which accelerations were derived from displacement/time data by Hunt (1965). Measurements were made from accelerometers mounted on the shank of the subject and the results obtained showed general agreement with data derived from cine film recording.

Smidt (1971) followed up suggestions made by Gage (1964) and studied the effect of "induced" abnormalities – by immobilizing certain joints. He used three orthogonally mounted accelerometers placed on the body close to the centre of gravity. Data was recorded over 4-6 strides and fcot switches were used to determine heel strike, foot flat, and toe off. Again, a Fourier analysis was performed on the acceleration curves of the fore-aft and vertical – the lateral accelerations were not particularly cyclic and hence not suitable for Fourier analysis. Smidt quantified the "smoothness" of the gait by taking the ratio of the sum of the even harmonic coefficients to the sum of the odd harmonic coefficients. A high harmonic ratio indicating a smooth acceleration curve. Smidt stated that the harmonic ratio could discriminate between the "induced" abnormal gaits.

The total movement of the shank (with the one exception of the transverse rotation) was studied by Morris (1973) using five accelerometers mounted on a perspex platform. Morris suggests that the inferior results obtained by earlier investigations using accelerometers was due to the use of unsuitable transducers. Strain-gauge accelerometers which deform elastically due to inertial force were used by Morris and stated to be the most suitable type. The signals from the accelerometers were recorded on a portable tape recorder carried by the subject or passed by a lightweight cable to a fixed recorder. The recorded data was processed on a small digital computer which allowed the use of interactive programmes. The operator selected one cycle of the data by setting cursors on a visual display of the data to mark the beginning and end points. This portion of data was then filtered to remove drift and to set a lower frequency limit to the signal pass band. Further processing obtained angular velocity, direction cosine, translational acceleration, velocity and position data. The system developed by Morris has the advantage that it can be used outside of a specialist laboratory, with little discomfort to the subject who may wear normal clothing. However, the system has so far only been developed for use on the shank. Attaching accelerometers to the thigh, for instance, will be difficult because of tissue movement; the site chosen on the shank was relatively free of such problems.

The use of accelerometers always requires some kind of physical attachment to the subject, and some kind of link to a recording device. Studies have been limited to one or two segments, and no investigator has attempted to incorporate ground reaction into the analysis, as far as is known.

1.3.4. Other Techniques, schaft and ender the Armanu,

Cine radiographic techniques have been suggested as a method of gait analysis (Eberhart (1951)). The equipment necessary is not only costly but it is also limited in its scope. The depth of field is restricted, and the width of the field of view is somewhat narrow. The only recorded use of such equipment for locomotion analysis is by Jenkins (1972); however, this study was of the

gait of chimpanzees. Recordings of the gait were made at 50 frames per second while the animal walked on a treadmill. The field of view was only 25.4 cm, which meant that the separate sequences had to be recorded for each joint. The data was quantified by measuring joint angles from the film, and the results were compared with the gait of man. The use of cine radiographic equipment is probably not worthwhile, because of the above mentioned restrictions and because manual reduction of the data is still required. It may, however, be useful to obtain data of the movement of marked positions on the skin with respect to anatomical skeletal landmarks.

A novel technique to measure the velocity of a point on the body was developed by Nadler (1958). A sound source (at 20 KHz) was attached to the point on the body to be measured and three microphones with their directional axes orthogonal were set up to receive the sound. Because of the Doppler effect the frequency of the sound received by the stationary microphones varied proportionally to the velocity of the sound source. This frequency variation was measured and hence the instantaneous velocity of the source would be described in three-dimensions by the signals from the microphones. More than one sound source could be used by choosing different source frequencies. The method has been used to study hand motion (Kattan (1969)), but has, so far, not been used for locomotion analysis. There are problems in using the technique because of reflections of the sound from the surroundings, and shielding of the sound by the body.

1.4 Television Systems

Several systems based on television, for the measurement of movement, have been independently developed. All of the systems use the same basic principle to obtain the spatial co-ordinates in one plane of a detectable point or area within the field of view of the camera. This principle is that one co-ordinate may be obtained by reference to the television rastor line on which the point is detected and the other co-ordinate may be obtained from its position on this line. Sampling of the position of a detectable point in time is obtained by the sequential scanning action of the television camera.

Furnee (1967) reported the development of a television-computer system to measure arm movements. A detailed description of the method may be found in Steilberg (1968), a review will be given here. The television standards used were the 625 line, 50 fields/sec British system (for more information on television standards see appendix Al). A 3.995 MHz crystal controlled clock was used to count intervals along a line giving, in 64 μ S, 256 intervals. 8 μ S of this was taken up by the line flyback period which meant that the active line time was divided into 226 intervals (the x-co-ordinate counter). For the y-co-ordinate an 8 bit counter was used which allowed 256 scanning lines to be counted, the remaining scanning lines were blanked off. Small electric lamps were used to pinpoint landmarks on the arm, the normal scene illumination and the camera settings were adjusted so that the light from the lamps gave the highest level in the video signal. A simple threshold detector was used which was set to give a constant duration output pulse whenever the video signal reached the level caused by the lamps. On receipt of this pulse the contents of the x and y counters were instantaneously stored in a buffer register. As the light from the lamp covered more than one TV line it was arranged that only the detector pulse received on the first line would cause readout of the counter contents. In the version of the system reported by Steilberg (1968) the co-ordinates contained in the buffer register were immediately transferred to the computer memory on a cycle stealing basis, during this transfer period no further marker co-ordinates could be registered. However as the system used a direct memory access method to transfer the data this period would have been of the order of microseconds (i.e. very much less than the duration of one line - probably about 4 μ S). Later versions of the system incorporated a 16 word buffer memory for each co-ordinate, and the contents of this memory were transferred to the computer or to a digital tape recorder during the field blanking period (Ingen Schenau (1973)). The sequential scanning action of a television camera means that the positions of the lamps are not all sampled at the same instant. To provide simultaneous sampling of the lamp positions the Dutch group introduced a synchronous shutter into the system, Ingen Schenau (1973) and Stokrom (1973).

This shutter rotated 50 times/sec and a window in the shutter exposed the field of view to the television camera for 2 mS; synchronising circuits ensured that the exposure was made during the field blanking period. The light pattern stored on the camera signal plate was then scanned in the normal way.

Methods for identifying the lamps from the co-ordinates are discussed in Ingen Schenau (1973); also various computer programs to filter the resulting data are presented. Non-linearities due to the camera are corrected by formula, found experimentally – the linearity of y was shown to be independent of the linearity of x. Scaling of the data was done by reference to the co-ordinates (corrected for non-linearity) of 3 points arranged in a triangle. The number of lamps that could be used to mark anatomical landmarks was limited to 5 (in the buffer memory version some locations must be reserved for pick up of spurious signals). So far only one camera has been used, so only movements in two dimensions have been studied. Most of the work done by the Dutch group has been in the study of arm movements, Stokrom (1973), Ingen Schenau (1973). Some locomotion studies have been made, but the results have not been reported, other than on the locomotion of cats, Furnee (1974). No attempt has so far been made to incorporate measurements of external forces.

A television system to measure three dimensional co-ordinates was developed by Waas (1969). Two television cameras were used to provide two planar views of electric lamps placed on anatomical landmarks of the subject. Up to 4 lamps could be used and it was necessary to place them in positions where they would always be in view of the two orthogonally positioned cameras. Digital counters were used to provide the co-ordinates, similar to the Dutch system. On detection of a lamp signal in the video the contents of the co-ordinate counters were read out and stored on magnetic tape. This transfer operation lasted for 9 full scan lines (570 μ S) and no further detection of marker signals could take place during this time. The system was designed so that the second camera only gave one co-ordinates to magnetic tape placed a severe restriction on the system. Markers had to be arranged so that at no time in the gait cycle did they come within 9 scan lines of each other. It is understood that this system is no longer in use.

A computer interface for television has been developed by Dinn (1970). This is a general purpose digital system which performs an analogue to digital conversion of the television video signal. The standard American television system is used (525 lines, 60 fields/sec.) and the sampled area of each field can be varied from a single point up to a 256 x 256 window, with the height and width of the window independently variable. The system could be set to sample every television line or every 2nd, 3rd, 5th, 8th or 12th line, with corresponding sampling intervals along the line. The amplitude quantisation of the video signal conversion could be set to 1, 2, 3, 4 or 5 bits (i.e. 2-32 levels of brightness). The interface could also be set up to sample every television field, every second field etc. up to every 64th field. The word length of the resulting digital data was also variable and could be set to 12, 16, 20, 24 or 32 bits, which gives a wide range of compatibility for different computers. The object of this system was to provide a general purpose facility which could convert television images into a digital equivalent which could then be processed by a digital computer.

Extensive use of this interface has been made in studies of human locomotion at Shriners Hospital for crippled children in Winnipeg. The experimental set up is described in Winter (1972), and shown in Figure 1.17. The interface is set to give one bit amplitude resolution (i.e. either bright or dark) and a sampling matrix of 96 points by 96 points for each field. Comparatively large reflective markers are used to indicate various landmarks on the limb. Winter shows that by using such large markers a more accurate estimation of the spatial co-ordinates of the centre of the marker can be made - a minimum of 10 sample points lie within the marker area of the video signal, and a spatial resolution of 1 mm is quoted. In order to use the comparatively coarse sample matrix it is necessary that the field of view of the camera only covers a small area. This restriction in turn makes it necessary to "track" the subject with the camera. An operator pushes the trolley mounted camera along a rail keeping the walking subject in view of the camera at all times. The spatial reference of the



Figure 1.17. Experimental set up of the television system in use in Winnipeg. (From Winter (1972)).

instantaneous camera position is obtained from large markers placed at known intervals in the background, one such marker always being within sight of the camera. These background markers are larger than the body markers and so can be identified in the resulting digital data. Even the restricted sample matrix of 96 x 96 for each television field results in a very high data rate of over 20,000 words/sec (assuming that the one bit analogue conversion is packed into 24 bit words for transfer to the computer). Consequently fairly large computers have to be used, in the Winnipeg case a CDC 1700. The television signal is recorded on a video tape recorder for late: digital conversion, after conversion computer programs calculate the absolute co-ordinates of the centre of the body markers with reference to the background markers. Corrections being made for the parallax error introduced by the position of the background markers being some distance behind the plane of wolking.

A kinematic study of normal locomotion using this system is presented in Winter (1974). From co-ordinate data for 3 to 4 strides fundamental kinematic information was calculated including – x, y trajectory plots, plots of vertical co-ordinate against time, velocities of markers, acceleration, joint angles and angular velocities and accelerations. The comparative ease with which the data for these calculations was collected demonstrates the power of the Winnipeg system. However at this stage only two-dimensional measurements can be made and the problems of introducing an additional camera to the system have yet to be overcome. No rotating shutter is used in the system. The reason for this being that in normal locomotion the vertical position of the markers only varies over a small part of the television scan and therefore the time between samples is virtually constant. Of course there is a lag between the sample instant for a marker at the top of the scan and a marker at the bottom of the scan; but this could be corrected as the time relationship between the two positions is fixed by the scanning rate, which is known.

On line use of a PDP 11/10 mini-computer was made by Cheng (1974) to obtain co-ordinates of markers from a television camera. This system is quite similar, in some ways, to the Dutch system. 8 bit counters are used for the horizontal and vertical co-ordinates. The horizontal counter is clocked at a frequency of 4.55 MHz, and reset by the line blanking pulses (using the American standard television system), which gives 241 horizontal intervals. The vertical counter is clocked by the line blanking pulses and reset by field blanking pulses, giving a count of up to 246. A simple threshold circuit is used to detect the presence of a marker signal in the video (either reflective markers or light sources are used), and on receipt of a marker pulse the contents of the horizontal and vertical counter are stored in a buffer register. At the same time a program detectable flag is set so that the contents of the buffer may be transferred under program control to the computer memory. On transfer the computer checks the data to see if it is "noise" (caused by the interface at the beginning of each field). If the data is not "noise" then it is compared with previous data to see if it is caused by a marker being detected on several lines. If the data is a new set of co-ordinates then it is stored for later output onto paper tape. Another program detectable flag indicates the end of a television field. During this programmed transfer and evaluation the interface is prevented from detecting further markers. The computer program written to process the interface data would, in the worst case, inhibit further co-ordinate generation for 117 μ S (best case time would be 74 μ S). This limits the system to detecting a maximum of one marker on any line, which effectively prevents markers being placed at the same vertical position on the body (such as markes on the pelvis for the frontal view). This could be improved, by resetting the "ready" flag immediately after the interface data has been stored, to a worst case time of 34 μ S (best case 25 μ S). However this is still an unacceptable limitation (greater than half of the television line would have been scanned in this time). No corrections are made for non linearity of the camera system and, because the system only operates in two-dimensions, corrections cannot be made for parallax errors.

All of the systems reported, and still in use, can collect data for twodimensional movements. At present none of the systems are operating in three-dimensions, and only the Winnipeg system incorporates other measuring facilities (EMG data). The Winnipeg system requires that the camera is moved with the subject, but this does give fairly high resolution. However a fairly large computer is required to derive the basic data, and it is unlikely that results could be viewed in the laboratory within a short time of the test. The results from Winnipeg have indicated the feasibility of using television to obtain useful displacement/time data. The Dutch system and that of Cheng have very much lower data rates but they do not make full use of the available resolution of a television camera; and the methods of data transfer to bulk storage limit the marker configuration that can be used.

CHAPTER 2

POSITION DETECTION OF THE BODY SEGMENTS

IN SPACE USING TELEVISION

- 2.1 Introduction
- 2.2 Detection of the Segment
- 2.3 Markers
 - 2.3.1 Response of Retro-Reflective Tape

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- 2.3.2 Size of Marker
- 2.3.3 Marker Shape
- 2.3.4 Marker Discrimination

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2.1 Introduction

The television camera is a sequential scanning device which converts a light pattern focussed onto a target plate into an analogue electrical signal the amplitude of which is proportional to the amount of light falling on the target. The time co-ordinate of this waveform is related to position on the target. With the British 625 line system the target is scanned from top to bottom by 292 lines every 20 mS; as a line is scanned the charge pattern on the target, corresponding to the light pattern, is substantially removed and a fresh charge pattern may be built up. The charge pattern will be retained on the target for some time until it is scanned. Unless some means of controlling the exposure of the camera target is used the trajectory, between samples, of a movement will be stored on the target (smear effect). This exposure may be controlled by using a rotating synchronous shutter (Ingen Schenau (1973)); although it is quite possible to compute the average position of a moving point between sample instants from the trajectory and dispense with the need for exposure control. The resolution of the television camera is I part in 292 in the vertical scan and I part in 1000 in the horizontal scan. The spatial resolution is, therefore, 0.34% and 0.1%. The sampling frequency of British television systems is 50 Hz; which, according to Winter's studies (Winter (1974)), should be sufficient for locomotion studies. The basic principles and parameters of television are further discussed in Appendix Al.

2.2 Detection of the Segment

For the purposes of locomotion analysis it is necessary to find the spatial co-ordinates of defined points on the skeleton. This requirement precludes the possibility of detecting the outline of a limb and then deriving the co-ordinates of that part of the skeleton. The outline of the limb has a certain degree of mobility with respect to the skeleton; also it would have to be assumed that the bone was placed centrally in the limb tissues so that rotation of the limb had no effect on the relative position of the bone and outline as the television camera is a two dimensional detector. A further objection to this method is the high data rate that would be required to define the outline. With the television camera field of view concentrated on, say, one lower limb a data

rate in excess of 30,000 words/sec. would be required. It would not be possible to measure rotations of the limb and there would be problems in detecting the outline when other body parts formed the background. Although the method is attractive in that it would require no attachments of any sort on the subject, it is impractical for the reasons outlined above. Methods of marking anatomical landmarks were, therefore, considered.

2.3 Markers

Anatomical landmarks may be indicated with active or passive light sources. Light emitting diodes (LED's) have been used as light sources in various opto-electronic systems (Selcom (1975), Mitchelson (1974), Cheng (1974)). With this type of source it is necessary to use a diffuser over the source in order to obtain radiation of light in as wide a solid angle as possible, because the LED normally has its maximum intensity of radiation in one main direction. Without a diffuser it would be necessary for the source to be always pointing at the camera, clearly this condition could not be met when marking a point on the limb, due to rotations. Using a diffuser reduces the already restricted optical power of the LED. Peak power can only be obtained when the LED is pulsed - up to a point the shorter the duration of the pulse, and the lower the repetition rate (duty cycle), the higher the optical power that can be obtained. To be able to detect short duration light pulses a camera target having a fast response would have to be used, which is costly. The highest power, currently available, LED's emit light in the infrared region; this has the advantage that the light is not visible and will, therefore, not distract the subject. Also ambient Illumination which does not emit in the infrared region can be arranged (Fluorescent lighting for example,) and optical filters may be used to ensure that peak signals from the camera target are only caused by infrared sources, and the game of the second

incandescent light bulbs can provide much higher intensity levels, with a much greater solid angle of radiation than LED's; but they tend to be bulkier and, of course, the light is visible and may distract the subject. All active light sources require a power supply. This may be provided by small individual batteries for each source, or a central power supply carried by the subject. If the higher power of LED's, obtained by pulsing them, is to be used then a pulsing circuit and a means of synchronisation with the television scan would be required. Inevitably, with active light sources, there will be connecting leads and also some reasonably firm method of fixing the source to the skin would be required.

Passive markers require no power supply or connecting leads, and are easily attached to the skin, with no restriction of the subject's movements. Several materials were considered from which to form markers, these included polished metallic surfaces, white paper, retro-reflective tape and coloured versions of these. The materials were compared by placing 5 mm diameter samples of each onto a plywood board (which effectively simulated skin tones) and observing the level of the video signal caused by each under the same lighting conditions. Retro-reflective tape gave by far the best response and was selected as the most suitable marker material.

2.3.1 Response of Retro-Reflective Tape

The retro-reflective tape used was 3 M's "Scotchlite" (see Appendix A4 for characteristics). This material is a plastic sheeting containing extremely small spherical glass lenses which are uniformly bonded at their equators. The optical glass lenses function as microscopic spherical mirrors which focus and return (retro-reflect) incoming light rays directly back to the light source. The sheeting has a pressure sensitive adhesive on the reverse side which is covered with a removable paper liner. To obtain the maximum response from this material, in the television video signal, the lighting must be positioned as close as possible to the camera lens.

With two Malham SE 23 lamps fitted with tungsten halogen 500W bulbs, one on each side of the camera lens, and a camera field of view of 2.5 m the following results were obtained:- 1) the video level of the marker was 90% higher than the level of skin tones 2) the level of signal was within 5% of its peak over the entire field of view 3) rotations of the marker of up to 30° resulted in a change of video level of no more than 5%. These results were

obtained using a marker of 5 mm diameter and a television camera with a plumbicon tube. Normal room lighting was left on during these tests as it was considered undesirable to use markers which would require low levels of background illumination.

On the basis of these results it was decided that passive markers of retroreflective tape would be used instead of active light sources, thereby eliminating the need for power supplies and connecting wires on the subject.

2.3.2 Size of Marker

The size of marker will depend on the type of system evolved. However the minimum size of marker is defined by the television camera parameters and the dimensions of the field of view. To be sure that the marker is detected in the video signal it must be large enough to cover at least two scan lines sufficiently to provide a detectable signal on each. The diameter, D, of a marker to meet these requirements is given by:-

$$D = \sqrt{(W.Hr)^2 + (H.Vr)^2}$$

where Hr = horizontal resolution of camera

Vr = vertical resolution of camera

- W = width of field of view covered by horizontal scan
- = height of field of view covered by vertical scan. H

For a television camera with a horizontal resolution of 1 in 1,000, and a vertical resolution of 1 in 292 covering a field of view of 2.5 m x 1.8 m a marker diameter of 7 mm would be required. A smaller marker could still be detected, although it would not give as high a signal level.

2.3.3 Marker Shape

The basic shape of a marker which is used to indicate a point on the body should be circular, so that permitted changes in orientation of the marker with respect to the camera axes do not change its effective shape. If it is desired to detect the same marker at two cameras whose axes are at right angles to each other (as in the case for 3-dimensional measurements) then the

marker should be spherical.

2.3.4 Marker Discrimination

The response obtained from retro-reflective tape is so good that all that is required to detect a marker signal in the video is a simple threshold detector. However an alternative method was considered which could be worth using in a "noisy" situation. This method uses patterned markers and a hardware pattern recognition system (Jarrett (1973)). A very simple pattern recognition system for the marker of Figure 2.1a is shown in Figure 2.1c. When the video waveform, shown in Figure 2.1b, reaches a lower threshold level an enabling pulse of duration T sec is triggered off, if at any time during this period the upper threshold limit is crossed the "marker detected" pulse is generated, as shown in the timing diagram of Figure 2.1d. This idea can be extended to more complicated patterns, which would reduce the risk of a pattern being generated by noise and also would eliminate the "smearing" effect of the television convera. An example of this is shown in Figure 2.2. This design of marker would eliminate the smear effect because the pattern would only be picked up at the end of the marker trajectory during each sample period.

In the laboratory conditions used it was not found necessary to resort to patiern recognition techniques for marker discrimination. A simple threshold detector as shown in Figure 2.3 was used and found to be reliable. A more sophisticated threshold detector which automatically adjusted its comparison threshold to be a certain proportion of the peak signal received was developed from a basic design by Texas Instruments (1974) by B. Andrews. The basic principle of operation for this detector is shown in Figure 2.4. The advantage of this type of threshold detector is that any variation in signal level from the marker is automatically compensated for. The circuit for this detector is shown in Figure 2.5.



Figure 2.1a Patterned marker.



Figure 2.1b. Video signal produced by marker.



Figure 2.1c. Hardware pattern recognition system for the marker shown above.

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Figure 2.1d Video waveform of patterned marker and timing diagram for the logic of Figure 2.1c.

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Figure 2.2. Pattern recognition system to eliminate "smear effect" of the television camera. The patterned marker and its video waveform are shown together with the decoding logic and a timing diagram.



Figure 2.4. Video digitising circuit with automatic trigger level (From Texas Instruments (1974)).



Figure 2.3. Threshold detector circuit used for marker detection.



Figure 2.5. Circuit for the scheme shown in Figure 2.4 (developed by B. Andrews (1976)).

CHAPTER 3

THE INTERFACE

3.1	Introduction
3.2	Analogue System
3.3	Digital System
3.3.1	Data Transfer
3.3.2	Co-ordinate Generator (CG)
3.3.3	Sync Generator and Simulator (SGS)
3.3.4	Address Register (AR)
3.3.5	Calibration (CAL)
3.3.6	Computer Instructions (INSI and INS2)

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3.1 Introduction

The currently functioning television/computer systems for locomotion analysis are all limited in several respects. This interface was designed to overcome most of these limitations and provide a certain degree of flexibility in its mode of operation. The acquisition of kinematic data is but one of the requirements for locomotion analysis. In a few cases it may be the only requirement, however a complete analysis would include measurements of other parameters, such as external forces.

The requirements to be met by the interface were as follows:- 1) to be capable of measurement in three dimensions; 2) the ability to provide the co-ordinates of more than one marker on any single television scan line; 3) that the number of co-ordinates collected during one television field is limited by the computer and other considerations, not by the interface; 4) to allow extension of the system without loss of performance; 5) to provide a system of calibration; 6) to allow simultaneous and synchronous operation with other data acquisition systems; 7) to be simple to operate and maintain.

Any system which uses a small computer, such as a PDP 12, must have a restricted data rate. The method used by Winter (1972), in which the whole video signal is converted into a digital equivalent and stored, is not practicable. However it is not necessary to restrict the data rate so much that only a very limited number of co-ordinates can be collected in each television field. In the following systems the data rate is restricted by only generating co-ordinates when a marker signal is detected in the video.

Frequent reference will be made in this section to the basic terms and parameters of television systems, further explanation of these will be found in Appendix A1. Similarly where reference is made to the PDP 12 computer further details will be found in Appendix A2.

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3.2 Analogue System

Initially an analogue method of interfacing the television cameras to the computer was considered (Jarrett (1973)). With this system detection of a marker pulse in the video signal caused the computer to sample two ramp voltages, the ramps being initiated by the line and field synchronising pulses of the television scan. The voltages sampled by the computer corresponded to the co-ordinates of the marker and were digitised and stored. A three dimensional system was proposed in which the video signal from the second camera was mixed with that from the first. The fields of view of the two cameras were arranged so that the side view camera observed the lower limb in the bottom half of its scan, and the front view camera (turned on its side) observed the lower limb in the top half of its scan. The relevant parts of the video signals containing co-ordinate information were then mixed to provide one composite video signal as shown in Figure 3.1. A block diagram of this system is shown in Figure 3.2, and it can be seen that this was a very simple method which required only three inputs to the PDP 12.

The advantages of this system were that it was extremely simple and could probably be used on different computers with little or no modification, and that it was possible to record three dimensional tests on a single video channel, allowing off line experiments to be conducted. The disadvantages far outweighed these merits in that the co-ordinates of only one marker on each television line could be acquired; the resolution was very limited; the system could not be expanded to cover several strides or the whole body without a further loss in resolution; ramp generators of high stability and linearity were required; and the potential data acquisition capabilities of the PDP 12 were wasted. Some of these limitations could undoubtedly have been overcome (using several sample and hold circuits, for instance, to immediately store the value of ramp voltages on detection of marker pulses), but investigations into a digital system (Jarrett (1973)) showed that it was possible to provide a much more powerful and flexible system in this way.

3.3 Digital System

The design of a digital system to meet the requirements listed at the beginning of this chapter requires that the performance capabilities of both television cameras and the computer are used to the full. One crucially important aspect is the means of data transfer between interface and computer.



Figure 3.1. Division of television field for 3-D analogue system. Two camera video outputs are mixed as shown.



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Figure 3.2. Three dimensional analogue system.

Other aspects that must be considered are the use of more than one camera to obtain three dimensional data, future extension of the system, simultaneous operation with other systems, control of the interface, calibration, and maintenance. By taking all these aspects into consideration at the design stage it should be possible to arrive at a near optimum solution with the minimum of compromise.

3.3.1 Data Transfer

There are two basic methods by which digital data can be transferred to the PDP 12. The first method, "programmed data transfer", requires that a flag is set in the interface when there is data ready to be transferred, a computer program senses this condition and transfers the data word from the interface to the Accumulator. The program must then store the data in memory, decide if any more data can be transferred, and clear the flag. This process is illustrated in Figure 3.3 with the time taken for each step shown in brackets, a total time of 19.05 μ S being required to transfer each word. The operation could be speeded up slightly if a block of data was transferred each time, even so it would still take about 15 μ S per word.

The second method uses the direct memory access facility of the PDP 12 -"Data Break". With this method data transfers to the computer are made under the control of the interface. When the interface is ready to transfer data a "break request" is made, the computer completes the current cycle and then enters the "break state". Once in the "break state" the interface has complete control and may transfer data from or to memory until the "break request" is cleared. Two types of data break are available ~ single cycle and three cycle. These modes are explained in detail in Appendix A2, but their basic characteristics will be stated here. Three cycle data break requires 4.8 μ S to transfer each word; the address in memory to which the data is to be transferred, and a count of the number of data words is provided by two sequential locations in memory (current address and word count registers). These locations are set to some initial value by the computer program, the interface simply provides the address (hard wired) of the first of these locations together



Figure 3.3. Programmed data transfer.

with the data word to be transferred. When data transfers are made the word count and current address registers are automatically incremented, overflow of the word count register indicating that all the data has been transferred. With single cycle data break the current address and word count functions are provided by the interface and only 1.6 μ S is required to transfer each word. All of these data transfer methods can be used to transfer data in either direction.

The fastest of these methods still takes 1.6 μ S to transfer each word, in addition to the time required to answer the break request (latency time; which could be anything up to 18.2 μ S, but more usually around 1.6 μ S). To transfer a vertical and a horizontal co-ordinate, therefore, will take 4.8 μ S, which is approximately 10% of the active line time of the horizontal scan. In terms of distance, if a field of view of 2.5 m horizontal length were being covered, this would mean that co-ordinates could not be generated for markers which were closer than 25 cm and appeared on the same television line. If a second camera were being used then only markers separated by at least 4.8 μ S scan time could be recorded. For some marker configurations this limitation is of little consequence, however if it is required to mark several points which lie close together (such as on the foot) then the limitation is unacceptable. This problem can be overcome, quite simply, by using a data buffer in the interface. As markers are detected their co-ordinates are immediately transferred to the buffer memory; allowing for the delays of the necessary control logic this operation may be completed in 100 nS or less, or 0.2% of the active line time (a distance of 0.5 cm in the above example).

The use of a buffer memory in the interface will still place some restrictions on data acquisition. However, these restrictions may be minimised by making the correct choice of data transfer time to load the buffer into computer memory. Three possible times are available for this operation. The first possibility requires the use of a double buffer memory – as one is being filled, the other is being unloaded into computer memory. The additional complexity and expense of a double buffer was considered to be unnecessary when the other methods were appraised. The second method uses the field blanking period, when there is no picture information, to transfer data. This period lasts for approximately 1.2 mS and therefore 750 words of data could be transferred using single cycle data break (250 using three cycle data break). It would be unwieldy as well as expensive to provide a buffer memory of such capacity in the interface, whereas a buffer size of, say, 50 words is practical but something of a compromise. The third, and chosen, time for data transfer is the line blanking period, which lasts for 12 μ S. If single cycle data break is used then up to 7 words of data could be transferred within this period. Transfers could be made on every active line so a total of 2000 words could be transferred during any single television field.

3.3.2 Co-ordinate Generator (CG)

A block diagram of the basic co-ordinate generator system is shown in Figure 3.4. The crystal controlled sync generator provides a composite sync to control the camera scan. Line syncs increment a vertical counter which is reset by a field sync. To take account of the effect of interlaced scanning (see Appendix AI), and also to indicate the transition from one television field to the next, the vertical counter counts over two fields i.e. up to 625. This is done by only resetting the counter on every other field sync. A horizontal counter is incremented by a high frequency clock (20 MHz), and counts approximately 1000 intervals along the television line before being reset by the line sync. When a marker is detected in the video signal a marker pulse is generated which causes the latch to immediately read the current contents of the horizontal counter. This horizontal co-ordinate is then transferred to the buffer memory and the system is then ready to repeat this process if necessary – total time ~ 100 n S. The horizontal co-ordinates of up to 5 markers can be stored in the buffer memory. At the end of the television line the contents of the vertical counter (i.e. the vertical co-ordinate) are transferred through the horizontal counter and the latch into the buffer memory. A "break request" is made and the contents of the buffer memory are transferred to the core memory of the PDP 12 during the line blank period. The interface is ready to repeat this procedure, if markers are detected, on the next line.



The vertical and horizontal co-ordinates require a 10 bit word for binary representation. The word length of the PDP 12 is 12 bits, thus two bits are available for coding purposes (4 separate codes). As the number of horizontal co-ordinates collected during any one line are variable (up to 5) it is necessary to use one code to identify the vertical co-ordinate. The three remaining codes could be used to indicate three cameras. This would be adequate for the three dimensional requirement, but to allow future expansion of the system it was considered desirable to provide codes for up to six cameras. To do this a 3 bit code is required. The block diagram of Figure 3.5 illustrates how the system, with coding, operates. The 6 marker detector outputs are fed into a 6 to 3 coder and priority register. When a marker is detected in a video signal a marker pulse is generated by the appropriate marker detector and the priority register provides a pulse which causes the contents of the horizontal counter to be read by the latch, as before. The coder provides a 3 bit code to indicate which of the 6 marker detectors provided the marker pulse. In the event that two or more marker pulses are generated at the same instant the priority register allocates priority to one of them and only provides one output pulse and the appropriate code. The two most significant bits of the code are loaded into the buffer memory along with the horizontal co-ordinate. The third bit of the code is clocked into an 8 bit shift register. As before the vertical co-ordinate is loaded into the buffer memory, along with its code, at the end of the line; and then the collected data is transferred, via data break, to the core memory of the PDP 12. This time, however, when all the horizontal and vertical co-ordinate data for the line has been transferred from the buffer memory the shift register word is then transferred. The allocation of codes is shown in Figure 3.6, and it can be seen that the vertical co-ordinate is unique and independent of the third bit. Data is always transferred to computer memory in the same order, that is the vertical co-ordinate followed by up to five horizontal co-ordinates and lastly the shift register word. It is then a simple matter for the program to reconstruct the appropriate codes, and hence define the cameras from which a particular co-ordinate came.





	Code bits	Allocation	
ø	1	SR	
ø	ø	ø	MD 0
ø	ø	I	MDI
ø		ø	MD 2
ø	1	1	MD 3
1	ø	ø	MD 4
	ø	1	MD 5
	1	ø	VC
	1 . 1	1	VC





Figure 3.6. Allocation of codes and position of code bits in data.

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With the data break method it is possible to run a program independently of data transfer (with due regard to areas of memory used for program and data transfer). As a maximum of 7 words are transferred during any one television line, and as data is only generated when a marker is detected, there is a considerable amount of time available for running programs. Some of this time can be used for collecting data, via the analogue to digital conversion facility, from other measurement systems such as a force plate. This data collection must be synchronised with the television system and the interface provides synchronising pulses for this purpose. To avoid the restriction of having to start data acquisition simultaneously a means is provided for indicating when additional measurements are started. This is done by using the spare bits in the shift register word (total 12 bits when transferred to the PDP 12). With this word the most significant bit is permanently set to '0' to avoid ambiguity with the vertical co-ordinate code. As the system is restricted to 5 horizontal co-ordinates on any one line then 6 bits of the shift register word are available for additional coding. When data collection from some other measurement system is started one of these bits is set to a 'l'. As the shift register word is transmitted with every set of co-ordinates the exact starting point of this other data collection is stored. An example of a set of data is shown in Figure 3.7, together with the translation of the codes.

For its operation the co-ordinate generator requires a set of synchronising pulses, a means of responding to computer software and the control facilities for single cycle data break transfers. A calibration system is required, and to simplify testing and fault finding it was considered desirable to provide a simulator. A block diagram of the total system is shown in Figure 3.8.

3.3.3 Sync Generator and Simulator (SGS)

The SGS derives from the television line and field sync inputs six related synchronisation pulses which are required at various points in the system. These are:-

location	ø	1		2	3	4	5	6	7	8	9	10	11	Octul value of bits 2–11
0	1	1	vc	ø	ø	ø	1	ø	1	1	ø	1	ø	ø132
1	ø	ø	нс	1	ø	1	1	ø	ø	ø	1	1	ø	13ø6
2	ø	ø	нс	ø	1	1	ø	1	ø	ø	ø	1	1	Ø643
3	ø	1	нс	ø	1	1	ø	ø	1	1	1	1	1	Ø637
4	ø	ø	нс	ø	ø	1	ø	ø	ø	I	ø	1	ø	ø212
5	ø	ø	SR	1	ø	ø	ø	ø	ø	ø	1	ø	1	Third code bits
6	lt	1	vc	ø	ø	ø	1	ø	1	1	ø	1	1	ØI33

Data as received from the interface. Bit 2 of the shift register (SR) word being set indicates that an external event has occurred.

and the second s			.	
locati	ion Ø		SR (bit)	Code
ø	I	1	X	VC
1.	ø	ø	1(11)	Camera I
2	ø	ø	Ø(1Ø)	Camera Ø
3	ø	1	1(9)	Camera 3
4	ø	ø	Ø(8)	Camera Ø
6			×	

Three bits codes for each HC. X =irrelevant.

Figure 3.7. Set of data showing de-coding.



Figure 3.8. Complete System.

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1) Field sync A - a 20 μ S pulse occurring at the beginning of each TV field.

2) Field sync B - a 4.7 μ S pulse which occurs when Field sync A and the Line sync are in phase, i.e. every second TV field (due to interlace).

3) Line sync - a 4.7 μ S pulse at the start of each TV line.

4) Line blank A - a 12 μ S pulse initiated by the leading edge of the Line sync.

5) Leading edge line sync - a 100 n S pulse initiated by the leading edge of the line sync.

6) Line blank B – an 11.9 μ S pulse which starts 100 nS later than Line blank A.

High and low logic level versions are provided of all the above syncs and the outputs are capable of driving up to 30 standard TTL (Transistor Transistor Logic) loads each.

The SGS also contains two 8 bit registers which may be set to any value by the computer software. These registers are the Field count and Line count registers. They provide the data inputs for the initial values of two 8 bit up/down counters; the field counter and the line counter. Field or line syncs are used to count down these counters from the initial value. When the counters pass through \emptyset an overflow pulse is produced and the counters are reset to the initial value held in the register. With the line counter the counter is also reset by a field sync at the end of each television field.

The field counter can be used to inhibit the co-ordinate generator so that co-ordinates are only generated on every 2nd TV field, every 3rd etc. up to every 256th TV field, according to the initial value held in the field count register. In this way it is possible to vary the sampling frequency of the system from 50 Hz down to 0.2 Hz. Obviously such a low sampling frequency would not be required for tocomotion analysis, but there are other applications for this system which would require this low rate.

The line counter has several functions. As with the field counter it is set to give an output pulse according to the initial value held in the line count register. The first use is to provide simulated marker signals. This is

done by using the overflow pulse to trigger a series of 7 dual monostables. This arrangement produces seven 90 nS pulses at intervals of approximately 8 μ S. Logic provides various combinations of these pulses, as shown in Figure 3.9. The outputs correspond to video signal levels and are capable of driving 75 inputs. These signals can, therefore, be substituted for the camera inputs and be used to test the complete interface and assist in program development by providing known inputs. The number of lines on which these simulated pulses appear is controlled by the value held in the line count register which is under control of the computer program. The number of lines can be varied from every line to every 256th line. Computer instructions are available to enable and disable the simulator.

Another function of the line counter is to provide synchronisation pulses to control data acquisition from other measuring systems. The overflow pulse is used to generate these pulses so that the frequency at which they occur may be set by the program. Synchronization pulses will always start after the beginning of a field after receipt of an external enabling signal, i.e. at the request of the other measuring system. The time at which this occurs, in relation to co-ordinate generation, is stored in the shift register word as previously described.

A possible future use for the line counter is to provide a series of out of phase field syncs. This can be done using the logic shown in Figure 3.10. At the beginning of each normal field a 'l' is clocked into the shift register. This causes a 160 μ S field sync to be generated by monostable 1 at FS1. An overflow pulse from the line counter clocks this 'l' along the shift register producing as it goes 160 μ S field syncs at FS2, FS3 etc. From the table in Figure 3.10 it can be seen that a series of out of phase field syncs can be produced according to the value in the line count register. In this way sampling rates higher than 50 Hz could be achieved by using more than one camera to cover the same field of view and using these out of phase field syncs to initiate the vertical scan of each camera. If six cameras covered the same field of view a sampling frequency of 300 Hz would be achieved.



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Figure 3.9. Simulated marker pulses.



Figure 3.10. Logic to generate out of phase field syncs.

3.3.4 Address Register (AR)

The memory of the PDP 12 is organised in 4 K word segments up to a total of 32 K words. A 12 bit memory address is required to access locations within each 4 K segment, and a 3 bit extended address is required to address the segments - in total a 15 bit address. The address register provides this and a set of computer instructions have been created to control it. The initial address may be set up to any value which is a multiple of 8 (10 in octal notation). The reason for this slight limitation is that by fixing the initial value of the first 3 bits of the memory address to β both the memory address and the extended address can be set to their initial value with one computer instruction. This instruction loads a 12 bit word from the accumulator into the Initial Data Address register; bits 9, 10 and 11 of this word corresponding to bits \emptyset , 1 and 2 of the extended address (8-mode field address in software terms). The remaining bits ($\emptyset - 8$) are used to set bits $\emptyset - 8$ of the initial memory address. The address register itself is a 15 bit binary counter which is -incremented by the Address Accept pulse - a control signal provided by the data break facility (see Appendix A2). The interface can therefore address any location in the PDP 12's memory up to the maximum of 32 K (only 16 K is available on the machine used at present, but it can be expanded to 32 K).

Computer instructions have been created to enable and disable the address register, and also to allow it to operate in a double (or circular) buffer mode. In this mode memory locations 100000_8 to 27777_8 (4 K to 12 K) are used. When the interface has used all the locations up to 17777_8 (4 K to 8 K) the computer is signalled and the program starts to unload this area of memory onto a mass storage device (such as magnetic tape or disc), while the interface is filling up locations 200000_8 to 27777_8 (8 K to 12 K). Similarly when the interface has used up these locations the address register is reset to 100000_8 and locations 200000_8 to 27777_8 are dumped onto mass storage. By using this facility it is possible to have continuous data rates of at least 4 K words/sec if a disk is available as the mass storage device. This effectively means that the duration of data acquisition is not limited by the core memory size of the computer. The capacity of an R K05 disk, as used on the PDP 12, is 1.6 M words. With an incoming data rate of 4 K words/sec (approximately

26 co-ordinate pairs per television field) a test could be run continuously for 6 minutes. Clearly this does not present a limitation as far as data acquisition is concerned, but there would be problems (of time) in processing such a large amount of data. Utilisation of the Double Buffer mode for transferring data to disk is further discussed in section 6.6.

Computer instructions to read the current memory address and extended (field) address are also available, and may be used at any time.

3.3.5 Calibration (CAL)

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To calibrate the field of view of each camera a grid of markers is placed in the relevant plane and the system acquires the co-ordinates of this grid. A computer program organises this data into a calibration matrix for the particular camera and all subsequent data generated by the camera is referred to this matrix, and calibrated. This is done by finding the nearest grid point to the data point, the position of this grid point in the matrix defines its true spatial position; the difference between the grid point and the data point is then taken and calibrated by assuming a linear relationship between adjacent grid points, this difference is then added to the known spatial position of the nearest grid point. This procedure can be stated as follows for the x co-ordinate:-

$$= x_{gn} \cdot K + L - \frac{\widehat{gdn} - \widehat{l}}{|x_{gdn} - x_{gd} (n - 1) if x_{gdn} - x_{i}|} \cdot K$$

$$(n + 1) if x_{gdn} < x_{i})$$

 calibrated co-ordinate of marker
 position of nearest grid point in calibration matrix
 co-ordinate of nearest grid point (grid data point), matrix column n.

= marker co-ordinate (data point)

K = calibration constant

L = shifting factor - to position origin

A similar equation is used to calibrate the y co-ordinate.

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The spacing of the elements of the grid should be based on the expected non-linearity of the system. The camera specifications state a linearity within 1%; to allow for this a grid spacing of 100 units is required. A non-linearity of 1% in 100 units would be 1 unit, and therefore the non-linearity becomes indistinguishable from quantization errors. For the fields of view used for locomotion analysis a grid spacing of 10 cm is suggested.

For a field of view of 2.5 m width there would be 25 grid points in the horizontal scan. The co-ordinate generator is limited to taking in a maximum of 5 co-ordinates in the horizontal scan line, therefore a system is required to overcome this limitation for the calibration grid. One way of doing this, of course, would be to slope the grid so that no more than 5 grid coordinates could appear on the same line. A correction would have to be made to compensate for this slope during calibration of data and this was considered to be inconvenient. An alternative solution was found by designing a hardware calibration control. This control operates by allowing the CG to successively generate the co-ordinates of columns of 2 markers from the grid until the whole field of view has been covered, the computer is then signalled that calibration co-ordinates have all been acquired. This process is shown, schematically, in Figure 3.11, and may be considered as a window 2 grid points wide moving over the grid. Co-ordinates for the calibration grid are generated over two TV fields, so that the effects of interlaced scanning may be taken into account (see Appendix AI). A set of computer instructions are provided to operate the calibration control, and for maintenance purposes there is a "free run" mode which allows the control to cperate continuously.

Ingen Schenau (1973) found, with his TV/computer system, that the linearity in the horizontal was independent of the linearity in the vertical and derived quadratic functions for correction terms of the form:-

$$f(x') = bx (x' - Kx)^2$$

 $g(y') = by (y' - Ky)^2$

where bx, by, Kx and Ky are constants. The K constant fixed the origin, and the b constant was found by fitting the quadratic functions to values obtained





for the co-ordinates of a grid of points. This gave the following equations with which data could be calibrated.

$$x = x' - 4.7.10^{-4} (x' - 128)^{2}$$

y = y' - 4.0.10^{-4} (y' - 128)^{2}

These equations applied to the particular camera and lens used and assumed that the characteristics would remain constant. With ageing of components the linearity of the television camera could change over a period of time. It is considered desirable, therefore, to provide a calibration system which can easily be used for different cameras and lens and take account of any change in linearity that may occur over a period of time.

3.3.6 Computer Instructions (INSI and INS2)

The computer instructions required to control the interface are generated using the input/Output (6000) class of the PDP 12 instruction set. The method of converting these software instructions into hardware operations is described in Appendix A2. A total of 28 instructions have been created, designed to ensure the minimum of manual intervention during use of the interface, efficient programming, and effective maintenance facilities. Details of the function of each instruction and examples of programming will be found in Chapter 5.

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CHAPTER 4

INTERFACE LOGIC

- 4.1 Introduction and Nomenclature
- 4.2 Marker Detectors. MD.
- 4.3 Sync Generator and Simulator. SGS.
 - 4.3.1 Internal Synchronisation Pulses. SGS-A.
 - 4.3.2 Line Count and Field Count Functions, SGS-B.
 - 4.3.3 The Simulator. SGS-C.
 - 4.3.4 External Synchronisation, SGS-D.
- 4.4 Co-ordinate Generator, CG.
 - 4.4.1 Enable Logic and Clock. CG-A.
 - 4.4.2 Priority Register and Coding. CG-B.
 - 4.4.3 Co-ordinate Counters and Latch. CG-C.
 - 4.4.4 Buffer Memory. CG-D.
 - 4.4.5 Buffer Memory Address and Control Logic. CG-E.
 - 4.4.6 Additional Code Bits. CG-F.
- 4.5 Address Register. AR.
 - 4.5.1 Initial Data Address Register and 15 Bit Address Register, AR-A.
 - 4.5.2 Address Increment Logic and Computer Bus Drivers. AR-B.
 - 4.5.3 Computer Bus Drivers. AR-C.
- 4.6 Calibration Control. CAL.
 - 4.6.1 Calibration Initialisation and Control Logic. CAL-A.
 - 4.6.2 Counter and Right Hand Limit Latch. CAL-B.
 - 4.6.3 Left Hand Limit Latch and Margin Logic. CAL-C.
 - 4.6.4 Window Control Logic. CAL-D.

4.7 Instruction Generator I. INSI.

4.7.1 Calibration Control Instructions. INSI-A and INSI-B.

4.7.2 Sync Generator and Simulator Instructions. INSI-C.

4.8 Instruction Generator 2. INS2.

4.8.1 Co-ordinate Generator Instructions. INS2-A.

4.8.2 Address Register Instructions. INS2-B to INS2-E.

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4.9 Construction and Planning

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4.1 Introduction and Nomenclature

A complete description of the logic of the interface is given in this In describing the function of the logic the signal naming and drawing section. conventions used by DEC have been adopted. This system was chosen because it allows the logic functions to be followed easily and is, of course, compatible with the PDP 12 manuals. Each drawing is allocated a name and a number, the number usually being an abbreviation of the name. Logical signal names are used in the drawings to minimise the number of signal line crossings and to facilitate explanation. The signal name consists of abbreviations which give the origin, function and assertion condition of the signal:-

The origin is specified by the first word of the signal name and is the drawing number upon which the signal is generated.

The signal description (function) is a description of the logical function of the signal when asserted.

The asserted condition is either H (high) or L (low) corresponding to +3 or 0 volts respectively, and is the signal level which indicates that the intended function has occurred (i.e. is True). The signal is considered not asserted when the signal level differs from the assertion level.

Example:-

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[SGS-A] LE LSY L Refers to a signal which originates on the the flar development of Sync Generator and Simulator drawing part A. The signal will be low when the Me alter a hade been and Leading Edge of the Line Sync occurs. the mer of ref. or i [CG-B] SGC H Refers to a signal which originates on the Co-ordinate Generator drawing part B. The signal sets the Generate Co-ordinate flip flop when it is high.

Signals originating from flip flops are defined in terms of the flip flop state, as shown in the following table:-

Signal Name	State of flip flop	Signal Voltage
[CG-B] GC (0) H	0	+3
[CG-B] GC (0) L	0	0
[CG-B] GC (I) H	1	+3
[CG-B] GC (1) L	1	0

Example:-

[CG-B] GC (I) L

Refers to a signal which originates on the Co-ordinate Generator drawing part B. The signal line is low when the Generate Coordinate flip flop is set.

On the drawings and in the description of the logic of each drawing the origin part of the signal name is omitted if the signal is generated on that drawing, otherwise it is shown enclosed in square brackets. The logic symbols used are those which convey the function of the logic element (conceptual logic) rather than the actual hardware device used, although the reference number of the actual device is also shown. These logic symbols are shown in Figure 4.22 at the end of the logic drawings.

The computer generates the signals [100] BA INITIALIZE H and [100] BB INITIALIZE H which are used to initialize the interface. These signals may be generated by the use of the 10 PRESET console switch or by the program.

In the following description of the logic frequent cross references are made between logic drawings. For this reason these drawings will be found together at the end of this section. The drawing numbers are referenced by the sub-headings of the logic descriptions. Other figures, which may show timing diagrams for instance, are placed by the relevant text.

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4.2 Marker Detectors. MD.

The circuits for the two types of marker detector used have been shown in Figures 2.3 and 2.5. The MD circuit board also contains circuitry used to condition the field and line syncs from the television sync pulse generator. These circuits are simple comparators with TTL compatible outputs, as shown

4.3 Sync Generator and Simulator. SGS.

The drawings for the SGS are shown in Figure 4.16, SGS-A to SGS-D. Generation of internal syncs is shown in SGS-A, line count and field count functions are on SGS-B, simulator logic is on SGS-C, and external sync control is on SGS-D.

4.3.1 Internal Synchronisation Pulses. SGS-A.

TTL compatible field and line syncs from the Marker Detector board (MD) are fed into schmitt trigger input gates and used to generate the signals shown on this drawing. FSYB is a field sync of 4.7μ S duration which occurs on every other television field, due to the interlace feature of the camera sync generator. Generation of the other signals is self explanatory from the logic.

4.3.2 Line Count and Field Count Functions. SGS-B.

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The Field Counter (FC) is an 8 bit binary up/down counter. The clock input, [SGS-A] FSYA H, will count down the counter from a preset binary number held in the Field Count Register (FCR). A low level borrow pulse occurs when the clock input is low and the counter is at zero. This borrow pulse is fed back to the load input of the counter and will cause the counter to be set to correspond to the data inputs, provided by the FCR. As soon as the counter becomes non-zero the conditions required to generate the borrow pulse are not met and the borrow output is returned to its normal high level. The borrow pulse lasts for approximately 40 nS, and is also used to preset ENCG when the Field Count mode is enabled ([INSI-C] ENFC (I) H). ENCG (I) H enables the Co-ordinate Generator inputs for the duration of one television field until ENCG is cleared by [SGS-A] FSYA H. When the Field Count mode is disabled, [INSI-C] ENFC (0) L, ENCG is held permanently set. The Field Count Register is loaded with the contents of the Accumulator (bits 4 - II) by [INSI-C] LDFC H.

The Line Counter (LC) is a similar up/down counter except that its clock input is the television line sync [SGS-A] LSY H. In this case the counter is also preset at the beginning of each television field by [SGS-A] FSYA L. The borrow pulse is produced as before and is used for several functions. The Line Count Register (LCR), which provides the data inputs to the counter, is loaded with the contents of the Accumulator (bits 4 - II) by [INSI-C] LDLC H.

4.3.3 The Simulator. SGS-C.

The logic in this drawing shows how [SGS-B] LC L is used to generate the simulated marker pulses. The simulator is enabled by the signal [INSI-C] ENSM (I) H, and when this condition is met the leading edge of [SGS-B] LC L will trigger the seven monostables SPT I to SPT 7. The -ve going edge of the pulse produced by each monostable triggers a second monostable to produce 90 nS duration pulses SP I - SP 7. These outputs are combined and buffered to provide various simulated marker pulse configurations capable of driving 75^a inputs as previously shown in Figure 3.9.

4.3.4 External Synchronisation, SGS-D.

External data acquisition is synchronised by the SYN flip-flop. When synchronisation is requested by [EXT] SYN (I) H (a signal provided by the external device, which may originate from a flip flop, as shown here, or may simply be a level) SYN is set on the -ve going edge of the next field sync, [SGS-A] FSYA H. SYN (I) H is then available to signify that synchronisation has started. It is used here in conjunction with a pulse generated by [SGS-B] LC L to gate line blank pulses. [SGS-B] LC L triggers monostable LBK GATE which is set to provide a 400 µS pulse. Whenever this pulse occurs, and SYN is set, six buffered line blank pulses will be available as BSYN H. Any number of pulses can be provided by changing the timing components of LBK GATE; the six pulses generated here are used as external sync inputs to the KWI2 clock of the PDP 12. The frequency at which this pulse train occurs is controlled by the frequency of [SGS-B] LC L, which in turn is set by the contents of the line count register, LCR.

4.4 Co-ordinate Generator. CG.

The drawings for the CG are shown in Figure 4.17 CG-A to CG-F. Enable logic and the clock is shown on CG-A, the priority register and coding is on CG-B, co-ordinate counters and the high speed latch is on CG-C, the buffer memory is on CG-D, buffer memory address and control logic is on CG-E, and CG-F contains the logic for the additional code bit storage.

4.4.1 Enable Logic and Clock, CG-A.

The marker detector inputs to the CG are enabled by the signal EMDI L. The detector inputs are inhibited during the line blank period by [SGS-A] LBKA L and also, at any time, by the signal [CAL-A] DISCG L. The facility to exercise external control over the CG is provided here by the switch inputs, whose conditions are sampled at the beginning of each television field. SWITCH I H and SWITCH 2 H will both set ENABLE on the occurrence of [SGS-A] FSYA H. SWITCH DISCG H will clear ENABLE when the field sync occurs. [100] BB INITIALIZE H (originated by program or console switch) will also clear ENABLE and hence inhibit the marker detector inputs.

The clock for the horizontal counter is shown here, it is a simple R-C multivibrator as described in Texas Instruments (1973a). The clock is reset on the trailing edge of [SGS-A] LE LSY L by a 35 nS pulse. This arrangement has proved to be entirely satisfactory as will be seen by the stability test described in the Results and Discussion chapter.

4.4.2 Priority Register and Coding. CG-B.

The marker detector inputs are controlled by the priority register PRI. The cascading input P_0 is fully over-riding and will inhibit each package when high. A marker detected pulse [MD] CHx H will produce the signal SGC H which clocks a 'l' into GC. GC (I) L immediately latches the data in the priority register and inhibits the PRI inputs. The timing diagram for this sequence of events is shown in Figure 4.1. The times shown in this diagram are maximums and in practice the operation is faster. In the event that marker detected pulses occur at the same time on more than one input,



Figure 4.1. Timing diagram showing the latching of the camera channel data in the Priority Register.

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the PRI will only give one output which will correspond to the input of highest priority at the time the data is latched. DØ has the highest priority and D5 the lowest. A 3 bit code, to indicate which input generated SGC H, is provided by C0 Ø H, C0 I H and C0 2 H according to the truth table shown in Figure 4.2. SGC H also sets the break request flag BRF, which will request data transfer to computer memory during the next line blank period by asserting BR L. The Break Request signal BR L is held asserted by the computer generated signal [100] BREAK (I) L until the last transfer is about to take place when [CG-F] TSR L clears BRF.

4.4.3 Co-ordinate Counters and Latch. CG-C.

The 10 bit vertical co-ordinate counter VC is incremented by the -ve going edge of [SGS-A] LSY H, and reset to zero by [SGS-A] FSYB H. The VC outputs are fed to the data inputs of the high speed, synchronous horizontal co-ordinate counter HC. The HC is incremented by the +ve going edge of [CG-A] CK H and reset to zero by [SGS-A] LBKB L. The contents of the HC are continuously strobed into the LATCH on the -ve going edge of [CG-A] CK H. When a marker is detected in the video [CG-B] GC (I) L is asserted and the strobe is disabled, the latch will now contain the horizontal co-ordinate of the detected marker. The timing diagram for this sequence of events is shown in Figure 4.3. At the end of each scan line [SGS-A] LE LSY L will be asserted and the HC will be preset to equal the contents of the VC on the next +ve going clock pulse. This data will then be available in the LATCH, and is the vertical co-ordinate corresponding to horizontal co-ordinates generated on that line.

4.4.4 Buffer Memory. CG-D.

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The outputs of the LATCH together with the code bits [CG-B] CO \emptyset H and [CG-B] CO I H provide the data inputs to the 16 word (12 bits/word) random access memory RAM. The data inputs are written in to the location addressed by [CG-E] UDC \emptyset to UDC 3 when [CG-E] RAM CE L and [CG-E] RAM WE L are both asserted. During write operations the data outputs OD \emptyset to OD II are high. Data is read from the location addressed by [CG-E]

	C0 Ø	C0 I	C0 2	INPUT
n an an that an	ø	ø	ø	ø
	ø	ø	1	I
and the second second	Ø		ø	2
a second second and second second	ø		ł	3
e North an Alfred May		ø	ø	4
	I a	ø	1	5
	- 1	I.	ø	None, VC code
n ta na kata ta wa kata i				None, VC code

Figure 4.2. Truth table for camera code.

(CG-A) CK H	
en general de mer en a gelen médienen <u>de la ser de la ser</u> et en general de gelen de la ser en en de la ser en de la ser en en de la ser en en en de la ser en en en en en	
Les strands Alter half man and man and an and and and and and and and an	
STROBE H CARL CONTRACTOR STROBE AND CONTRACTOR STR	
LILOL	
With the second of the heather of photometric for the later of the second of the second of the second of the heather of photometric for the second of the heather of the second of th	

Figure 4.3. Timing diagram to latch horizontal co-ordinate.

UDC \emptyset to UDC 3 when [CG-E] RAM CE L is asserted and the write enable input (WE) is held high. During read operations the accessed data is placed on the computer data bus via bus drivers. The timing diagram for write operations is shown in Figure 4.4, the CE input must be held low for 50 nS (Access time) and the data input must be available for 20 nS and held for 5 nS after the WE input has been returned to a high level. These times are maximums and typical times are quoted as 35 nS, 18 nS and 0 nS respectively, Signetics (1974). The timing for read operations is not critical as will be described under CG-E. The address inputs are always set up in anticipation of any read or write operation.

4.4.5 Buffer Memory Address and Control Logic. CG-E.

The address of the location to be accessed in the RAM is provided by the up/down counter UDC. [CG-A] 10 INIT L sets the UDC to zero, which is the first location to be used for write operations. The UDC is incremented up on the +ve going edge of [CG-B] GC (1) L, i.e. when the horizontal co-ordinate has been read into memory and GC is cleared. GC is cleared by the signal IGC L, which is generated by the RESET monostable. RESET is triggered on the +ve going edge of [CG-B] GC (I) H and provides a pulse of approximately 35 nS duration after a delay of 80 nS (maximum delay 130 nS). This delay allows sufficient time for the horizontal co-ordinate to be latched and stored in the RAM. UDC 2 (1) H provides the 'D' input to the limit flag LF, and when this signal is asserted LF will be set on the next RESET pulse (i.e. when a fifth horizontal co-ordinate has been generated). LF (1) L generates IGC L and inhibits the generation of any further horizontal coordinates. [CG-B] GC (I) H generates the chip enable and write enable pulses - RAM CE L and RAM WE L - to write into memory a horizontal coordinate. These signals are also generated by [SGS-A] LE LSY H (a 100 nS pulse occurring at the end of each scan line) to write into memory the contents of the vertical counter which are held in the LATCH. The functions of the UDC during write operations are illustrated in Figure 4.5. A complete timing diagram for generation of the horizontal co-ordinate is shown in Figure 4.6.



Figure 4.4. Timing for writing data into the Random Access Memory.

	3			ø	Write	Additional Functions
	ø	ø	ø	ø	нс і	None
	ø	ø	ø	1	HC 2	None
	ø			ø	НС 3	None
jî. A va	ø	ø	l	I	HC 4	None
	ø	1	ø	ø	HC 5	Set limit flag
	ø	1	ø	Ĩ	vc	None

NB. The number of HC's is variable, the VC will always be written after the last HC, and is therefore not a function of the UDC address.

Figure 4.5. Random Access Memory address counter (UDC) functions during write operations. (up count).

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If horizontal co-ordinates have been generated the break request flag [CG-B] BRF will be set and a break request will be made at the beginning of the line blank period (break request enabled by [SGS-A]LBKA L, and held enabled by [100] BREAK (I) L until all transfers have been made - see CG-B). When the break request is accepted the computer generates [100] ADD ACCEPTED (I) L which is used to trigger a 1 μ S pulse from monostable AA. This pulse in turn generates RAM CE L which makes the contents of the currently addressed location of the RAM available at the RAM outputs. As this data is provided on the computer IO bus some 500 nS before it is required the access time of the RAM is not critical. These outputs are taken via buffer amplifiers with open collector outputs and put onto the EXT DATA bus of the computer.

The first word of data to be transferred will be the last word that was read into the RAM, i.e. the vertical co-ordinate. On the -ve going edge of AA L the UDC is down counted by I, and addresses the RAM location containing the next data word (a horizontal co-ordinate) which is then transferred to computer memory as before. This process is repeated until all the horizontal co-ordinates have been transferred, which is indicated by the UDC underflowing (i.e. UDC output = IIII). When this occurs UDC 3 (I) H generates RAM CE H which disables the RAM outputs. The next AA L pulse will down count the UDC to III0 which provides a clear pulse and resets the UDC to zero. These functions of the UDC during read out of data are shown in Figure 4.7.

4.4.6 Additional Code Bits. CG-F.

The third code bit for the horizontal co-ordinate is clocked into the SHIFT REGISTER by the +ve going edge of [CG-B] GC (1) L. As each horizontal co-ordinate is generated codes are shifted along by one bit; the code for the last horizontal co-ordinate generated on any line will be at C_A . The SHIFT REGISTER data is transferred to the computer when the UDC underflows on down count. [CG-E] UDC 3 (1) H gates [CG-E] AA H to generate TSR L. This signal enables the EXT DATA bus drivers and the contents of the shift register are transferred to computer memory. Bit \emptyset of this word is permanently set at zero to maintain the uniqueness of the vertical co-ordinate code. Bit 3

n - Constant States - States

 $\label{eq:product} \mathcal{F}_{1} = \{ f_{1}, f_{2}, f_{3}, f_{$

an garan ay karang sa	3	2	I	ø	Read	Additional Functions
i. Ne frei w	ø	$\mathbf{I}_{A} = \mathbf{I}_{A}$	ø		VC	None
	na ∮ ta	a salarini	ø	ø	HC 5	None
na tradition quaditi taa ta	an 🖉 👘	Ø	han k ara	e og lende	HC 4	None
	ø	ø	1	ø	HC 3	None
(ø	ø	Ø	ge 🖡	HC 2	None
	ø	ø	ø	ø	HC I	None
Neray P	de la g		e tradición de	. 1 55	-	Read shift register word
$\frac{1}{2} = \frac{1}{2} \qquad p = \frac{1}{2} \frac{1}$	tiet st	an an an an Arabana Gala Arabana an A	, v Ba	i se esta		and clear break request flag
	ľ		· •	ø		Reset UDC to Ø

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NB. The number of horizontal co-ordinates is variable and the VC will always follow the last HC and will be read out first.

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Figure 4.7. Random Access Memory address counter (UDC) functions during read operations. (down count).

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is set by [SGS-D] SYN (1) H which will indicate if an external device is being sampled; bits 1, 2, 4, 5 and 6 can be used in a similar way if required. TSR L also clears the break request flag [CG-B] BRF, to end the sequence of data transfer to the computer.

4.5 Address Register AR.

The drawings for the AR are shown in Figure 4.18 AR-A to AR-C. The initial data address register and the 15 bit data address counter is shown on AR-A, address increment logic and some computer bus drivers are on AR-B, and the rest of the bus drivers are on AR-C.

4.5.1 Initial Data Address Register and 15 bit Address Register. AR-A.

This drawing shows the Initial Data Address Register IDA, the 12 bit Memory Data Address register DA and a 3 bit Data Field Address register DFA. IDA is loaded with data from the accumulator, AC, by the +ve going edge of [AR-B] STO IDA H. $Q\emptyset$ to G2 of the IDA provide the data inputs DØ to D2 of the DFA. G3 to G11 of the IDA provide the data inputs DØ to D8 of the DA. The DA and DFA are preset to equal these data inputs by AR-B L0 IDA L. The DA and DFA is a 15 bit synchronous counter which is incremented (or preset to the value held in the IDA if [AR-B] L0 IDA L is asserted), by the +ve going edge of [AR-B] IA L.

4.5.2 Address Increment Logic and Computer Bus Drivers. AR-B.

The computer instruction 6331 (LDCA) generates [INS2-B] BIOT 6331 L and [INS2-B] LDCA L. These two signals are combined to produce STO IDA H, the combination being used to improve noise immunity. This signal generates LO IDA L, and triggers the monostable LDCA CLOCK to produce a 300 nS pulse which in turn generates IA L. These signals load the IDA register with the data held in the Accumulator and preset the DA and DFA with the new contents of the IDA register on the +ve going edge of IA L. A timing diagram of this sequence of events is shown in Figure 4.8. The delays introduced by the various logic elements have not been included as their effect on the timing



has been designed out. IA L is also produced by the [100] ADD ACCEPTED (1) L signal from the computer, the DA and DFA being incremented on the +ve going edge of this signal to provide the next address in computer memory in readiness for the next data transfer.

When the Double Buffer Mode of operation is set ([INS2-E] DBM (I) H) LO IDA L is generated whenever the DA is at 7777₈ and DFA bit I is high; on the next clock pulse (IA L) the contents of the IDA register are loaded into the DA and DFA. The timing diagram for this operation is shown in Figure 4.9. The table in Figure 4.10 shows the areas of memory used by the AR according to the initial DFA. The start location within the first memory field of these areas depends on the initial contents of the DA register.

The bus drivers which put the DFA on the Extended Data Address bus of the PDP 12 are shown here and are enabled by [INS2-C] ENFAD (1) H. The current DFA may be read at any time and is made available on bits 9-11 of the 10 bus by [INS2-B] RCFA H.

4.5.3 Computer Bus Drivers. AR-C.

[AR-A] DA \emptyset to 11 are put onto the Data Address bus of the PDP 12 via bus drivers which are enabled by [INS2-C] ENAD (1) H. The current DA may be read at any time and is made available on the 10 bus by [INS2-B] RCA H.

4.6 Calibration Control. CAL.

The drawings for the CAL are shown in Figure 4.19 CAL-A to CAL-D. Calibration initialisation and control logic is shown on CAL-A, the counter and right hand limit latch are on CAL-B, left hand limit latch and margin logic is on CAL-C, and the window control logic is on CAL-D. Three of the terms used in the description of the CAL logic are explained here. The Left Hand Limit (LHL) is the horizontal co-ordinate of the left hand edge of the calibration window. The calibration control will enable the co-ordinate generator from this point until the Right Hand limit (RHL) is reached. This limit being the horizontal co-ordinate of the right hand edge of the calibration window. The co-ordinate generator is inhibited once this RHL has been passed. The window will move [AR-B] IA L [AR-A] DA Ø (I) H II (I) H [AR-A] DFA Ø (I) H [AR-A] DFA I (I) H [AR-A] DAI CA H [AR-A] DA 3 CA H [AR-B] LO IDA L Preset DA and DFA Address = 27777 to = IDA

Figure 4.9. Double buffer mode timing diagram.

	Initial contents of DFA			Initial data field	Area of Memory used in DBM	
	ø	ø 1 2			K	
	ø	ø	ø	0	0-12	
÷ 11	ø	ø	1	1	4-12	
	ø	1	ø	2	8-12	
	ø	Ĩ	1	3	12-16	
	Ĩ	ø	ø	4	16-28	
		ø	1	5	20-28	
	· [1	ø	6	24-28	
			I	7	28-32	

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Figure 4.10. Areas of memory used in the double buffer mode depending on the initial data field.

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across the television field until the Right Hand Margin (RHM) is passed by the LHL, the co-ordinate generator is inhibited when this happens and the calibration complete flag is set. This moving window has already been shown in Figure 3.11.

4.6.1 Calibration Initialisation and Control Logic. CAL-A.

The calibration control is initiated by [INSI-B] CALGO H, which triggers the CAL GO monostable to generate a 45 mS pulse. The START and ZERO LHL flip flops are cleared and then reset as shown in the timing diagram of Figure 4.11. These flip flops set up the initial conditions for the calibration control. START (0) L generates DISCG L and inhibits the CG until the beginning of a television field. ZERO LHL (0) L makes the Left Hand Limit zero; this condition may also be generated when the control is in the Free Run mode ([INSI-B] FR (I) L) and [CAL-C] RHM CONT L is asserted. To indicate that calibration has been completed CAL COMP H is generated by [CAL-C] RHM STOP L.

The calibration control is made operative by [INSI-B] CAL MODE (I) H and will inhibit the Co-ordinate Generator when DISCG L is asserted. This inhibit signal may be generated by any of the four signals shown and will control the times during the line scan in which co-ordinates may be generated. When a co-ordinate is being generated [CG-B] BGC (I) L is asserted and will clock a 'I' into the shift register, CAL SR, on its +ve going edge (i.e. at the end of co-ordinate generation). CAL SR Q_B provides the 'D' input to the SET RHL flip flop which is clocked by bit 9 of the horizontal co-ordinate counter [CG-C] BHC9 H. The timing diagram of Figure 4.12 shows how SET RHL (I) H is asserted. CAL SR and the SET RHL flip flop are both cleared by FSYB L.

4.6.2 Counter and Right Hand Limit Latch. CAL-B.

The calibration control has it own horizontal counter, HC, which is incremented by [CG-C] BHC9 H. The right hand limit latch, RHL LATCH, stores the current contents of the HC when [CAL-A] SET RHL (1) H is asserted. At the start of alternate television fields the RHL is set to all 'l's by [CAL-A] FSYB L.

CALGO H
CAL GO H
FSYB H
CAL GO SYNC L
START (I) H
Figure 4.11. Initialisation of calibration control timing diagram.
[CG-C] BHC 95H excess of all and an an and an an an and an an an and an
CG-B] BGC (I) L service servic
[CAL -A] SET RHL (I) H
n en en ante esta de la seconda en la seconda de la se En esta de la seconda de la

Figure 4.12. Timing diagram to set the right hand limit of the calibration window.

4.6.3 Left Hand Limit Latch and Margin Logic. CAL-C.

The left hand limit latch, LHL LATCH, is loaded with the contents of the RHL LATCH at the start of alternate television fields by the leading edge of [SGS-A] FSYB H. The timing of this operation is shown in Figure 4.13, in which typical propagation times are given for the various signals (from Texas Instruments (1973b)). The data for the LHL LATCH inputs must be held for 5 nS from the +ve edge of the clock signal [SGS-A] FSYB H as shown. The LHL LATCH is set to zero at the start of calibration by [CAL-A] ZERO LHL (0) L. The contents of the LHL LATCH are compared with the contents of the right hand margin register, CAL RHM REG, and as soon as the left hand limit is greater than or equal to the right hand margin RHM STOP L is generated to inhibit further co-ordinate generation. The RHM REG is loaded with the contents of bits β - 3 of the accumulator by [INSI-B] LDCAM H. When the calibration control is in the free run mode [INSI-B] FR (I) L inhibits RHM STOP L.

4.6.4 Window Control Logic. CAL-D.

The right hand limit comparator, RHL COMP, compares the contents of the RHL LATCH (A) with the outputs of the horizontal counter [CAL-B] HC β -7 (B), and when A is less than B, RHL L is generated to inhibit the CG. Similarly the left hand limit comparator LHL COMP compares the contents of the LHL LATCH (A) with [CAL-B] HC β -7 (B), and as long as A is less than B generation of co-ordinates is inhibited by LHL L.

This logic provides a calibration "window" whose limits are reset on alternate fields until the whole field has been covered.

4.7 Instruction Generator I. INSI.

The drawings for Instruction Generator I are shown in Figure 4.20 INSI-A to INSI-C. The method of generating instructions is described in Appendix A2. The description of the logic for the instruction generator is limited here to a list of the instructions in the form of the octal code for each instruction followed by its function. The signal or combination of signals required to generate the function is shown after the function description.



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4.7.1 Calibration Control Instructions. INSI-A and INSI-B.

The device selector for the 630X (Calibration Control) instructions is shown on INSI-A together with the appropriate buffering for [100] BMB 9-11, and [100] BA INITIALIZE H. The decoding and associated logic for this set of instructions is shown on INSI-B as follows:-

6301	Set MON EN flip flop. [INSI-A] IOT 6301 L.
6302	Load CAL RHM REG with bits β -3 of the accumulator.
	LDCAM H.
6303-1	Generate CALGO H to start calibration, clear CC flag,
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	and set MON EN flip flop. CAGO L and [INSI-A] IOT
	6301 L.
-2	Set CAL MODE flip flop, which also enables the interrupt.
	CAGO SET CAL MODE L.
6304	Clear all flip flops. CLR L
6305-1	Generate CALGO H to start calibration, set MON EN
n de la construcción de la construcción A construcción de la construcción de la construcción A construcción de la construcción de la construcción de la	flip flop. CAGO FR L and [INSI-A] IOT 6301 L.
-4	Set Free Run flip flop and clear CC FLAG. CAGO FR SET
in a ser ga as an	FR L.
6306	Clear CC FLAG. [INSI-A] IOT 6304 L.
6307-1	Set MON EN flip flop. [INSI-A] IOT 6301 L.

-2 Skip if calibration has been completed. SCAC H.

-4 Clear CC FLAG. [INSI-A] IOT 6304 L.

[INSI-A] IO INIT L also clears all the flip flops.

4.7.2 Sync Generator and Simulator Instructions, INSI-C.

The device selector and decoding with associated logic for the 631X instructions is shown here as follows:-

6311	Load Field Count Register FCR with bits 4-11 of the accumul-
	ator. LDFC H.
6312	Load Line Count Register LCR with bits 4-11 of the accumul-

ator. LDLC H.

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Field Count Mode; sets Enable Field Count flip flop		
ENFC, which allows [SGS-B] ENCG to be controlled		
by the contents of the FCR. ENFC L.		
Set Enable Simulator flip flop ENSM. ENSM L.		
Clear ENFC. CFC L.		
Clear ENSM. CSM L.		

[INSI-A] IO INIT L also clears ENFC and ENSM.

4.8 Instruction Generator 2, INS2.

The drawings for Instruction Generator 2 are shown in Figure 4.21 INS2-A to INS2-E. The method of instruction generation and the presentation of the logic description is the same as for Instruction Generator 1.

4.8.1 Co-ordinate Generator Instructions. INS2-A.

The device selector and decoding for the 632X instructions is shown here, together with the appropriate buffering for [100] BMB 9-11. These instructions are as follows:-

6321	Enable CG,	sets ENCG flip	flop. ENCG L.
6322	Disable CG,	clears ENCG.	DISCG L.

[INS2-A] 10 INIT L also clears ENCG.

4.8.2 Address Register Instructions INS2-B to INS2-E.

The device selector for the 633X instruction set is shown on INS2-B together with the decoding and logic for some of the instructions as follows:-

6333-1 Load Initial Data Address register IDA with the contents of the accumulator LDCA L.

-2 Clear Change Buffer Half flags, FLAG I and FLAG 2 (on INS2-E), LDCA CL FL L.

6335-1 Clear accumulator. RCA CLA L.

RCA H.

6336-2 Clear accumulator. RCFA CLA L.

-4

Read current data Field Address into the accumulator. RCFA H.

The decoding for the rest of the 633X instructions is shown on INS2-C as follows:-

6331 Set ENAD flip flop to enable Memory data Address onto address bus. ENAD L.
6332 Set ENFAD flip flop to enable data Field Address onto field address bus. ENFAD L.
6334 Clear ENAD and ENFAD flip flops. CLAD L.

[INS2-A] 10 INIT L also clears ENAD and ENFAD.

The device selector for the 634X instructions is shown on INS2-D together with some of the decoding. These instructions are also associated with the Address Register as follows:-

6341 Colores of Set Double Buffer Mode flip flop, DBM. DBM L.

6342 Clear DBM. CDBM L.

6343-1 gooding Enables Double Buffer Mode interrupt, DBI. ENDBI L.

6344 Disciple DB1. CDB1 L.

6345-1 Skip if Change Buffer Half Flag is set, FLAG 1 or FLAG 2 (on INS2-E). SCBH H.

The Constant 4 and Clear FLAG Land FLAG 2. SCBH CL FL L.

The decoding for the rest of the 634X instructions is shown on INS2-E together with the interrupt and skip logic for the Double Buffer Mode of operation. The following instructions are included here:-

6346-2Skip if Upper Buffer Half is being filled. SUBH H.6347-1Clear FLAG 1 and FLAG 2. CDBF L.

[INS2-A] 10 INIT L also clears FLAG 1, FLAG 2, DBM and DB1.

FLAG 1 is set when data Field Address bit 1 changes from \emptyset to 1 and FLAG 2 is set when data Field Address bit 2 changes from \emptyset to 1.

4.9 Construction and Planning

Texas Instruments 7400 series TTL logic is used throughout the interface with the exception of the random access memories which are Signetics 8000 series. The technical specifications for the devices used will be found in Texas Instruments (1973b) and Signetics (1974). The integrated circuits (1 C's) are mounted on "Veroboard" and all interconnections are hand wired. The layout of the I C's was designed to minimise the length of the interconnections. Two methods of describing the wiring were used. The first consisted of a series of drawings showing the positions of the 1 C's and the interconnections between them, a separate drawing being provided for each colour of wire used. This method allowed the position of each wire to be specified precisely so that some attempt to minimise critical cross talk effects could be made. The wiring for the Co-ordinate Generator and the Sync Generator and Simulator was described in this way. The second method of wiring description was simply to provide a list of interconnections as shown in Figure 4.14. A drawing of the I C layout and pin configurations was also provided. The technician then made the appropriate connections keeping wire lengths as short as possible. Checking of the wiring was carried out before the components were inserted by testing for continuity between the specified interconnected points.

De-coupling capacitors $(0.1\mu$ F ceramics) were connected between the +ve supply and ground on at least every other 1 C. These de-coupling capacitors were also provided for every 1 C that had a clock input, (such as D type flip flops etc.), to reduce the possibility of the devices being clocked by noise on the power lines. 47μ F electrolytic capacitors were also mounted on each board for de-coupling. Unused inputs to logic elements were held at the appropriate logic level, or paralleled to other inputs. For low logic levels the input was connected direct to ground, but where high levels were required these were provided by the output of an unused gate, this method providing the best noise immunity.

PIN A	PIN B	Colour	No A	No B	Comments	Signal Name
AI-6 AI-5 AI-4 PIN 71 PIN 74 PIN 75	A2-6 A2-5 A2-4 A2-12 A2-11 A2-11 A2-1	Green " " "	2 2 2 2 2 2 2 2	2 2 1 1		BMB 3 (0) H BMB 4 (1) H BMB 5 (1) H BMB 6 (0) H BMB 7 (1) H BMB 8 (0) H
A2-8 B6-13	B6-13 B6-12	Green Wire	 2	2 1		632 Select L " " L
B6-11 B6-10 B6-5	B6-10 B6-5 B6-2	Wire Green	 2 2	2 2 		632 Select H " " H " " H
PIN 55 PIN 57 PIN 59	B6-9 B6-4 B6-1	Yellow n n	2 2 2	2 2 2	Aside "	BIOP I H BIOP 2 H BIOP 4 H
в6-6 в6-3 в6-8	87-5 87-3 87-9	Yellow "		1 1 1	A side "	IOT 6322 L IOT 6324 L IOT 6321 L
в7 8 в7 6	88-13 88-5	Yellow "		1	A side "	IOT 6321 H IOT 6322 H
88-12 88-6	A8-10 A7-5	Yellow "		1	A side	ENCG L DISCG L
А 7-6 В2 - 8	A8-13 A7-4	White "		 2		Clear ENCG L 10 INIT L
	2	3	4	5	6	7

Columns I and 2 give the pin numbers to be interconnected. Column 3 gives the wire colour to be used

Columns 4 and 5 give the number of connections on each pin.

Figure 4.14. Extract from the wiring list for Instruction Generator 2.



Figure 4.15. Comparator circuit used to generate TTL compatible field and line synchronising pulses from standard sync pulse generator syncs.



i (
Drowing Number SC	GS-A
SYNC CENERATOR	AND
Internal Syncs	





81-C] ENSM (I) H [SGS-B] LC L



Figure 4.16 SGS-D. Sync generator and simulator – external synchronisation and sync pulse generator.

Drawing Number SGS-D SYNC GENERATOR AND SIMULATOR External Synchronisation and Sync Pulse Generator



Figure 4.17 CG-A. Co-ordinate generator - enable logic and clock.

 $\{\xi_{i}^{n}\}$

Enable Logic and Clock











Figure 4.17 CG-D. Co-ordinate generator - buffer memory.





Drawing Number CG-E		
CO-ORDINATE GENERATOR		
Buffer Memory Address and Control Logic		

Figure 4.17 CG-E. Co-ordinate generator - buffer memory address and control logic.





Figure 4.17 CG-F. Co-ordinate generator - additional code bit.



Figure 4.18 AR-A. Address register - initial data address and 15 bit address registers.



Figure 4.18 AR-B. Address register - address increment logic and computer bus drivers.





Figure 4.18 AR-C. Address register - computer bus drivers.

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Figure 4.19 CAL-8. Calibration control - horizontal counter and RHL latch.



Figure 4.19 CAL-C. Calibration control - left hand limit latch and margin logic.





Figure 4.20 INSI-A. Instruction generator I - calibration control instructions 630X.

Drawing Number INSI-A
INSTRUCTION GENERATOR I
Calibration Control Instructions 630X



(continued).



⁶³IX.

G



Figure 4.21 INS2-A. Instruction generator 2 - co-ordinate generator instructions 632X.


Drawing Number INS2-3
INSTRUCTION GENERATOR 2
Address Register Instructions, 633X

Figure 4.21 INS2-3. Instruction generator 2 - address register instructions 633X.

-

ENFAD L

PXO,

ENFAD

7476

a

ENFAD (1) H

Figure 4.21 INS2-C. Instruction generator 2 - address register instructions 633X (continued)



ENAD L

ENAD L

7610

[INS2-B] IOT 6331 H -[INS2-A] MB 1\$ (0) H -





Figure 4.21 INS2-D. Instruction generator 2 - Address Register Instructions 684X.



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Figure 4.22. Logic Symbols used.

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A	В	С
ø	ø	ø
ø	1	1
1	ø	1
I	1	ø



Inputs				Outputs	
Preset	Clear	Q	Q		
L	Н	X	X	Н	L
н	L	X	X	L	н
L	L	X	X	Н*	H*
н	н	†	Н	н	L
H	н	+	L	L	н
H	н	L	×	ಇ	Ā ,

H = high level (steady state)

L = low level (steady state)

- t = transition, from low to high level
- X = irrelevant

Q = the level of Q before the indicated input conditions were established * = This configuration is non stable.



CHAPTER 5

PROGRAMMING

- 5.1 Introduction
- 5.2 Instruction Set
 - 5.2.1 Address Register Instructions
 - 5.2.2 Co-ordinate Generator Instructions
 - 5.2.3 Sync Generator and Simulator Instructions
 - 5.2.4 Calibration Control Instructions
- 5.3 Programming Examples
- 5.4 A Method of Decoding
- 5.5 Software Summary
 - 5.5.1 Real Time Display
 - 5.5.2 Data Acquisition
 - 5.5.3 Calibration Data Acquisition
 - 5.5.4 Calibration
 - 5.5.5 Data Display

5.1 Introduction

The instruction set created to control the interface is described in this section. The object in providing these instructions was to allow flexible program control with the minimum of manual intervention. The description of the instruction set is followed by some programming examples. A method of decoding the co-ordinate data generated by the interface is shown and a summary of the software developed is given. Full details of this software will be found in Appendix A3.

5.2 Instruction Set

Machine language programs for the PDP 12 computer are assembled using the LAP6 - DIAL operating system, DEC (1970). To simplify the use of the interface instruction Set, mnemonics have been created for each instruction by the program TVI MN, which is shown in Appendix A3.

In the description of the instructions the mnemonics for each instruction will be given, followed by the octal code, followed by the operation performed. These instructions are used directly in 8 mode, but must be preceded by the instruction 10B in line mode programming.

5.2.1 Address Register Instructions

ENAD 6331 - Enable Address; the data address register of the interface is enabled onto the external address lines of the PDP 12 computer (12 bits) by setting the address enable flip flop.

ENFAD 6332 - Enable Field Address; the data field address register of the interface is enabled onto the external data extended address lines of the PDP 12 (3 bits) by setting the field address enable flip flop.

LDCA 5333 - Load Composite Address; the initial data address register of the interface is loaded with the contents of the accumulator. Bits $\emptyset - 8$ of the Data Address register are set to correspond to bits $\emptyset - 8$ of this initial address and the Data Field Address register is set to correspond to the remaining bits, 9, 10 and 11. Bits 9, 10 and 11 of the Data Address Register are set to zero. The contents of the accumulator remain undisturbed. This instruction also clears the 'change buffer half' flags of the double buffer mode, after the initial address has been set.

CLAD 6334 - Clear Address and Field Address Enable flip flops; the interface data address is taken off the external address lines of the PDP 12.

RCA 6335 - Read Current Address; the accumulator is cleared and the contents of the 12 bit Data Address Register of the interface are read into the accumulator. The previous contents of the accumulator are lost.

RCFA 6336 - Read Current Field Address; the accumulator is cleared and the contents of the 3 bit Data Field Address Register are read into bits, 9, 10 and 11 of the accumulator.

DBM 6341 - Set Double Buffer Mode; the address register is set into the double buffer mode of operation. When the 15 bit address reaches 277778 the next address will be that held in the initial data address register.

CDBM 6342 - Clear Double Buffer Mode; the address register is reset to the normal mode of operation.

ENDBI 6343 - Enable Double Buffer Mode Interrupt; if the computer interrupt is turned on (I ON instruction) then an interrupt request will be made when the data buffer changes halves. The data buffer changes halves when the 15 bit address changes from 17777₈ to 2000_8 or from 27777_8 to 1000_8 .

CDB1 6344 - Clear Double Buffer Mode Interrupt; no interrupt request will be made when the buffer changes halves.

SCBH 6345 - Skip if Change Buffer Half flag is set; the next instruction in the program will be skipped if either of the change buffer half flags is set. The flags are then cleared.

SUBH 6346 - Skip if Upper Buffer Half is being filled; the next instruction in the program is skipped if the 15 bit address is 20000, or greater.

CDBF 6347 - Clear Flags; the change buffer half flags are cleared.

5.2.2 Co-ordinate Generator Instructions

The concretion dependence in the con-

ENCG 6321 - Enable Co-ordinate Generator; The marker detector inputs to the co-ordinate generator are enabled allowing co-ordinates to be generated and data transfer to take place via the single cycle data break facility. DISCG 6322 - Disable Co-ordinate Generator; the inputs to the coordinate generator are disabled and the break request flag cannot be set, inhibiting any data transfer.

5.2.3 Sync Generator & Simulator Instructions

LDFC 6311 - Load Field Count Register; the 8 bit field count register is loaded with the contents of bits 4 to 11 of the accumulator. The contents of the accumulator are undisturbed.

LDLC 6312 - Load line Count Register; the 8 bit line count register is loaded with the contents of bits 4 - 11 of the accumulator. The contents of the accumulator are undisturbed.

ENFC 6313 - Enable Field Count; the field count function of the sync generator and simulator is enabled. The sampling rate of the co-ordinate generator will be controlled by the contents of the field count register.

on every television scan line specified by the contents of the line count register.

CFC 6315 - Clear Field Count; the field count function is disabled and the co-ordinate generator will sample every television field. The contents of the field count register are undisturbed.

CSM 6316 Clear Simulator; generation of simulated marker signals is disabled. The contents of the line count register are undisturbed.

5.2.4. Colibration Control Instructions

ENMON 6301 = Enable Monitor Output; this output provides a 1 volt signal at the scan time corresponding to the position of the window. The signal may be mixed with the video signal from the camera viewing the calibration grid.

LDCAM 6302 - Load Calibration Margin; bits \emptyset to 3 of the contents of the accumulator are loaded into the calibration right hand margin register. When the left hand co-ordinate of the calibration window exceeds the value held in this register the co-ordinate generator is disabled and the calibration complete flag is set.

CAGO 6303 - Calibration Got the calibration control is set into operation. The co-ordinates of the window are set to the beginning of the television line

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scan and collection of data will start at the beginning of the next television field (line β). The calibration complete flag is cleared and the monitor output is enabled. The calibration mode flip flop is set which enables the interrupt. An interrupt will occur when calibration is completed if the interrupt facility in the PDP 12 has been switched on (ION).

CLCAL 6304 - Clear Calibration mode; all flags and mode flip flops in the calibration control are cleared.

CAGOFR 6305 - Calibration Go Free Run mode; the calibration control is set into operation as before except that the calibration complete flag is inhibited and the right hand margin becomes inoperative. The window will therefore operate continuously. This instruction is used for maintenance purposes.

CCAFL 6306 - Clear flag; the calibration complete flag is cleared.

SCAC 6307 - Skip if Calibration is Complete; the next instruction in the program is skipped if the calibration complete flag is set. The flag is then cleared.

5.3 Programming Examples

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The first example program shows how the interface is initialised and set into operation to generate co-ordinate data. In this example sense switch \emptyset is used to start and stop data collection, and a limit is placed on the amount of data collected. If this limit is exceeded the program automatically stops data collection by disabling the co-ordinate generator, the program then enters a routine to process the collected data (not shown). The interface will start transfer of data at location $2\emptyset\emptyset\emptyset_8$ of memory field I as defined by the composite address. The address limit is location $4\emptyset\emptyset\emptyset_8$ of memory field 2 as defined by 'end memory address' and 'end field address'. This limit may be exceeded by a maximum of $3I_{10}$ words allowed for by the instruction on lines 76 and 77. This example also demonstrates how a program may be run independently of data transfer. Interaction with the interface is provided by the subroutine (SAI) which monitors the locations in memory used by co-ordinate data.

The second example shows how a program may control some of the other parameters of the interface. In this example the Field Count Register is set to 905_8 and the Field Count mode can be enabled if sense switch 1 on the computer is set. This will limit the sampling rate of the Co-ordinate Generator

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					100
0000			*20		
0331				FXWMFTE BROCHWW	1
0002			/		
0003			19-1-76		
0004			1		
0005				LODSYM	/LJAD INTERFACE
3396			/		MNEMONICS
			• •	PADDF.	11.V 15/10 VI 0.5
0307					
0010				*20	
3311	0050	6002		IOF	/TURN INTEREUPT OFF
ØØ12	ØØ21	6322		DISCG	/DISABLE CO-ORDINATE
ØØ13	33 55	7330		CLA CLL	/GENERALOR
0314	3023	1.055		TAD CAD	/SET UP INITIAL ADER
0015	9924	6333		LDCA	/IN ADDRESS REGISTER
Ø 316	0025	6331	•	ENAD	/ENABLE ADDRESS LIVES
0017	0026	6332		ENFAD	
9950	ØØ27	6141	3	LINC	
Ø321				LWODE	
3388	9339	9449		SVS Ø	/ENABLE CG ?
II.	3334	6333		JMP 1	/NO. WAIT
0324	0032	2500		IOR	ITES, ENARLE CG
0025	0033	6321		ENCG	
	2034	6056		JMP SA1	/GO TO SUBEOUTI VE
0386					
0327	ana 3035	3460		SNS I Ø	CONTINUE ?
3333	0036	6934		JWB S	/ Y F.S
0031		9539		IOB	/NU, DI SABLE CG
0032	0040	6355		DISCG	
0033	0341	0.539		IOB	ZREAD & SAVE CURRENT
8034	0042	6336		RCFA	/FIELL ADDRESS
0035	0043	4053		STC CFA	
					ZREAD'& SAVE CURRENT
ØJ36	3344	3530		IOB	
9937	3045	6335		RCA	/MENJRY ADDALSS
9340	3] 46	4054		STC CA	
9341	3347	1320		LDÁ I	/GENERATE I/J PRESET
3342	3959	1351	and the second second	3323	VIO CLEAR ALL FLAGS
0043	3351	3334		ESF	
3344	0352	6839		JAP PROC	VENTER PROGRAM TO
3945	9000	C 2.14,17		Unit Thou	PROCESS LATA
					FROOTED LATER
0346					
3347	an the sector of				
3754	4				
0051	0053	3333	CF A.	3	. •
0052	3954	0003	CA,	J	
9353	0055	2331	CAL	2001	/COMPOSITE ADDRESS
0954		•	4		
3 055			.		
	ten kara sa	•			
2356					
0057			VSUBED	UTINE TO READ CUA	RENT ALLRESS USED Br
0060	1. 1. 1. 1.		/INTERI	FACE AND CHECK A	GALNST PRESET ADDRESS
2361	n n n n n n n n n n n n n n n n n n n		/LIMIT	•	
0062					
3363	State State State State			LMODE	
3364	7362	1030	SA1,	LDA	Index provided Attraction
	3456	1009	2411		SAVE RETURN ADDRESS
0065	0057	0030		Ø	
9966	2060	#101		STC SA10	
0067	0061	0500		IOB	/READ CURRENT FIELD
0373	3966	6336		RCFA	ADLRESS
2371	2763	1440		SAL	/=END FIELD ADDRESS ?
3372	0964	0198		LFA	in τη τη φαρεία ψη βραγή του τους δραματίσται σωματή το του διατηθικό τους τους τους τη ψηγη. Τη ποιος Για ποιος
0073	0065	6131		JMP SA10	
3373					/NOS RETURN
	0066	0500		IJB	YES, READ CURRENT
0375	0067	6335		RCA	ZMEMORY ADDRESS
-	an a				

		54
0376 0373 1560	15/31 F	
0376 - 0373 1560 0377 - 0371 - 0337	PCL I 0037	ZER 5 LEAST SIGNIE
0077 0071 0037 0103 0072 1440	SAF	ZRITS TO ZERO
0101 0073 0103	лан Тар	Z=EVD NENORY ADDRESS
0191 9073 9193	JAP SAID	VNJ, HETOHN
0103 0975 1920	LDA I	YES, ADD 2 10 HETURN
0104 0076 0002	5	ADDRESS
3105 0977 1149	ADM	 (31/1/11/10/0
ð136 - 0100 - 0101	SA10	
0107 0101 6000	SA10, JMP 0	/RET URN
9110	1	
Ø111	1	
0112 0102 0002	FEA 2	ZEND FIELD ADDRESS
0113 0103 4000	EMA, 4000	ZEND MEMORY ADDRESS
0114 0115		
0115 0116		
3116		
Ø120	PROGRAM TO PROC.	666 NATA
0121	*200 *200	10-0-0 - 1219 1 ()
9122 9209 9916	PROC NOP	•
	· _ · • •	
NO EERORS of a second		
CA Ø954		
CAD Ø955		
CAGU 6303		
CAGDER 6395		
CCAFL 6306		
CDPF 6347		
CDPI 6344 CDPM 6342		
CFA 3953		
CFC 6315		
CLAD 6334		
CLCAL 6304 CON CLASS		
CSM 6316 State Codes		
DBM 6341		
DI SCG 6322	•	
FFA 3102		
EMA 3103		
FNAD 6331		. •
ENCG 6321		
FNFAD 6332		
ENFC 6313	J	
ENMON 6331		
ENSM 6314		
LDCA 6333		
LDCAM 6302		
LDFC 6311		
LDLC 6312	e e e e e e e e e e e e e e e e e e e	
PROC 3839		· ·
RCA 6335		
RCFA 6336		
SA13 0056 SA13 0131 0050		
SCAC 6307		
SCFH 6345	•	
SUBH 6346		

					1 4 1 1 2
0730			*23		
0001				EXAMPLE PROGRAM	4 9
0002			/ 2016	LAMAPEDS PROGRA	и с.
9093 aaax			/12-1-		
0004			/		<i></i>
0005				LUDSYM	/LOAL INTERFACE
0396			/		MARMONICS
3007			/		
Ø310		·		PMJDE	· · · · · · · · · · · · · · · · · · ·
3911				*20	
JJ15	Ø959	6008		IUF	ZTURN INTERRUPT OFF
0013	0021	6322		DISCG	/DISABLE CG
0014	0355	7300		CLA CLL	
0015	3953	1962		TAD CAL	/SET UP INITIAL ADDA
3316	Ø 0 24	6333		LDCA	/IN ADDRESS REGISTER
Ø Ø 17	0025	7230		CLA	
0953	0026	1060		TAD SLCT	/SET UP LINE COUNT
0021	3327	6312		LELC	/REGISTER
1022	0039	7225		CLA	
0 J23	9931	1061		TAD SFCT	SET UP FIELD COUNT
3324	0032	6311		LDFC	ZREGISTER
3325	0033	6341			
				DBM	/SET DEL BUFFER MUDE
1026 2007	0034	6331		ENAL	ZENABLE INTERFACE
0327 0327	0035	6332		ENFAD	ADDRESS LINES
0030	2036	6141		LINC	
0031				LMODE	
0332	0037	3441		SVS 1	VENABLE FIELD COUNT? "
ØØ33	9043	6043		JMP •+3	CR.V
0034	0341	0530		IOP	· /YES
Ø935	0342	6313		LVFC	
Ø936	0043	0442		SNS 2	ZEVABLE SIMULATOR?
ØØ37	0344	6047		JMP + + 3	C.V.V
3343	0045	3599		IJB	ZYES
3941	9346	6314		EVSM	
3342	3347	3440		SNS 0	VENABLE CG?
3343	0350	6047		JMP •-1	/NO. WAIT
0344	0051	0593		IOB	IYES
0045	37352	6381		ENCG	
3346	Ø 353	3460		SAS I Ø	/CONTINUE SAMPLING?
0347	0354	6353		JMP -1	/YES
0 3 50	2355	0500		IOB	
0051 0051	2055	6322			/NO, LI SABLE CG
3352 3352	0057	6220		DI SCG	
0353	0051	0220		JWB NB	/GO TO NEW PROGRAM
0054		•			
0055 0055					
0256					
Ø957	0963	0177	SLCT.	0177 -	/LINE COUNT
3363	0061	0005	SFCT,	5	/FIELL COUNT
0361	Ø362	6395	CAL	6002	/INITIAL ADDRESS 6000
396S			/		IN MEMORY FIELD 2
0063			1		
3364			1		•
0065			1		
0066				*800	
0067	7203	0016	VP.	NOP	
0.373			/	· • • • •	
0971		· · · ·	1	•	
			•		

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CAGO 630;	3
CAGDER 630	
CCAFL 630	
CDRF 634'	
CDEI 634	
CDBM 634	
CFC 631	
CLAD 633	4
CLCAL 630	4
CSM 631	5
DPM 634	
DISCG 632	
ENAD 633	
ENCG 638	
ENIBI 634	
ENFAD 633	2 , the second se
ENFC 631	
ENMON 630	
FNS4 631	
LDCA 633	
LDCAM 630	
LDFC 631	
LDLC 631 VP 020	e. O server production and the server production of the server of the server of the server of the server of the ser
RCA 633	
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SCBH 634	
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such that co-ordinates will only be generated on every 5th television field The Line Count Register is set to 177, and simulated marker pulses (10 Hz). will be generated if the simulator is enabled (by setting sense switch 2). These simulated pulses will appear on two lines in each television field as defined by the contents of the Line Count Register; the combinations of pulses previously shown in Figure 3.9 will be available on each of these lines and may be used to provide inputs to the marker detectors. In this way co-ordinates of known values will be generated and may be used to test data processing programs, data displays etc. This program also shows how the Address Register can be used in the Double Buffer mode to provide a re-circulating data buffer in computer memory. The Initial Data Address register, in the interface is set to 6002_{R} which is translated by the interface into a 15 bit starting address for the Address Register - location 6000 in memory field 2. When co-ordinate data is generated it will be transferred to computer memory starting at this location, and the Address Register will be incremented upwards. When location 7777, of memory field 2 has been filled the interface will automatically reset the Address Register to the starting address held in the Initial Data Address register. By using the Address Register in this way the area in memory which the interface may access can be limited, in this case to 102410 locations. The use of the Double Buffer mode to "double buffer" incoming data (so that data may be transferred to mass storage as it is received) is discussed in the next chapter.

The Co-ordinate Generator is enabled by setting sense switch \emptyset on the computer console. As soon as this is done the interface will begin to generate the co-ordinates of any marker signals detected in the video channel inputs. Generation of co-ordinates will continue until sense switch \emptyset is reset. The program could easily be expanded from this point to process data and, for example, to display the trajectories of markers in real time.

Solitore Semucry

5.4 A Method of Decoding

The order and format in which data is stored in computer memory by the interface has been described in relation to the hardware in Chapter 3 and an illustration was given in Figure 3.7. In order to explain a method of decoding the data, the data format will be described in relation to programming. In

this section a "data block" refers to the data generated by the interface for one television line, and will therefore be of variable length (3 to 7 words). A "data record" is all the data generated by the interface during a particular test. The length of this record is limited by computer core memory size or, if data can be double buffered and transferred to disk storage, by available disk space.

Due to the way in which the Co-ordinate Generator operates the first word of any data block will always be a vertical co-ordinate, there may then be up to 5 horizontal co-ordinates followed by the shift register code word. This code word will always be followed by the vertical co-ordinate of the next data block, except for the last word in any data record. The address of this last word will, however, have been read and stored by the computer program using the appropriate interface instructions. This data format is illustrated in Figure 5.1.

The camera code for each Horizontal Co-ordinate (HC) is made up of 3 bits; two of which are in bits Ø and I of the HC word, and the least significant bit is contained in the Shift Register (SR) word. The bit format for a data block is shown in Figure 5.2. The position in the SR word of the additional code bit corresponding to each HC is clearly shown in this figure. To reconstruct the camera code for each HC the subroutine shown in Figure 5.3 and 5.4 may be used. This subroutine would be entered once for each horizontal co-ordinate, starting with HCl as shown in Figure 5.2. The reconstructed camera code is left in the Accumulator on exit from the subroutine.

The method shown here is just one of several possible ways of reconstructing the camera code. The details of this method may be changed to suit other parts of a program, as has been done in some of the programs shown in Appendix A3.

5.5 Software Summary

All programs for data acquisition and interface control have been written in assembly language as have programs for calibration and data display, as this was the most suitable method available at the time. Full details of the programs summarized in this section will be found in Appendix A3, in the form of listings and, where appropriate, flow charts.



Figure 5.1. Data format for interface generated data.





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	PAUDE	
SCUDE	8439 ·	ZREIURN ALLRESS
	LINC	
	LMUDE	
	RJK I 1	VCOLE PIT INTO LINK
	STC SR	ZAND REPLACE SK
	ADL HC	VEETCH HC
	RJR 12	/CODE BIAS IVID 10,11
	ROL I 1	VADL THIRE CODE BIT
	RCL I	/CLFAR BITS 0-8
	7779	
	PDP	
	PMULE	
	JAP I SCJUE	/DETURN

Figure 5.4. Computer program to decode interface generated data.

5.5.1 Real Time Display

The program DYDIS (Dynamic Display) provides a real time display of data generated by the interface. Co-ordinate data is transferred, by the interface, to a 1,000 word re-circulating buffer in computer memory. The program then decodes the data and stores it in one of six display buffers according to camera code. Any one of these buffers may be selected for display at any time during the running of the program. The camera code of the data currently being displayed is included in the display. The interface simulator can be controlled and may be used to provide simulated inputs to the marker detectors to generate co-ordinates for display. The Field Count mode may also be selected to reduce the sampling rate of the interface. Because the generated co-ordinates are displayed in real time the data rate is limited in order to avoid display flicker, this limit has been found to be approximately 4,000 words/sec. If it is desired to generate and display a large number of points in one television field and a reduction in sampling rate is acceptable then the Field Count mode can be used. · "这个是你的你的你,这个人的是一个人。"

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5.5.2 Data Acquisition

The main task of acquiring co-ordinate data and decoding it is accomplished by the program DP (Data Process). This program controls the acquisition of data from the interface, decodes it and stores the decoded data on magnetic tape. Six of the analogue channels of the PDP 12 may also be sampled on receipt of clock pulses generated by the interface, and this data will also be stored on magnetic tape. The sampling rate for this facility is controlled by the contents of the line count register. Processed co-ordinate data is stored in the format:- television field number (time co-ordinate), followed by the vertical co-ordinate, followed by the horizontal co-ordinate. These three co-ordinates are provided for every point detected in the video signals of each camera in the system. Data from each camera is stored in a separate sequence of tape blocks. The end of each sequence, or camera record, being indicated by at least three consecutive words of 7777_8 . The camera (channel) number is indicated by bits 1, 2 and 3 of the time co-ordinate word; and bit \emptyset of this word, if set, indicates that the analogue channels of the computer were sampled.

Other facilities provided by the program include the ability to set a limit on the amount of memory used by the interface, the interface is disabled when this limit is reached. The sampling frequency of the interface may be controlled by entering the Field Count mode, and the simulator may also be used by this program. The various options are selected and their parameters are controlled from the computer console switches and by presetting registers in the program.

5.5.3 Calibration Data Acquisition

The acquisition of a matrix of calibration points from a grid of markers placed in the field of view of the camera is accomplished by the program CALMTX (Calibration Matrix acquisition). This program operates the calibration control of the interface, to generate the co-ordinates of the grid of markers. This data is then decoded and stored on tape in the format:- vertical coordinate followed by horizontal co-ordinate, for each point detected in the No time (field) co-ordinate or camera code is stored as these video signal. parameters will not change during data acquisition. Having acquired the grid co-ordinates the program then goes on to reduce this data, by simple averaging, to one co-ordinate pair per grid point. The results of this data reduction are displayed so that the success of the grid acquisition can be verified. If the program is allowed to continue then the reduced grid data is re-organised into a calibration matrix for use with the program CAL (Calibrate). This matrix consists of two arrays, one for the vertical co-ordinates and one for the horizontal co-ordinates. The positions of the co-ordinates in the arrays correspond to the positions of the markers on the grid. The results of this data reorganisation are displayed and if satisfactory may be stored on tape.

5.5.4 Calibration

The calibration program, CAL, is designed to implement the first method of calibration outlined in section 3.3.5. The locations on tape of the calibration matrix and the data to be calibrated are provided in response to questions displayed on the VDU (Video Display Unit). The starting block on tape to which calibrated data is to be written is also provided in this way. Once calibration of the data has been completed these questions are repeated and a new set of data may be calibrated. The program processes the data, television field by television field. First of all the data for one complete field is examined and co-ordinate pairs which meet a proximity criteria are averaged to provide one pair per marker. The subsequently reduced data is then calibrated against the calibration matrix. The flow chart and listing for this program in Appendix A3, show how this is done.

5.5.5 Data Display

A display program (DISC-CAL) provides a means of displaying calibrated data. 1024 co-ordinate pairs are read from tape into a display buffer, 512 of these pairs may be displayed at any one time. Selection of the starting point of the display is made by setting a potentiometer (analogue channel \emptyset) on the computer. The position in the display of a cursor is controlled by a second potentiometer (analogue channel 4), and the camera number, field number, and the values of the vertical and horizontal co-ordinates of the point indicated by this cursor are displayed in the top left corner. If the analogue channels were sampled this is indicated by the display of the letters FP (Force Plate). A typical display produced by this, program is shown in Figure 5.5. A second version of this program (DISF-CAL) displays a cursor for every point in the field selected by the potentiometer setting of analogue channel 4. The field number is displayed in the top left corner as shown in Figure 5.6.

Three other programs based on the above display programs have been written. These versions allow uncalibrated data to be displayed on the VDU. The data is scaled to fit the grid dimensions of the VDU. The first version, DISC, displays co-ordinate data together with a read out of the co-ordinates and other information of the point in the display indicated by a cursor. The second version, DISF, is similar except that a cursor for every point in a selected field is shown on the display. The third version, DISG, is for



Figure 5.5. Computer generated display produced by the program DISC-CAL from marker trajectory data. The figures are a read out of co-ordinates and camera channel number for the point indicated by the cursor.



Figure 5.6. Computer generated display produced by the program DISF-CAL for the same data as in the previous figure. The cursors show the points generated during television field 29, the subject is walking from right to left.

displaying grid data acquired by the program CALMTX. This data is organised in horizontal and vertical co-ordinate pairs and does not include a field word. A cursor is provided to select individual points in the display and produce a read out of the co-ordinates. The memory location (with the beginning of the initial tape block considered as location zero) of the point is also indicated. This program would provide the basis of an editing facility to remove unwanted points from grid data.

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CHAPTER 6

RESULTS AND DISCUSSION

6.1	Introduction
6.2	Interface Design
6.3	System Performance
6.3.1	Stability
6.3.2	Moving Markers
6.3.3	Extraneous Light Sources
6.3.4	Errors and Resolution
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6.5	Gait Data Acquisition and Marker Trajectory Identification
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6.1 Introduction

This chapter describes how the system was tested in all aspects of its design and in its suitability for human locomotion analysis. Measurement errors and methods of calibrating the data are discussed. The co-ordinates generated by the interface for the trajectories of markers placed on a walking subject are presented and a means of identifying markers from co-ordinate data is described. Some modifications to the basic design are suggested to give improved performance. The performance of the system is summarised and comparisons are made with other methods. The applications of the system are discussed and recommendations for future work are given. A photograph of the interface and its connecting cables to the PDP 12 is shown in Figure 6.1. A subject with markers in place is shown in Figure 6.2, the photograph was taken from behind the television camera light source in normal room lighting and gives an impression of the brightness of the markers compared with skin tones.

6.2 Interface Design

The efficacy of the interface design was evaluated using computer programs and the simulator. Initially programs similar to those shown in the examples of section 5.3 were used. These programs allowed the interface to operate under constant conditions, when the simulator was used to provide the marker detector inputs. It was thus possible to check that registers in the interface had been loaded with the correct data, that control logic was functioning correctly and that data transfers were taking place. Several important factors were revealed during the initial testing phase, which resulted in minor modifications to the original design.

The first modification was to terminate some of the signal lines from the PDP 12 computer. It was found that noise on the 10T pulses ([100] B10P 1-4) and the initialise lines ([100] BA and BB INITIALIZE) could occasionally cause false operations. This problem was solved by terminating these lines with the circuit shown in Figure 6.3, as recommended in Digital (1972). The other signal lines from the PDP 12 were also extremely noisy, and although this did



Figure 6.1. Television interface connected to the PDP 12.



Figure 6.2. Subject with reflective markers on anatomical landmarks, the lighting is positioned to obtain maximum brightness from the markers as seen by the television camera.



Figure 6.3. Terminating circuit for computer bu lines to reduce noise.

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not appear to present any problem they were terminated with similar circuits as a precaution (Accumulator lines [100] BAC 0-11, Memory Buffer lines [100] BMB 0-11, Data Break control lines [100] BREAK and [100] ADD ACCEPTED). The signals on these lines were "cleaned up" considerably by terminating, and thus the chance of false generation of logic signals in the interface was reduced.

The second of these modifications concerned the timing of the data transfer to computer memory. Originally the address accepted signal ([100] ADD ACCEPTED (0) H) on the PDP 12 Data Break control lines was used to strobe co-ordinate data onto the 10 bus data lines. The falling edge of this signal was also used to down count the address of the random access buffer memory in the Co-ordinate Generator, to access the next co-ordinate word in readiness for the next data transfer cycle. According to the "Single Cycle Data Break Input Transfer Timing Diagram", reproduced in Figure 6.4, this should have been satisfactory; however it was found that data was not being stored in computer memory. It will be seen from this timing diagram that data must be specified by time TP2 and will be strobed into a Central Processor register at TP3. The Address Accept pulse starts at TP1 and ends at TP3, and should therefore present the Interface data on the 10 bus at the correct times. Furthermore the internal computer logic signal in the Central Processor which ends the Address Accept pulse also causes the data presented on the 10 bus to be stored. As there is a typical delay of 43 nS in the interface before the data is removed from the 10 bus there should have been ample time for the data to be stored in the Central Processor (there would also be additional time caused by the connecting cable delays). Consultation with Digital Equipment Corporation engineers confirmed that this method of operation, although not normal practice, should have been satisfactory. The problem was avoided by using the logic described in section 4.4.5, which extended the duration of the Address Accepted pulse. An alternative solution, which provides all the necessary control signals required in the interface, is shown in Figure 6.5.

The final modification required was to the horizontal Co-ordinate Counter in the Co-ordinate Generator. Originally three SN 74161 binary counters

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Figure 6.4. Single cycle data break input transfer timing diagram. (From Digital (1971)).



were used in cascade. From the manufacturer's published characteristics for this device it was reasonable to expect them to operate at the design frequency of 20 MHz (Texas Instruments (1973a and 1973b), a typical maximum operating frequency of 25 MHz when used in cascade being quoted. However it was found that the devices would not operate at 20 MHz and a modification had to be made. This could have taken the form of "carry anticipate" circuitry as described in Texas Instruments (1973a) but a pin compatible counter (SN 74S163) with higher frequency capabilities became available and was directly substituted as described in section 4.4.3. In all other aspects of the interface design a "worst case" design approach had been adopted and in consequence no other problems of this nature occurred.

With these minor, but important, modifications the interface functioned as it was designed to. Figure 6.6. shows a partial print out of data generated by the interface. The Line Count Register was set to 378 and a simulator output having 7 marker pulses on it provided the input to the marker detector of channel Ø. The first column of the print out is the location in memory of the vertical co-ordinate which is shown in the next column. The next five columns are the horizontal co-ordinates of five marker pulses and the final column contains the Shift Register code word. The interface was generating co-ordinates on every television field, and the data generated over two fields is shown here. It can be seen that the horizontal co-ordinates remain almost constant as expected. The slight variations are due to one of two causes. Where there is only a 1 bit change then this could be due to the uncertainty caused by a marker pulse falling between two counts. Any greater change is most likely due to the fact that the simulated pulses are generated by monostable multivibrators with pulse durations of up to $42 \,\mu$ S, a slight variation in this time would produce such a change in co-ordinate value. Such variations are not critical and do not impair the usefulness of the simulator. The stability of the Co-ordinate Generator when used with camera inputs is discussed in the next section. It can also be seen from this print out that, although the simulator is set to generate pulses on every 37th_R line, the first line in each television field on which co-ordinates appear is line 418. This

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0541	6041	113	0750	0461	0244	0041	1400
0550	6120 1	114	0751	0462	0245	0042	1400
0557	6137 1	114	9751 .	0462	0245	0042	1400
0566	6176 1	113	0750	0461	0244	0041	1400
0575	6835 1	114	0751	0462	0245	0042	1400
		113	0750		0245	0041	1400
0613		113	0750	0461.	0245	0041	1400
0655	6372 1		0751	0462	0245	0042	1400
0631		114	0751	0462	0245	0042	1400
0640		113	Ø750	0461	0245	0941	1400
		114	0751	0462	0246	0042	1403
0656	6576 1	113	0750	0461	Ø245	0041	1400
Ø665	6627 1	114	0751	0462	0246	0042	1400
0674		113	0750	0461	0245	6641	1400
0703	6725 1	113	0750	0461	0245	0041	1409
0712	6764 1	113	0750	0461	0245	0041	1400
0721	7023 1	114	0751	0462	0246	0042	1400
0730	7062 1	113	0750	0461	0244	0041	1400
Ø737		114	0751	0462	0246	0042	1400
0746	7160 1	114	0751	0462	0245	00.42	1400
07.55	6641 1	113	0750	0461	0244	0041	1400
0764	6180 1	114	0751	6462	0245	9642	1400
0773	6137	114	0751	0462	0245	2042	1400
1002		113	0750	0461	0244	0041	1430
TOTI	6235 1	T12	0751	0462	0245	0042	1400
1020		113	0750	0461	0245	0041	1400
1027		113	0750	0461	0245	0041	1400
1036		114	0751	0462	0245	0042	1400
1045		114	0751	0462	0245	0042	1400
1054		113	0750	0461	0245	0041	1409
1063	6581 1		07.51		0246	0042	1400
1072		1113	0750	0461	0245	0041	1400
3961101			1				1400
1110		113	07,50	9461	0245	0041	1400
			0750	0461	0245	0041	1400
1126			0750	0461	0245	0041	1400
1135		113	0750	0461	0245	0041	1400
1144	한 것 같은 영향을 위해 한 것을 다 가슴다. 한	이 승규는 가격 가격하는 것			0245		1400
1153		114	0751	0462	0245	0042	1400
1162	7169 1	113	0750	0441	<u>m</u> 245	2041	1400
1 employed	CARD ON THE AS MAD			and a second s	S. E. Same		

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Figure 6.6. Print out of data generated by the system for simulated marker inputs. The first column shows the memory location of the vertical co-ordinate which is in the next column. The next five columns are the horizontal co-ordinates for five markers and these are followed by the shift register code word in the last column.

is due to the fact that the Line Counter is reset at the beginning of each field by the field sync. This print out also shows that further co-ordinate generation was inhibited on each line after five markers had been detected.

The program DYDIS is used extensively to check correct system operation, again by using the simulator to provide marker detector inputs. Figures 6.7 and 6.8 are photographs of the display produced while this program is running. Four simulated marker signals on each of 8 television lines in every field are being generated (data rate of 2400 words/sec). Three of the markers are on channel \emptyset and one marker is on channel I shown in Figures 6.7 and 6.8 respectively.

6.3 System Performance

The ability of the system to generate co-ordinates of markers and provide repeatable measurements is shown here. The material used for markers and the positioning of light sources has been discussed in section 2.2.1. The same degree of lighting has been used for all the tests reported here. This consisted of a single Malham SE23 lamp fitted with a 500W tungsten halogen bulb positioned as close as possible to the television camera lens. This configuration was used for each camera where two cameras were used. Normal room lighting was maintained.

6.3.1 Stability

To ascertain that the system could provide repeatable measurements a stability test was carried out. Stationary markers were used mounted on a board in the configuration shown in Figure 6.9. The distances between markers are also shown in this figure. The field of view covered by the camera in the plane of this board was 2.8 m by 2.1 m and the marker size required would be 7.7 mm calculated as shown in section 2.2.2. It was found, because there is a certain degree of flare, that a marker of 5 mm diameter could cover one or two television lines and this size of marker was used for the stability test. A thirty minute warm up time was allowed and then the co-ordinates of the stationary markers were generated by the interface. The interface was set to sample the spatial position of the markers once every 255th television field



Figure 6.7. Real time computer display of data generated by the interface using the simulator. Channel Ø data.



Figure 6.8. Data generated for channel I at the same time as that for channel \emptyset shown above.
2 3 8 m 8 0.25 m \$ 0.75 m 4 0.5 m. 8 •**⊗**... 8 5 6 1.1.1. and the second of the 10 a far i the deep to sea the 8 To Remove house a constance south on and at a strate with a strate state of the 📚 i tha is a chaitea a' 177 i ... 8 **8** 13 12 11 自己的 动 戴皮 建铁瓦姆热 薄荷 核 化二溴苯乙二甲 was alle in the second and second in the Figure 6.9. Configuration of markers used to test the stability of the En char anter system. dans concerter and we have been possible a flat to be The Rive of Androphick \$350 Stores The standard with the standard the state of the second second the data and the state of the

(5.1 sec). Sixteen sets of co-ordinates were obtained and then the system was left for two and a guarter hours after which time a further sixteen sets of co-ordinates were obtained. The co-ordinates generated for each marker were then compared. Almost perfect agreement was found between each set of data. The co-ordinates generated for markers 10, 11, 12 and 13 are shown in Tables 6.1 and 6.2, similar agreement was found between the repeated measurements for the other markers. Table 6.1 shows the co-ordinates for the "even" television field (vertical co-ordinates between 0 and 312) and Table 6.2 shows the co-ordinates for the "odd" fields. These particular markers have been chosen for illustration because they occur towards the end of the television field and any malfunction in the vertical co-ordinate counter, for instance, is more likely to have occurred by this time. These results show that the system can provide repeatable measurements of the spatial position of markers. The results shown above were obtained using a simple threshold detector to detect markers in the video signal. Similar results were obtained for the more elaborate marker detector described in section 2.2.4.

6.3.2 Moving Markers

To demonstrate that the system can generate the co-ordinates of moving markers a rotating disc was used. A marker was placed near the outer edge of this disc at a radius of 22.5 cm. The field of view of the camera in the plane of the disc was 3.2 m by 2.4 m and a marker size of 7 mm diameter was used. The disc was rotated by a synchronous electric motor through a variable reduction gearbox. Figure 6.10 is a plot of the co-ordinates generated by the interface for one complete revolution of the disc. The vertical coordinate has been scaled, the scaling factor being found from the diameter of the disc in horizontal co-ordinate units (142) and in vertical co-ordinate units (54) giving a scaling factor of 2.63. It can be seen that one complete revolution of the disc was made in 19 television fields or 380 mS (2.63 revs/sec). The marker will, therefore, reach a peak velocity in the x and in the y directions of 3.7 m/S and a peak acceleration of 61.4 m/S². It can be seen that at least one pair of co-ordinates was generated for the marker in every television field. The velocities and accelerations reached by the marker

TV Field	10)	11			2		13		
0	239	504	275	150	273	504	270	860		
2	239	504	275	150	273	504	270	860		
4	239	504	275	150	273	504	270	860		
6	239	504	275	150	273	504	270	860		
8	239	504	275	150	273	504	270	860		
10	239	504	275	150	273	504	270	860		
12	239	504	275	150	273	504	270 ·	860		
14	239	504	275	150	273	504	270	860		
	Co-o	rdinates	g ene rat	ed after	30 minu	ut <mark>e w</mark> ar	m up pe	riod.		
TV Field	10		11		2		13			
0	239	504	276	151	273	504	271	858		
2 2	239	504	276	151	273	504	271	859		
4	239	504	276	151	273	504	271	858		
6	239	504	276	150	273	504	271	858		
8	239	504	276	151	273	504	271	858		
10	239	504	276	151	273	504	271	858		
12	239	504	276	151	273	504	271	859		
4	239	504	276	150	273	504	271	858		
	1. A.	L. Barry								

Co-ordinates generated 135 minutes later.

Table 6.1. Co-ordinates generated by the interface for markers 10, 11, 12 and 13 of Figure 6.9 during "even" television fields, showing the stability of the system. The interface was set to sample at a slow rate, one field every 5.1 secs.

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TV Field	10					2	13	
I	551	504	587	151	585	503	583	860
3	551	504	587	151	585	503	583	860
5	551	504	587	151	585	503	583	860
7	551	504	587	151	585	503	583	860
9	551	504	587	151	585	503	583	860
11	551	504	587	151	585	503	583	860
13	551	504	587	151	585	503	583	860
15	551	504	587	151	585	503	583	860

Co-ordinates generated after 30 minute warm up period.

TV Field	10				12		13	
1	552	504	588	151	586	503	583	859
3	552	504	588	151	586	503	583	859
5	552	504	588	151	586	503	583	859
7	552	504	588	151	586	503	583	859
9	552	506	588	151	586	503	583	859
11	552	504	588	151	586	503	583	85 9
13	552	504	588	151	586	503	583	859
15	552	504	588	151	586	503	583	859

Co-ordinates generated 135 minutes later.

Table 6.2. Co-ordinates generated by the interface for markers 10, 11, 12 and 13 of Figure 6.9 during "odd" television fields, showing the stability of the system. The interface was set to sample at a slow rate, one field every 5.1 secs.

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Figure 6.10. Plot of data generated by the system for a marker on the periphery of a rotating disc. The vertical co-ordinates (y) have been scaled and the television field numbers, during which each part of the trajectory was formed, are indicated.

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Antoniellenten will no generated in the second s Second compare favourably, as a realistic test for a locomotion measurement system, with the maximum velocities and accelerations reported by Winter (1974) and shown in Table 6.3. The fastest moving marker in this table is the heel marker (5) for fast walking (average cadence of 114 strides/min), which reaches average maximum vertical and horizontal velocities of 1.76 m/S and 3.78 m/S respectively.

The co-ordinate data generated by the interface for the rotating markers shows up an interesting characteristic of the television camera. This is the storage property of the pick up tube target. It can be seen that the sequence of co-ordinates generated for the marker in each television field is a part of the total trajectory of the marker. That is, it is the path traversed by the marker during the time taken to scan one complete television field (20 mS). If this sequence of co-ordinates is averaged then the average position of the marker between sample instants will be found. If the marker is moving with constant velocity then there will be no error caused by this averaging process. If there is any acceleration, however, then there will be an error, which will be discussed in 6.3.4. The missing portion of the marker trajectory between television fields 12 and 13 was caused by the disc mounting assembly which concealed the marker at this point.

The two types of marker detector have both been used in this type of test and found to perform satisfactorily. Co-ordinates are generated on receipt of a positive going edge from the marker detector, which corresponds to the leading edge of the marker pulse. In most cases this does not lead to any significant error because the duration of the marker pulse is short and similar to the time taken to generate co-ordinates. However, if the marker is moving parallel to the television camera scanning lines then co-ordinates will be generated for the leading edge of the trajectory only. In Figure 6.10 it can be seen that this has probably happened on some television fields (8 and 9 for example). This would be a source of measurement error, however the logic shown in Figure 6.11 could be used and then a series of horizontal co-ordinates would be generated for a trajectory lying parallel to the line scan.

6.3.3 Extraneous Light Sources

Co-ordinates will be generated for extraneous light sources of sufficient brightness in the field of view of the camera. Precautions can be taken to ensure that the number of such sources is minimised or eliminated by removing

Average cadences: Fast-114/min, Normal-93/min, Slow-82/min												
					Vertical. (Max.		94. 3 X.	Horizonul, (X)				
Marker No.	Speed of walk	No. of subjects	Displacement Range (cm)		ity (cm/sec) Down		n (cm/sec ²) Down	Velocit Min.	y (c m/sec) Max.	Acceleration Min.	n (cm/sec ²) Max.	
1	Fast	8	5-9(1-2)	34(7)	32(10)	570(180)	500(190)	75(20)	154(35)	- 480(190)	460(170)	
	Normal	12	5-8(0-7)	31(4)	27(6)	530(120)	390(70)	66(16)	126(12)	- 380(90)	360(60)	
	Slow	8	4-9(0-7)	25(5)	19(5)	360(84)	280(50)	46(13)	104(15)	- 400(90)	310(60)	
2	Fast	8	8-9(1-8)	55(7)	41(11)	800(160)	820(340)	26(15)	235(52)	980(530)	1270(439)	
	Normal	12	8-1(1-9)	46(7)	36(10)	660(150)	620(100)	23(11)	201(15)	760(250)	1060(210)	
	Slow	8	7-(1+2)	35(9)	25(7)	430(140)	410(100)	19(7)	156(30)	6:30(170)	690(150)	
3	Fast Normal · Slow	8 12 8	7:4(1:2) 6:6(0:9) 6:2(1:1)	49(9) 38(8) 29(8)	34(14) 34(14) 34(9) 23(7)	72(x190) 55(x1(k)) 37(x120)	690(310) 490(100) 370(60)	15(11) 14(9) 12(7)	244(57) 204(17) 167(26)	- 94()(440) - 77()(230) - 6()()(150)	1380(560) 1060(120) 800(150)	
. 4	Fast	8	17-3(1-0)	105(26)	120(33)	1280(480)	1920(880)	0(0)	346(82)	- 3030(1390)	1590(610)	
	Normal	12	16-8(1-5)	97(14)	99(9)	1320(610)	1490(210)	0(0)	294(27)	- 1930(220)	1170(210)	
5	Slow Fast Normal Slow	8 8 12 8	16-9(1-7) 25-0(1-8) 24-4(1-7) 23-9(2-4)	81(21) 170(46) 147(13) 125(19)	87(14) 168(41) 143(10) 123(19)	800(220) 1710(700) 1350(200) 1050(280)	1300(290) 2890(1200) 2250(270) 1690(290)	0(0) 0(0) 0(0) 0(0)	239(34) 378(93) 323(28) 266(38)		830(180) 2000(870) 1340(160) 990(210)	
6	Fast	8	11-9(1-2)	96(14)	91(13)	1690(510)	2010(200)	0(0)	408(103)	-3260(1590)	2540(530)	
	Normal	12	11-8(1-6)	91(11)	77(8)	1230(200)	1640(200)	0(0)	338(29)	-2240(330)	2070(260)	
	Slow	8	11-3(1-7)	85(19)	74(21)	980(210)	1250(250)	0(0)	277(42)	-1700(380)	1530(360)	
7	Fast	8	11-9(1-7)	100(16)	106(23)	1550(430)	2690(570)	0(0)	425(198)	- 3040(1360)	3660(1270)	
	Nor nal	12	12-6(2-7)	98(18)	98(6)	1210(180)	2320(400)	0(0)	351(30)	- 2100(210)	2800(280)	
	Slow	8	12-9(2-3)	87(16)	78(21)	1070(280)	1930(510)	0(0)	286(42)	- 1550(370)	2210(380)	

Table 6.3. Linear trajectory data of anatomical landmarks during locomotion. Presented by Winter (1974).



shiny objects, and by the use of drapes. The camera lens aperture is set to obtain maximum contrast between markers and background. If co-ordinates of extraneous light sources are generated then they can be eliminated in subsequent data processing to be described in section 6.5, their only effect is to increase the data rate.

6.3.4 Errors and Resolution

The resolution of the system is one part in 292 in the vertical scan and one part in 1000 in the horizontal scan. The resolution in terms of distance is determined by the field of view of the camera.

The co-ordinates of a marker are generated when the video signal level caused by the marker rises above a pre-determined threshold. Figure 6.12 shows three markers all of which would be given the same vertical co-ordinate, because the signal level caused by each only rises above the threshold level on line 2. The actual vertical co-ordinate of the centres of markers 1 and 3, however, differs by $\frac{+}{2}$ a line from marker 2. This difference represents an uncertainty in the vertical co-ordinate of $\frac{+}{2}$ a line. A similar situation exists for the horizontal co-ordinate and there is an uncertainty in its position of $\frac{+}{2}$ a horizontal unit.

A more serious error can occur, as already mentioned, when a marker is moving parallel to the camera scanning lines. If the marker is moving with high velocity then even the logic shown in Figure 6.11 would not provide enough co-ordinates to cover the entire trajectory. The magnitude of this error depends on the horizontal field of view of the camera and on the marker velocity. If co-ordinates are only generated at the beginning of the trajectory then the error in average position of a marker moving at 5 m/S horizontal velocity could be as high as 5 cm in a 20 mS period between samples. This error could be reduced by designing logic to generate the co-ordinates at the beginning and at the end of a trajectory. Alternatively, since in locomotion the highest components of velocity are in the horizontal direction (Winter (1974)), the camera could be turned on its side and high speed horizontal trajectories would then cross the scanning lines.





Figure 6.12. Three markers which would all be given the same vertical co-ordinate (line number).

The error caused by averaging a marker trajectory between sample instants is proportional to the acceleration of the marker during this interval and is given by -1/8 a t² (for constant acceleration), where a is the acceleration and t is the time between sampling instants. For this system t is 20 mS so the error becomes -0.05 a.10⁻³. For an acceleration of 50 m/S² an error of 2.5 mm would arise from the averaging process. Since such high accelerations are only occasionally reached it would seem that averaging of marker trajectories is an acceptable procedure for most applications.

There is an inherent phase difference in sampling instants for different markers. This depends on their spatial relationship to each other with respect to the television camera scanning rastor. The position of a marker in mid field, for example, would be sampled some 10 mS later than a marker at the beginning of the field. The range of vertical movement of anatomical landmarks tends to be restricted in locomotion and there would, therefore, be little phase error between samples for the same marker. Corrections can be made for phase errors between markers because the position in the scanning rastor of a marker is related to time.

Phase errors and errors due to averaging of trajectories could be eliminated by the use of a rotating shutter. Such a method is used in the Dutch system Ingen Schenau (1973). The shutter consists of an opaque disc with a transparent window, it rotates in synchronism with the television field synchronising pulse so that the window is positioned over the camera iens during the field blanking period. The size of the window is chosen so that the camera is exposed to the field of view for approximately I mS. The light pattern picked up is stored on the camera target plate until it is scanned. The disadvantage with using this method is that a camera tube with a very rapid response is required in order to register the reduced light levels in the short exposure time. Such tubes tend to be much more expensive than the normal Vidicon tube;

The television camera scanning rastor is not perfectly linear and hence errors will arise due to these non-linearities. The manufacturer's specification quotes a maximum non-linearity of $\frac{+}{-1}$ % in the line scan and $\frac{+}{-\frac{1}{2}}$ % in the field scan, with the total error not occurring in less than half a line or half a field (KGM (1971)). A corresponding non-linearity will be introduced into the co-ordinates of markers detected in the video signal. Corrections can be made for this error by referring measurements to a calibration grid, either directly or by the use of equations as discussed in section 3.3.5.

Errors due to parallax can be corrected, if the system is used in a three dimensional configuration, by the same techniques that are used in cine film analysis (e.g. Paul (1967)).

6.4 Calibration

Data can be calibrated by generating the co-ordinates of the spatial position of markers at a known separation. This was effectively done to plot out the trajectory of the marker on the rotating disc of Figure 6.10, and it can be seen that the circle has been faithfully reproduced.

It has been possible to acquire the co-ordinates of a grid of markers using the Calibration Control, but it has been necessary to include a sloping row of markers at the top of the grid. The top row of markers is used to set the limits for the Calibration Control window referred to in section 3.3.5. For the control to function correctly markers must either slope downwards from left to right with respect to the television camera scan line or be horizontal to this line. If the markers slope upwards then the control will set the wrong window limits. This situation was catered for in the design by incorporating a "free run mode" and a monitor output. The control would be operated in this mode and the camera rotated until it could be seen on the monitor that the control was functioning correctly. It was found, however, that it is inconvenient to rotate the camera and that the control could operate successfully off a sloping row of markers. An example of a grid of points generated by the interface using this control is shown in Figure 6.13. A new design for a simplified Calibration Control is discussed in section 6.8.

The operation of the calibration program CAL was successful when a simulated calibration matrix was used to calibrate real data. Some 2000 co-ordinate pairs were reduced to one co-ordinate pair per marker in each

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and he was a successful. One factor which are straight a used and

Figure 6.13. Data points generated by the interface for a grid of markers using the calibration control. The sloping row of markers used to set up the window limits can be seen at the top.

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television field and calibrated against the calibration matrix in a matter of seconds. The part of the grid data acquisition program (CAL MTX) which organised the grid data generated by the interface into a calibration matrix was not however successful. One factor which occasionally caused malfunction of the program was that the number of co-ordinates collected for the grid markers was underestimated. The program had been written to cater for a maximum of 2000 co-ordinate pairs and this limit was sometimes exceeded. Also no facility was provided by this program to select out unwanted co-ordinates, such as those generated for the sloping row of markers, which would lead to errors in building the calibration matrix. Such a facility could be provided very effectively by utilising the visual display unit of the PDP 12.

6.5 Gait Data Acquisition and Marker Trajectory Identification

In the first example of gait data generated by the system data was collected simultaneously for two television channels and the force plate. One of the television channels was connected to a simulator output which generated a marker pulse half way down the television field (line 160). The second television channel was connected to a camera output to record the side view trajectories of markers placed on a subject's limb. Markers were placed over the hip, knee and ankle joints and on the foot. Some of the data generated for these markers is shown in Figure 6.14 the read out for the cursor showing that the force plate was also sampled during the television field indicated. This is a display produced on the PDP 12 visual display unit by the program DISC (Display with cursor). The number of points displayed is limited by the computer program to 512, this limitation being necessary to avoid display flicker. The co-ordinates shown are unprocessed in that they have not been averaged to produce one co-ordinate pair per marker in each television field. Data that has been processed in this way (by the program CAL) is shown in Figure 6.15; this data was also calibrated against a simulated calibration matrix. Here the complete trajectory is shown, and also a stationary marker that was positioned in the field of view of the camera to provide a check on the stability of the system during this test. No significant change was observed in the co-ordinates generated for this marker. At the same time that



Figure 6.14. Computer display of unprocessed data showing part of the trajectories of markers placed on a subject's limb. Markers were placed on the hip, knee, ankle and foot.



Figure 6.15. Data of Figure 6.14 averaged to produce one co-ordinate pair per marker per television field and calibrated against a simulated calibration matrix. The bright spot is a stationary marker placed in the field of view to check stability.

the interface was generating co-ordinate data the computer was sampling the six analogue channels of the force plate. This data is shown in Figure 6.16.

The combination of data inputs described above tested a number of aspects of the interface design. The internal logic signals which generate the simulated marker pulse also generate the clock pulses which are used to initiate analogue to digital conversions of the force plate transducer signals. This means that co-ordinate data is actually being generated and transferred to computer memory between analogue channel samples. This showed that even time critical computer programs can be successfully run during interface operation. Also the multi-channel capability of the interface is illustrated by this test.

The data generated by the interface consists of a set of co-ordinate pairs for each television field. Co-ordinates may occasionally be generated for extraneous light sources in the field of view of the camera, and trajectories of markers may cross, making marker identification difficult. Obviously it is necessary to define which co-ordinates belong to which markers so that the data can be analysed. Marker identification can be achieved by the application of a linear extrapolation routine such as that reported by Ingen Schenau (1973). With this method the first two points of a marker trajectory are identified and then the routine automatically locates the remaining points. This is done by making an estimate of the expected marker positions from the two previous positions, a boundary is placed around this estimate and a search is made for a co-ordinate pair within this area. The estimated x co-ordinate is found from

$$x_{+2} = x_{+} + 2(x_{++} - x_{+})$$

where t is the time co-ordinate.

The estimated y co-ordinate is found from a similar equation.

The process of extrapolation and search is illustrated in Figure 6.17. The extrapolation assumes that velocity of the marker is constant and accelerations are allowed for by the search boundary. The data from the test discussed above has been processed in this way, the trajectory for each marker being identified and stored separately. The resulting data was plotted on the

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Figure 6.16. Ground reaction force data from the force plate acquired at the same time as the interface generated the co-ordinate data shown in Figure 6.15.

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Figure 6.17. Extrapolation and search routine used to identify markers from co-ordinate data. The actual marker position is shown by X and the estimated or extrapolated marker position is shown at 0 over the time intervals t to t+5.

computer graph plotter and this plot is shown in Figure 6.18. The co-ordinates in every second television field have been joined together to show the relative instantaneous spatial position between markers. The stationary marker was filtered out by the extrapolation routine.

To successfully identify marker co-ordinates, using the procedure described above, care must be exercised in the marker configuration used on the subject. The co-ordinates shown in Figure 6.19 represent the side view data generated for a subject with a total of 10 markers. Markers were positioned over the hip, knee and ankle joints, on the pelvis and on the foot. Four of the markers were intended for the front view camera only and covered the pelvis, knee and ankle; as shown in Figure 6.20. It can be seen in Figure 6.19 that front view markers were occasionally picked up by the side view camera (as indicated by the cursors). At certain phases of the gait, marker identification, by the simple routine described above, for the ankle marker was impossible. Identification of the knee marker was satisfactorily accomplished despite similar pick up of the front view marker. It might be possible to develop a more sophisticated trajectory identification routine to solve this problem, however a simple solution can be provided by suitable marker positioning. The ankle joint marker for the front view camera could be shifted up the shank to lie a constant distance above the joint, and then pick up by the side view camera would not present a problem. A similar solution would be to provide a single marker for the ankle joint which could be seen at all times by both front and side view cameras. The size of the search boundary in the marker identification routine is defined by the expected accelerations and velocities that can be reached in the x and y directions. The size of this boundary in turn defines how close markers can be placed to each other. Markers with high expected accelerations and velocities will require large search areas and this should be noted when positioning markers. Similarly care should be taken to ensure that markers are not hidden from view if at all possible. In the tests illustrated above the subject walked with arms folded across his chest to avoid obscuring hip and pelvis markers. If this is considered undesirable then it would be necessary to provide secondary markers to be used when the primary marker was obscured.



Figure 6.18. Computer plot of data generated by the system. Markers in every second television field are joined together.

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Figure 6.19. Side view data generated for a subject with front and side view markers. The cursors show that data has been generated by the side view camera for the front view markers during part of the trajectories.



Figure 6.20. Front view data generated simultaneously with the data shown above. The subject had markers on the pelvis, knee and ankle. The side view ankle marker has also been picked up by the front view camera.

6.6 Simultaneous Data Processing and Data Rates

The ability of the system to run a program to acquire, simultaneously, data from other instrumentation while generating co-ordinate data has been shown above. The interface has been designed in such a way that the computer time required for the generation of co-ordinate data is minimised. This has made available a useful period of central processing time for running concurrent programs. The duration of this period is closely related to the data rate generated by the interface, which depends on the number of markers used, the number of lines on which markers are detected and the television field rate (which can be reduced if required by the interface). It is difficult to predict, exactly, data rates because the length of marker trajectories during each field are dependent on their average velocity during this period, however estimating that markers would be picked up on 5 lines then the data rate for 10 markers at the normal field frequency of 50 Hz would be 7500 words/ second (3 words for each point - vertical and horizontal co-ordinates plus the code word).

The program DYDIS (Dynamic Display) has been used to assess simultaneous processing and data rates. The simulator was used to provide known inputs and the number of markers generated in each field was increased until display flicker was just noticeable, the data rate was then slightly reduced until there was no flicker. This was achieved when 3 markers were generated on each of 16 lines (5 words/line) at the normal field frequency of 50 Hz. This gave a data rate of 4000 words/sec; or, expressed in terms of markers, 2400 co-ordinate pairs/sec. The processing that is carried out by this program has been discussed in section 5.5.1.

For locomotion studies it will not usually be necessary to process data during a test run to any great extent. Also when a large number of markers is required the possibility of simultaneous processing is precluded because of the very high data rates involved. Even with 16K of core storage available, very little of which is required for the data acquisition program, the duration of a test would be severely limited. The use of the interface Address Register Double Buffer mode to extend the test duration was discussed in section 3.3.4.

The double buffer consists of two 4K areas in computer memory and 4K of data can be written onto one track of the PDP 12's RK05 magnetic disk. One track of data can be written onto disk in 40 mS so that, allowing time for data checking, re-writing, track access time, and possible recalibration of the disk address, data rates of 20 K words/sec should be quite feasible. The time required for data transfers from the television interface would be "invisible" to the disk data transfer program as will be discussed in the next section. The RK05 disk and its controller are described in Appendix A2.

6.7 Effect of Interface on Overall Computer Systems

The television interface uses the direct memory access facility of the PDP 12 (Single Cycle Data Break) for data transfers. Other peripherals, such as the disk, use the same method. The sharing of this facility is accomplished by a multiplexer (DM 12). This device examines data break requests on each cycle and allocates the facility to the peripheral with the highest priority, which can be allocated at installation time. Highest priority should be given to the device with the shortest latency time, where latency is defined by the maximum time which a device can wait for access to the computer memory before the data is lost. In the case of the television interface this time is the duration of the line blank time (12 μ S) although it is preferable for the request to be granted almost immediately so that all data transfers can be completed within the line blank time. In the case of the disk there is a maximum latency time of 22.5 µS, because the disk has a 4 word data silo which can be emptied before data is lost. This silo is normally kept full during write operations. The television interface has therefore been given the highest priority. This interface is limited to transferring a maximum of 7 words during any one line blank period, there will then follow a period of at least 40,45 before there is likely to be another data break request from the interface. The time required to transfer the seven words would be 11.2μ S for a 1.6 µS cycle time; the disk data silo could therefore be half empty before a data break request by the Interface, and still data would not be lost even if the interface transferred its maximum number of words.

Most of the PDP 12 instruction set can be used without any special consideration for the interface operation. However certain instructions should be avoided because of the short latency time of the interface. These instructions are those which use an extended cycle time such as the sample instruction SAM N when used in the normal mode (instruction time of 18.2μ S); this particular instruction can, however, be operated in a fast mode when it will only take 1.6 μ S. Other instructions which should be avoided because of their long execution time are the Linc Tape instructions (unless the "No Pause" condition is enabled), and the relay buffer to accumulator instruction RTA. All other instructions, including all input/Output instructions, can be used quite satisfactorily.

6.8 Recommended Modifications and Additions

One modification that should be made to the interface concerns the Address Register. Unless this is operating in the Double Buffer mode the register will address locations from the Initial Data Address (IDA) up to 32K (15 bits), and locations from zero upwards will be addressed as the register overflows. This only occurs under extreme or fault conditions (when excessively high data rates occur) when software protection may fail. Protection against this event occurring can be provided by hardware in one of two ways. Either the Co-ordinate Generator should be inhibited once the address limit of the computer is reached (lok at present) or it should be arranged to reset the Address Register to the contents of the IDA register on overflow.

The second modification concerns a re-designed calibration control to avoid the limitations discussed in section 6.4. The logic for this control is shown in Figure 6.21 and a timing diagram is in Figure 6.22. This logic simply enables the Co-ordinate Generator for 64 horizontal units at a time until the entire television field has been covered. Only five markers can be registered during any 64 unit period but only fault conditions are likely to cause this number of markers to occur during such a short period. The existing instruction set can still be used with this control, although a right hand margin cannot be set by software.





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ENCG H		
BO in third field		
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Figure 6.22. Timing diagram for calibration control of previous figure.

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A recommended addition to the system is to use light activated switches (LAS's) to control data acquisition. These would be positioned at the start and end of the walk path (the area monitored by cameras), and just before the force plate to initiate data collection from this device. Switch inputs have been provided for this purpose in the interface and a noise immune switch such as that shown in Figure 6.23 could interface the LAS's to these inputs. Only a pulse of duration longer than 5 mS would give an output (SYNC H). The LAS marking the end of the walk path (which would inhibit the Co-ordinate Generator when activated) could also be used to generate an interrupt to the computer to signal the end of a test.

If this interface is to be implemented on other computers, or even on a PDP 12, it would be cheaper to use status and control registers for the hardware generation of software instructions. This method is discussed in Appendix A2.

6.9 Conclusions

The system that has been described here offers a means of automatically acquiring displacement/time measurements of human locomotion. Repeatable measurements can be obtained and it has been shown that co-ordinates can be generated for markers moving with relatively high velocities and accelerations, comparable with those reached during fast walking. The system is flexible in that up to six cameras can be used simultaneously in almost any position. Thus it is possible to obtain three dimensional measurements and cover several strides of the gait by appropriate positioning of the cameras. The only limitation in camera positioning is that the light source of a camera must not be in the field of view of any other camera. This is a limitation of the chosen marker system; if active light sources were used as markers then this limitation would not exist. Passive markers have been used throughout the testing procedures and found to perform adequately, this means that the test subject is not encumbered by connecting leads, power packs, or "strap on" markers. Normal room lighting can be left on during data acquisition. Markers can be positioned quite close to each other, although care must be taken where expected marker velocities and accelerations are high. The interface will generate synchronising pulses at a program selectable rate to control the



Figure 6.23. Logic for noise immune switch.

acquisition of data from other instrumentation, such as a force plate. A means of generating the co-ordinates of a calibration grid has been built in to the system. This will allow non-linearities to be corrected if the highest degree of accuracy is required. Measurement errors have been discussed and seen to be relatively small, the implications of these errors in biomechanical analyses are further discussed in Andrews (1976). The computation of other parameters from the displacement/time measurements, such as derivatives, is briefly discussed in Jarrett (1976) and more extensively in Andrews (1976).

The data rates generated by the system depend on the number of markers used and can be very high. This can be accommodated by double buffering the data onto disk storage; the facility to do this has been provided in the interface. Alternatively the data rate can be reduced by placing a rotating shutter in front of the camera lens to reduce the sampling period. This shutter also has the advantage of defining a consistent sampling instant, but requires the use of more expensive television cameras. The system can operate at lower sampling frequencies (down to 0.2 Hz), if this is acceptable for the motions being measured, which will reduce data rates considerably. The interface has been very reliable in use, no faults have arisen to date, but a built in marker pulse simulator will facilitate fault tracing. This simulator also allows a rapid check of system function and is useful in software development. It is clear that software must be designed on an interactive basis, preferably with extensive use of data display routines. Providing data rates are not too high it is possible to process incoming data in real time, the program DYDIS does this and produces a display of decoded data. Basic processing of the raw data can be adequately performed on a mini-computer such as a PDP 12. The identification of marker trajectories is made possible by the use of a simple linear extrapolation routine, manual intervention being required only to provide the first two data points.

All of the diternative systems have been extensively reviewed in Chapter I where their principal advantages and disadvantages were examined. Methods Involving manual transcription of data, such as the use of cine film, are time

consuming and prone to human error. Automated versions of these methods are costly, still require a lot of manual intervention and still suffer from the basic disadvantages of photographic media - such as slow turnaround from test to results. The systems of locomotion analysis which involve contact with the subject, such as goniometers, are generally undesirable because they may influence the gait. and their measurement ability is often limited. The other opto-electronic techniques such as SELSPOT (Selcom (1975)) and CODA (Mitchelson (1974 and 1975)) are powerful measurement systems. They can sample at higher frequencies than a television based system and, when fully developed, may offer higher resolving power. They can provide outputs in analogue form which is easy to store, or can be interfaced to a computer. Such interfacing would be similar in many respects to that required for the television system. However, these systems both require active light sources to indicate the anatomical landmarks and these sources must be switched on and off involving either trailing connecting wires or a telemetry link. Also the power of the presently available light sources which must be used (Light emitting diodes) is limited which puts constraints on the range of operation of the system. an apple of the

The other television systems that have been developed are all limited in their performance capabilities in comparison with the system described here. At present none of them can use more than one camera simultaneously and their basic designs will make this extension difficult. None of the systems have been designed with the intention of collecting data from other measurement devices and consequently the ease with which this can be done is limited. The acquisition of the co-ordinates of a grid of calibration points has not been considered in any of the systems, except in the Dutch system (Ingen Schenau (1973)), but even this system was not purpose designed to take in the grid co-ordinates. The results of tests for stability and response to moving markers have been reported here but no similar tests have been reported for the other systems with which to make comparison.

The system will have applications both in the research laboratory and in the clinic. In the research situation it will be possible to conduct large numbers of tests with comparative ease. This has not been practicable in the

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past because of the time consuming manual interpretation that has been required to produce results for anything but the simplest of analyses (Jarrett (1974)). Also the research environment demands a system with some degree of flexibility, and especially the ability to acquire data from other transducers simultaneously. In the clinical situation the system offers a completely automated facility for data collection. The complexity of an analysis is variable - simple plots of change in segment angles may be derived, for instance, or data for a complete kinetic analysis could be collected. One of the most important advantages of this system in the clinical environment would be its non-contacting nature and also the complete silence of the system. Important areas of use in the clinic would be "before and after" studies of treatment regimes, identification of the "key" joint where several joints may be affected to varying degrees by a particular pathology, and in observing the different characteristics induced in the gait by an appliance.

6.10 Future Work

Research is currently in progress on methods of filtering co-ordinate data generated by systems such as the one described here, this research also includes investigations into digital differentiation schemes to derive velocities and accelerations (Andrews (1976)). This work will allow the data generated by this system to be used to provide a kinetic analysis of locomotion. The form of this analysis requires to be developed from existing work (Paul (1967), Morrison (1967), Poulson (1973)) to be compatible with suitable marker configurations for the television system. It will be advisable to structure this analysis in such a way that useful intermediate results can be obtained easily – to produce parallax corrected angle/angle diagrams for example. The incorporation of other measurement devices is seen as an important option to be built in to the analysis. These devices should include load measuring devices such as force plates (one or two), and pylon transducers; accelerometers; and possibly electromyograph recorders.

Presentation of data is an area which requires considerable investigation, the most promising direction would seem to be a graphically oriented one to

make use of the outstanding pattern recognition abilities of the brain. Successful routine clinical use of a system, such as the one described here, will only be achieved when the resultant data can be presented in such a way that abnormalities in the gait can be easily and quickly recognised. If this is achieved then it may be possible to use a very basic model of mini-computer (with consequent economy) to collect and process data.

APPENDIX A.I.

BASIC PRINCIPLES OF TELEVISION

- Al.l Principles
- AI.2 Scanning
- AI.3 Synchronisation

Al. | Principles

In order to reproduce pictures which are acceptable to human vision television exploits a particular characteristic of the eye. This characteristic is known as "persistence of vision". The effect of this is that the eye perceives an image of a source for a certain period after the source has disappeared; a modulated source is, therefore, averaged by the eye. Experiment shows that it is necessary to project about 50 still shots of a moving scene, every second in order to allow the eye to average the pictures and reduce any flicker, due to changes, to an acceptable amount. It follows that a television system must scan the scene to be transmitted at least 50 times every second if flicker is to be acceptably low.

To represent a still picture in electrical form it is necessary that each level of brightness of the picture is specified by a unique and discrete electrical signal. This would require the picture to be broken up into an infinite number of elements each of which would have to be sampled, and allocated a value of electrical signal corresponding to its brightness. The whole array, for a moving scene, would have to be sampled 50 times every second to reproduce a picture acceptable to the eye. As usual a compromise is made and the picture is broken up into a finite number of elements which will produce a reasonably sharp picture at a bandwidth suitable for transmission. A modern, high definition, transmission system divides the picture into 300,000 to 400,000 picture elements and requires a bandwidth of several MegaHertz.

The signal levels corresponding to each element have to be transmitted sequentially. Practical television systems transmit the electrical signals corresponding to the picture elements starting at the top left hand corner of the picture. The signals corresponding to the top line of picture elements are first transmitted, then those comprising the next line, and so on until the whole picture has been transmitted; this process of transmitting a picture as a succession of horizontal lines is known as scanning. In conventional television systems scanning atways starts from the left hand side of the scene, as viewed by the camera.

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To convert the light signals into electrical signals a photosensitive surface is used. This surface, or target, varies in conductivity according to the intensity of light falling on it. The target is scanned by an electron beam which causes a current to flow in a signal plate, varying in magnitude according to the conductivity of the target. The current is passed through a signal resistor which develops a potential difference proportional to the current, this pd then being amplified. This system which applies to the vidicon and plumbicon pick up tubes is illustrated in Fig. Al.I. Other pick up systems exist, but they all work on similar principles.

Al.2 Scanning

The scanning of the electron beam is controlled by synchronising pulses. Deflection of the beam is accomplished by vertical and horizontal deflection coils which apply a magnetic field of varying strength across the path of the electron beam. As the electron beam passes through the magnetic field it is deflected at right angles to its direction of travel and to the direction of the field. The path followed by the electron beam in scanning the charge pattern on a camera target is shown in Figure A1.2. Starting at A the electron beam is made to travel horizontally at constant speed across the target to the right hand side; it then returns at a much greater speed and commences the next horizontal or line scan. The return traverse is known as the line flyback. Simultaneous to the line scan and flyback the electron beam is moved comparatively slowly and at constant speed downwards, the field scan. When the required number of lines has been scanned the electron beam is moved vertically back by the field flyback. Field synchronising pulses initiate field flyback and line synchronising pulses initiate line flyback.

To reduce the bandwidth required still further a system known as interlaced scanning is used. In this system the television camera transmits information in the same way as before, except that the complete picture is only scanned 25 times in every second. However to maintain the flicker below an obtrusive level each picture is scanned twice, the second scan taking place between the lines of the first scan. This technique is illustrated in Figure A1.3. Each complete scan is known as a field and there are thus



Figure Al.I. Camera pick up tube. (From Wharton (1967)).



Figure Al.2. Scanning path



Figure Al.3. Interlaced scanning.
two types of field, "odd" and "even", interlaced to form a complete picture. The advantage of this system is that flicker, due to the succession of fields, is reduced by comparison with an equivalent sequentially scanned picture without an increase in bandwidth.

In the British system 625 lines are scanned in two fields. The number of active lines in each field is $292\frac{1}{2}$, after accounting for those blanked during field flyback.

AI.3. Synchronisation

Field and line synchronising pulses are generated by a central sync pulse generator. They control the time characteristics of the camera scan, and the relationship between field and line syncs determines the interlace of odd and even fields. During line and field flyback the video signal is suppressed, an interval known as the blanking period. This means that a number of lines do not transmit video information between fields and that a certain portion of each line does not carry video information. The lines and proportion of each line which carry picture information are said to be "active".

The video output from the camera may also incorporate the synchronising pulses in which case it is referred to as "composite video". The composite waveform, showing details of the line sync pulses and line blanking is shown in Figure A1.4. The composite waveform showing details of the field syncs and blanking is shown in Figure A1.5. The equalizing pulses shown in the field sync waveform are not necessarily present in closed circuit systems. They are a refinement added to broadcast systems to reduce the effect of the half line which occurs at the end of alternate fields, just before the field sync pulse. This half line can impair the interlace of the receiver, by disturbing the field synchronisation. Also in closed circuit systems the field sync may be one pulse of about 160 μ S duration, instead of five broad pulses.



Figure Al.4. Line synchronisation waveform and blanking for the British 625 line television system (From Wharton (1967)).





APPENDIX A.2.

THE PDP 12 COMPUTER

A2.1	Introduction
A2.2	Input/Output Transfer Instructions
A2.2.1	Programmed Data Transfer
A2.2.2	Control and Status Registers
A2.3	Direct Memory Access
A2.3.1	Single Cycle Data Break
A2.3.2	Three Cycle Data Break
A2.3.3	Multiple Use of the Data Break Facility
A2.4	RK05 Disk and Control

A2.1 Introduction

The PDP 12 is a mini-computer designed for use in a laboratory environment. It is a 12 bit word length machine and can therefore basically address 4096 (4K) memory locations. An additional three address bits, the extended address, are provided to allow addressing of up to 32K of memory. The basic cycle time of the computer (the time taken to access and interpret one word from memory) is 1.6μ S, although certain instructions will extend this time. There is a 10 bit analogue to digital converter to which up to 32 channels can be multiplexed, and which is controlled by a programmable clock; eight of the channels are prewired to precision potentiometers. Magnetic tapes and disk provide the means of mass storage for data and programs. Six program controlled relays are also provided for control of external equipment. Communication with the computer is achieved via a teletype on the computer console switches. Data may be output on punched tape, on a graph plotter or displayed on a point plot visual display unit (grid dimensions 512 x 512 points).

Full details of the computer will be found in the reference and maintenance manuals (Digital (1970 and 1971)), however those aspects which directly concern the television interface will be briefly described here.

A2.2 Input/Output Transfer Instructions

The PDP 12 has two distinct modes of operation. LINC mode and PDP-8 mode, each of which has its own instruction set. The LINC mode instruction set includes instructions to control some peripheral devices such as LINC tape systems, the visual display unit, and the analogue to digital converter. Most peripherals and certainly any interface will be controlled by the Input/Output Transfer (IOT) class of instructions in the PDP-8 mode instruction set. A special LINC mode instruction, IOB, allows this class of instruction to be used in LINC mode programs without changing modes.

A2.2.1 Programmed Data Transfer

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When an 10T class of instruction (6000) is decoded in the Central

Processor the computer enters a $4.25\,\mu$ S expanded cycle, and enables the Input/Output Pulse (10P) generator to produce time sequenced 10P pulses as determined by the three least significant bits of the instruction. A timing diagram for the IOP pulses is shown in Figure A2.1. These pulses are transmitted to all peripheral devices together with the contents of the Memory Buffer (MB) which holds the instruction. Figure A2.2 shows the function of each part of the IOT instruction. Bits 3–8 of the MB contents are transmitted to the peripheral devices in both (1) H and (0) H versions to simplify the logic required for decoding. This logic is shown in Figure A2.3 and gates the 10P pulses to the device when the appropriate code appears on the MB lines. The device code is assigned by wiring the appropriate MB lines to the inputs of the AND gate. In the example shown the device code is $3l_8$ (11/91/9/2). Any combination of the three 10P pulses can be generated depending on bits 9-11 of the instruction, therefore there can be up to 7 discrete instructions for any one device code. From one to three IOP pulses will be generated in each instruction; any device operation which requires a sequence of pulses can take advantage of this, and accomplish the sequence during one instruction. This type of operation can be used to advantage, for example, when loading a register with data may cause a flag to be set elsewhere in the interface; a second IOP pulse generated by the same instruction can be used to clear the flag without the need to resort to a second instruction.

Three other control lines are available for programmed data transfers. These are the Clear Accumulator, Skip and Interrupt Request lines (EXT AC QLEAR BUS L; EXT SKIP BUS L; and EXT INT RQST BUS L). The Clear Accumulator line is used when making data transfers from an interface to the accumulator. During each 10P data from the interface is strobed into the accumulator. This is done by making an inclusive "OR" of data already in the accumulator and data on the accumulator input lines. If there is no data from the interface or if the interface data is zero then the contents of the accumulator will remain unchanged. If it is desired to read the contents of an interface register then the accumulator must first be cleared. This









Figure A2.3. Device Selector logic. (From Digital (1971)).

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can be done by the program, but it can also be done by using the clear accumulator line, which is preferable to avoid the possibility of programming errors. The Skip line allows the program to test the status of a flag in an interface. An IOP generated by an instruction will gate the status of the flag onto the Skip line, causing the next instruction in the program sequence to be skipped if the flag is set, (increments Program Counter). The Interrupt Request line will cause the current program to be interrupted if the interrupt facility of the computer is turned on (ION) and the interface pulls the line low. The computer will store the contents of the program counter in absolute memory location \emptyset if the processor is in PDP-8 mode or $4\emptyset$ if it is in LINC mode. The program will then jump to location 1 or 41, where it will be directed to an interrupt service routine. This routine will then test the status of flags in the external devices (using the Skip facility) to find out which caused the interrupt and will then take appropriate action.

All programmed data transfers between a device and the computer take place via the accumulator. Data in the accumulator is available on the [100] BAC Ø-11 lines; and data from a device is available to the accumulator on the [EXT] 10 BUS Ø-11 lines. The initialize lines [100] BA and BB INITIALIZE H will be asserted whenever the computer power is switched on, the 1/0 Preset console switch is depressed, or when the 1/0 Preset Pulse is generated by program (Special Functions bit 6 set). The signal is used to clear all device flags and registers etcetera.

A2.2.2 Control and Status Registers

The methods of hardware instruction generation described above have been used in the television interface (see Chapter 4, Interface Logic – Instruction Generator I and Figure 4.22 for example). Usually each hardware operation is generated by a separate instruction; a great saving in components and the number of instructions used can be made by utilising status and control registers. Only two instructions are basically required; one to load the register and one to read it. The various status bits are set by the interface (such as "change buffer $\frac{1}{2}$ ") and the control bits are set by data transfer from the computer (e.g. "Double Buffer mode"). Figure A2.4 shows how



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Figure A2.4. Status and control register for the address register instructions.

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such a register might be used for some of the Address Register Instructions.

A2.3 Direct Memory Access

Direct memory access is provided in the PDP 12 on a cycle stealing basis by the Data Break Facility. When a break request is generated from an external device the computer completes the current instruction and then enters the "Break" state. The time required to enter this state is referred to as the latency of a break request and depends on the instruction currently being executed. This latency time is usually from $1.6 \,\mu$ S to $4.8 \,\mu$ S for three cycle instructions but can be anything up to $18.2 \,\mu$ S for some extended cycle instructions. The transfer of data can be either from or to the computer. To effect an input data break transfer the interface must specify the appropriate address in memory, provide the data word, indicate that transfer is to the computer, indicate whether 3 cycle or 1 cycle data break is required, and request a data break.

A2.3.1 Single Cycle Data Break

The timing diagram for input data transfers is shown in Figure A2.5. Data transfers to memory take place via the Memory Buffer to the location specified by the external data address lines. This address is provided by a 15 bit register in the interface and must be present on the address lines in anticipation of the data break cycle. When the address has been strobed into a central processor register the address accept pulse is generated and transmitted to the interface. This pulse is usually used to increment the interface address register in readiness for the next data transfer, and to clear the device break request flag if all data transfers will have been completed at the end of the cycle then the computer will return to normal programmed operation on completion of the data transfer. The B-BREAK signal is generated by the computer and remains low for the duration of data break transfers. The data to be transferred must be available on the external data lines by TP2 of the cycle and must not be removed until after TP3. The B-BREAK signal



Figure A2.5. Single cycle data break input transfer timing diagram. (From Digital (1971)).

is useful as a data gating signal. BTS 5 and BTS 2 are "time state" signals generated by the computer, they are present on every cycle and must be gated with a data break control signal (e.g. B-BREAK) if they are to be used by the interface during data break cycles.

The initial conditions in the interface for single cycle data break transfers must be set up under program control. In the television interface the only conditions are the initial address for data transfers and the address register mode of operation. Usually an interface may also include a word count register which defines the number of data words to be transferred and is set up by program. In the television interface this register is set up automatically and depends on the number of markers detected.

A2.3.2 Three Cycle Data Break

The timing diagram for input or output transfers is shown in Figure A2.6. The difference between this method of data transfer and the previous one is that the computer provides registers for the current address and word count functions. If the extended addressing facility is to be used then the interface must provide a 3 bit extended address. The register used for the word count function is a memory location specified by the address (usually hard wired) placed on the external address lines by the interface. The next sequential memory location is the current address (CA) register. The word count register is preset by the program to the negative of the number of words to be transferred. The current address register is preset to the initial address minus one (A-I). Upon receiving a three cycle break request the computer enters the first of the break cycles on completion of the current instruction. During this cycle the word count (WC) register is incremented and if the register becomes zero as a result a WC overflow pulse is transmitted to the device. This signal signifies the end of a block transfer and is used to remove the break request signal. On the next break cycle the computer enters the current address state and the contents of the CA register are incremented and used as the address for the data transfer. The last break cycle stores the data presented on the external data lines by the interface



Figure A2.6. Three cycle data break timing diagram. (From Digital (1971)).

in the memory location specified by the CA register.

A2.3.3 Multiple use of the Data Break Facility

If more than one device requires the use of the data break facility then a multiplexer, the DM12, must be used. Separate cables are taken from the DM12 to each device for the data break control signals, the external data address, and the external data. Each device is allocated a priority and the break request lines are sampled, on every cycle, by the DM12 which gives bus control to the device with the highest priority requesting a break. On giving control the external data address lines of the device are gated to the Memory Address register in the central processor. This allows the memory address to be set up prior to the break cycle. The break cycle is then entered as before (single or three cycle) and all control signals are directed to the device with bus control.

A2.4 RK05 Disk and Control

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The disk drive controller (RK8F) can control up to four RK05 moving head disk drives. Each disk contains 1.6 million words of data storage. Data is arranged on the disk in tracks and sectors of a track. There are 400 data tracks (200 on top and 200 on bottom surfaces of the disk, each top and bottom pair being referred to as a cylinder), divided into 16 sectors which each contain 256 data words. The single cycle data break facility is used to transfer data to and from the disk controller, in which there is a four word data silo. During write operations the controller endeavours to keep the silo full in order that disk latency time is kept at a maximum. If at any time the silo is empty when the disk is ready to accept data then a "write error" will occur and the whole sector will have to be re-written. This error is indicated by the "Data Request Late" bit in the status register being set, and occurs if the processor does not respond to a break request from the controller within 22.5μ S - the maximum latency time of the disk. Data break transfers are made via the DM12 multiplexer and the disk has been granted second highest priority with the television interface having the highest priority.

The transfer rate to or from disk is 8.32μ S per word, or 40 mS for a complete track of data (40% words). Each sector of the disk contains, in addition to the data words, control sections and a header which provides a sector and cylinder address. Errors can arise in positioning the disk heads and this can be checked by comparing the disk cylinder address of a sector header with the cylinder address previously sent to the disk drive. If an address error is indicated then the disk heads must be returned to the home position (cylinder \emptyset) which is referred to as re-calibration, and the operation to find the required cylinder repeated.

In combining data transfers from the television interface and to the disk (double buffering) in order to obtain the maximum data rates it will be necessary to first of all position the disk heads on the required cylinder and then write 4096 data words (one track). On completion of this operation the disk heads will be moved to the next track (by the program) and a check of cylinder address carried out with re-calibration if required in readiness for the next 4096 word block transfer. Checking of data will be limited if the highest possible data rates are required.

The details of the RK05 disk and its controller given above are only meant to provide a pointer to combined operation with the television interface. Full details will be found for disk operation in the appropriate DEC manual.

COMPUTER PROGRAMS.

Interface Mnemonics

Real Time Display

Data Process

Calibration Data Acquisition

Calibration

Display Calibrated Data - DISC-CAL

DISF-CAL

Display Interface Data - DISC

DISF

Display Grid Data - DISG

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a (35 a 306	ZPRIGRAA "TVI-AN" A	ND THEN ASSEMBLING, SYMBOL	3134			CLPI=6344 /DISARCE LREA INI SCRH=6345 /SKIP IF CHANGE RUFFER
5 3:57	ZTABLE CAITAINING 7	VI AVEMOVICS WILL THEN	0105			ALL FLAG IS SET.
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3 454	CrC=6315	/CLEAR FIELD CVT	FNURI	6363		
335 5	C5.4=6316	/CLEAR SIMULATOR	1 VE A1: 5 VEC	6313		
0156			PAPA -			
1957	/		F VSK	6314		
-9 46 C	/CG INSTRUCTIONS	ALLARDER CG	SLCA	6333		
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	1374	3143	85.13	ເວສຳ	11ES -	0172	052 7	1340		SIA	
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						n dan di silah kening kenanggan nyang meningan penyahan dara penyaharan menangkan kenangkan kenangkan penyang —	a den de parte a la construction de				ى يەپ <u>دەرىمە</u> رى مەرەپ يەرەپ	
	0173	053.1	3535		WORDI		087.0	9614	0376		SET I 16	
	3174	3531	1120		ALA I		0271	3615	0300		0	
	0175	9532	0010		19	•	027 2	(1616	1003		LDA PSTAD	
	0176	3533			STC WORD2		9273	3617	41 91 [.]		STC VC	VC STORED
	0177	0534			LDA		a27.4	0620	1030		LDA	
	A233	0535		WJRD1,			0275	9621	<u> </u>		PSTAD	
1.1	0231	3536	4212		STC DEL		0276	9628	4302		STC B2	/START ALDR TO B2
	9833	9537	1963		LEA		927 7	Ø623	1003	VCTLST,		
	0203	0543	0093	WURD2.	4304		0300	0624	0035		BS BS	
	0204	3541	4213		SIC DW2	e de la companya de l	0391	116 25	1443		SAL	CURRENT ADDA?
	3235	8542	5644	DF D.	LDF 4	/LDF N	0302	06.56	0105		CAD	4.1.5
	2236	0543	1959		LDA I		0303	0627	0456		SKP	CRV
÷	0207	0544	0953		23		0304	0630	6655		JAP A2	/1ES
	0219	0545	1129	1. 	ALA I	•	0375	0631	0236		ASK I 16	101 th 31 4 th 0 1.31.15
	9211	0546	0983	MARKD,	0999		0306 (1207	1632	1022		LDA I B2	ZGET NEXT COURD
	0212	3547	1943		STA		3307 3314	Ø633	1560		PCL I 1777	
	J213	955.1	9552		PUINT		2311	9634 2635	1777 1460		SAF I	
	0314	0551	1333		LDA		2312	3636	6333		6000	/VC?
$\frac{1}{2}$	0915	0552	09.)4	PUINT,	9999		9313	0637	6623		JAP VCTEST	/.NO
	9216	9553	1 84 3	2.00	514	CORRENT HC TO FIRST	0314	0640	1300		LUA	/YES
			0.100	LJC	0.740		9315	9641	9032		ES .	
	0217	0554	2309		2320		0316	8642	1123		ADA I	
	0220	0555	9511		CLA		0317	0643	7776		-1	
	3221	3556	1123		ADA I		7393	0644	1629		ESE I	
	0289 0289	9557	7430		-377	ATTATA NO 493 PROVAD I	0321	3645	63.30		6.3.30	
	0640	9569	1 040	JC	STA	/FIXED VC TO SECOND L	0382	3646	1443		SAL	
10	0224	0561	23.31		2001		0323	0647	0033		ESTAD	/ERROR?
문문	0725	0562	1323		LDA I		0324	3650	6655		JMP A2	
61	3226	0563	3777		3777		0325	0651	1023		LDA I	
	2027	3564	4.136		STC LC		3326	0652	7330		7:3:30	
2 .	3233.	3565	3377		SIT I 17		Ø327	9653	41.03		STC FLAG	ISET ERROR FLAG
	2231	3566	9177		177		0330	9654	6623		JEP VOTEST	
	0232	0567	0.161		SET I I		Ø331	0655	1000	A2.	l da	
	2233	0579	3323		2		9332	Ø6 56	ØØ92		HS	
	2234	3571	0076		SHI I 16		0333	0657	1120		ALA I	
	3235	0572	7763		-14		0334	0660	7776		-1	
	3236	0573	1020		LDA I		3335	Ø6 61	1629		'FSE I	
	2237 .	0574	7433		74:40		0336	0665	60:30		6000	
	09.40	0575	1777	CDI S.	DSC I 17		0337	0663	4004		STC PSR	ISR WORD ADDR
	3241	3576	0236		K5K I 16		0343	3664	S416		ADL 16	
	3242	3517	6575		JOP +-2		9341	0665	0017		CON	
	3243	3613	1026	DI SP.	LEA I LC		0342	0666	1120		AIA I	
	0244	0631	3341	•	SCH 1		0343	3667	0256 		0256	VROL A FORMED
	ð 245	06:52	1560		PCL I		3344	0670	4672		SIC +2	
	9246	0603	7000		7830		0345	0671	1034		LUA BSR	
	3247	9604	4397		STC D		3346	3672	9993		9636 550 560	VRJL N
	Ø250	0635	3556		XSK I DC	VEND OF BUFFER ?	3367	0673	1944	~~~~~~	STA PSR	
	8251						0350 0551	9674	1909	SCAVC+	LUA	
	0958	2686	3456		SKP	√40	0351 apro	3675	0304		PSR DUR	
	3253	36.37	6473		JMP NDATA	/YES	0359	0676	4305		STC BHC	/HC ADLR+1
	2254	3613	1336		LDA EC	/LUADS VC	Ø353		1020		LDA	
	6255	0611	0147		DIS D		0354 0355	0739 9791	9101 1560		VC FCL I	
	0 256	0612	6699	_	JMP DISP		Ø356	0732	6090		6392	
	0257									·		
	8869						0357 J369	07 3 3 07 84	1120		ALA I -473	
	0861			1			0361	3735	0471	÷	APO 1	/JDL JR EVEN FIELD?
	3962						3362	3735	6711	ł	JAP +3	FOLD ON EVEN FIELD:
	3263						0363	3737		ł	ALA I	
	0264						0364	3713	3473		47.5	
	3865			·			Ø365	0711	1129		ALA I	
	8266		3110	1	1.01.10		0366	9712			-200	
	J 267	3613	3653	DPROC.	LDF 13	/DATA FIELD=13	-	177 4 14			Carlor Ne	

0013310.4		and a stated and a state of the	21. 22. 20. 24. 24. 2018/2019 2. 21. 22. 20. 21. 21. 21. 21. 21. 21. 21. 21. 21. 21					nggi si sa si kang sa si	anisiana, association			
	0367	3713	9917		COM	ZINVERT	0466			1		
	0370	0714	1560		BCL I		0467			/		
	0371	0715	7 3 3 3		7990		9479			/		
	0372	0716	1040		STA	/REPLACE SCALED VC	0471			/		
		0717	0131		VC		6472				*230	
	0373 9374	0725	1303	PHC,	LLA	/PROCESS HC	0473	0200	4135		4136	
		0721	0305	FIIOF	BHC		9474	02.01	2241		2241	/C
	9375		1127		ADA I		0475	0202	1077		1077	
12.6	9376	0722			+1		9476	0203	7710		7713	78
	0377	3723	7776		BSE I		3477	0204	4477		4477	
	8430	0724	1620			· · · ·	0500	0205	7744		7744	/A
	8431	Ø725	6000		6040		0501	0206	3077		3077	
	34.32	0726	1049		STA	/HC ADDR	8502	0207	77.26		7706	1.8
	9473	0727	2335		PHC	AC ADDA	9503	0210	0000		8033	
	3434	0733	1443		SAL	ADUC-DETAD?	0594	0211	0000		0003	
	0435	0731	0393		BSTAD	/BHC=BSTAD?	0595	0212	0030	DU1.	0000	
4 a 6 1 1 1	84.36	6732	6737		JAP CJUE	GN		0213	0030	UW2,	8833	10-7
	8407	9733	1033	i an shi ta	LDA	IYES	0506 0507	0613	0050	/	0.00	
	8413	0734	0332		P2							
	0411	0735	4243		STC BSTAD	UPDATE START ADDR	0510					
	0412	0736	6470		JAP NDATA	and the second second	0511			*	* 220	
	0413	0737	1004	CODE	LDA PSR	/SR WORD TO AC	2512	2002	4130		4136	13
100	3414	0743	3261		EOL I 1	a tha a status and a share	0513	0223	4136		2101	/1
	0415	3741	1344		STA BSR	TREPLACE SR WORD	0514	0221	2101			/2
	3416	0742	1305		LEA BHC		0515	0222	4523		4523	
	9417	\$743	1043		STA		9516	9553	4122		4122	/3
	0423	3744	9132		НС		3517	0224	2414		2414	14
	3421	0745	0312		RJR 12		9520	Ø225	5172		5172	15
	8482	37 46	0261		R-36 1 1		0521	0226	1596		1506	16
	6423	0747	1560		BCL I	/CAMERA CODE	0522	Ø227	4443		4443	11
	3424	9750	7770		7770		Ø523			/		
	8425	9751	1943	•	STA		0524			1		
	8426	0752	3762		CAACO		0525			1		
	34279	2753	1043		STA		0526				*233	
	9439	37 54	9776		MARK		0527	0230	3641		3641	13
	3431	8755	1120		ALA I	· · · · · · · · · · · · · · · · · · ·	0530	0231	0177		9177	/1
		0756	0643		0643	CREATE LDF N	0531	Ø232	2151		2151	12
	3432	3757	4760	•	SIC LI		0532	2233	2651	•	2651	/3
	3433			DE.	LDF 7	/LDF N	0533	0234	0477		3477	14
e po	3434	0763	3647	DF	ALA I		3534	0235	Ø€ 51		Ø651	15
	3435	2761	1123	04400			3535	3236	4225		4225	16
	3436	8762		CAXCO.	903J		1536	0237	6053		6053	17
	2437	.3763	1123		ADA I	CREATES STA I CUSES	0537	0.007		1		
	3449	0764	1073		1370		0540			1		
	3441	0765	1043		STA	/REGISTERS 10 TO 15)				1		
	0442	0766	0772		CASH	* * * * * * * * * * * * * * * * * * *	05/1					
	9443	976 7	5005		STC CAMU		3542				*133	
	3114	0773	1000		LDA	•	3543	31 /1/4	3 1 30	COUNT.	3	
	445	3771	3108		HC		3544	0109	3330 3300			
	31.14	3772	3929	CAMH	6905	ISTORES HC IN CURRECT	0545	9191	3603	VC.	ø	
•	3447	3773	1323		LLA I	/FIELD)	0546	0192	3333	HC.	0	
	3459	0774	4923		4323		0547	0193	9033	FLAG.	0	
	9451	0775	1129		ADA I		0551	9194		CAELR	6332	
	0452		2002	MARX,	0000	/CHEATES STC	Ø551	0105	6333	CAL	6002	
	9453	2777			STC INDI		0550			/		
		1733			LIA		#553			/		
	3454				HC		3554			/		
	3455	1391		TATIT	8093	/SETS UP MARKER TJ	0:55				*20	
	0456	1002		INDI.		/SAUW PUSITION OF	9550	3353	3,331	FOODAL*	1	
	3457		1999		LEA	ZREFRESH FOR EACH CH	0557	0321	9177			
		13.)4	3131		VC	ZEFRESH FOR EACH CH ZSTURES VC IN CURRECT	0567 0567	9955		MJDI	6030	
	3463						-1.1 · 1					
		1335	<u>9933</u>	CAMV.	0993				•		•	
	3463		9933	Camv,	LDF 13	/FIELD	0561	3303			h poi viers	
	3463 3461	1335 1336	9933	CAMV			0561 3562		3 93 3		H POINTERS 0393	
	9463 3461 8462	1335 1336	99.19 0653	CAMV.	LDF 13		0561 3562 8563	3424	3003 9003		H POLVTERS 0393 2303	
	0460 3461 8462 3463	1335 1336	99.19 0653		LDF 13		0561 3562	3424	3 93 3		H POINTERS 0393	

0545 0567 0577 0577 0573 0573 0573 0573 0573 0573 0576 0577 0409 0631 0631 0633 0533 0631 0633 0533 0634 0633 0534 0631 0633 0534 0631 0633 0575 0577 0633 0577 0633 0575 0577 0633 0575 0577 0633 0575 0576 0577 0633 0575 0577 0633 0575 0577 0633 0575 0577 0633 0575 0577 0631 0631 0634 0631 0634 0631 0634 0657 0577 06573 0576 0577 0633 0631 0634 0657 0577 06573 0576 0577 06573 0576 0577 06631 0760 0657 0577 06631 0760 0657 0577 0663 0577 0663 0577 0663 0577 0663 0577 0663 0577 0663 0577 0663 0577 0663 0577 0663 0577 0663 0577 0663 0577 0663 0670 0663 070 0670 0670 0670 070 070 070	3326 9027 0030 3331 3331 3311 2012 0913 2914 2315 3315 3315 3304 0335 3304 0335 3304 0335 3304 0335 3304 0335 3304 0335 3304 0335 3304 0335 3304 0335 3307	0793 3000 0000 0000 0000 3777 3777 3777 3777 3777 3777 00000 0000 0000 0000 0000 0000 0000 0000 0000 0000 00000	AUTU, AUTU, PSTAL, PSTAL, PSTAL, PHC, LC, L,	3334 333 3403 9333 *10 37777 3777 3777 37777 3777 3777 3777 3777 3777 3777	/CA41 /CA42 /CA43 /CA44 /CA5 /CA46			FNAD FNCG FNEMI ENFAD ENFAD ENFA FCOUNT FLAG HC INEI. LCOUNT LECA LLCAM LLFC LDLC SARK MARKD MUDI NDATA PUINT FCA SCAC SCAVC SCPH SUPA VC CTEST WORD2	0103 0102 1302 1021 6333 6302 6311 6312 9776 9546 9546 9720 9720 9720 9720 9720 9720 9720 6335 6336 6397 66345 6345 6345 9191		
CALDR CALDR CAGJ	3105 1134 6333						·				
CAGUER CARCO CARCO	6395 3762 3772 1335										•
CORU. COAFL CIBF	6347 6347		•								
CDPI CDP4 CDIS CSC	6344 6342 3575 6315		••								
CFC CLAD CLCAL CJEF	6315 6334 6304 -737							,			
CJUAT CSA D	0103 6316 0337							,			
рру LC Гг D5 1	6341 0006 1760 1540										
DED HISCG DISP D2DDC	0613 0613 8883									·	
LE DE1 L42	3518 3818 9813										

Flow Chart for data process program (DP).













*			0074			1	
			9976 3077				TA STARTING AT LOCATION
	3713	*20				19 OF MEMORY FIELD 1	
	0331	/DP - LATA PROCESS	0100				
	0378	1	9191			TO 7777 OF MEMORY F	
	70.13	/17-6-75	0192			/LIMIT MAY BE PLACED	
	0334		0103			/E4A, THESE ARE INIT	IALLY SET 10 2
al en e			3104			/AND 4000 RESPECTIVE	LY•
al de la companya de	3335		0105			1	
	0036	/M.J.JARRETT.	0196			THE SAMPLED ANALUGU	E DATA IS IN DE 0
	0 737		0107			ABSOLUTE LUCATIONS	
변경은 성격되었다.	0313			•		/STORED IN THE FIRST	
	0711		0110				
	0)12	PRIGRAM CONTROLS ACQUISITION OF DATA	0111			/TAPE IF SNS 3 IS SE	
and the second sec	3 51 3	VERDY INTERFACE, AND STORES IT ON TAPE	3112			VFOR EACH ANALJGUE C	e ملک e
	3314	(CUVIT 3) IN THE FORMAT - TV FIELD NUMBERS	Ø113				
	9315	/VERTICAL COURDINATE HURIZONTAL	0114				
		CODEDINATES WITH THE CAMERA NUMBER	0115				
	0016	CONTAINED IN BITS 1.2.3 OF THE TV FIELD	0116			1	•
이 같은 것 같은	0917	NUMPER. BIT O OF THE TV FILLD NO IF SET	0117			LOLSYM	
	9363		0129			PMJLE	
	8781	VINDICATES THAT THE FUNCE PLATE IS BEING	0121			*20	
	0122	/SAMPLED	0122	9920	5500	JMP I LATA	
	. 3323	가는 그 사람은 정말을 가지 않는 것이라. 것이 아니는 것이 아니. 이 아니는 것이 아니는 것이 아니는 것이 아니는 것이 아니는 것이 아니. 것이 아니는 것이 아니는 것이 아니는 것이 아니. 것이 아니는 것이 아니. 것이 아니는 것이 아니는 것이 아니. 것이 아니는 것이 아니는 것이 아니. 아니는 것이 아니는 것이 아니. 것이 아니는 것이 아니는 것이 아니 아니는 것이 아니. 것이 아니는 것이 아니는 것이 아니. 아니는 것이 아니는 것이 아니. 것이 아니는 것이 아니. 것이 아니는 것이 아니. 아니는 것이 아니. 아니는 것이 아니는 것이 아니. 아니는 것이 아니는 것이 아니. 아니는 것이 아니 아니는 것이 아니. 아니는 것이 아니. 아니는 것이 아니. 아니는		0000	2200	*233	
	3724		0123				
	3225	13 MULE IND PRESET START 20 AFTER SETTING	0124		· · · · · ·	/DATA ACOUISITION	•
	3326	/LESIRED SEASE SWITCHES ETC.	0125	3803	6002	DATAL, IUF	
	0.327		0126	0201	6355	DISCG	
			0127	0202	7330	CLA CLL	
العربية والمراجع	0030		0130	0503	1191	TAD SFCT	/LD SIM FIELD CT
	7731		0131		6311	LDFC	
	9038	/SNS Ø - ENABLES FIELD COUNT	3132	0205	7300	CLA CLL	
	8733	/SVS 1 - EVAPLES SIMEATOR			1132	TAD SLCT	
	1134	1545 P - EVABLES CUURDINATE GENERATOR	0133			LILC	/LD SIM LIVE CT
s	1135	VIA RESET AFTER ENABLING CG THEN CG IS	9134		6312		VED SIN GIVE OF
	3036	/LISABLED AVE THE DATA CULLECTED IS PROCESSED	3135	0210	7230	CLA	
	1337	/SVS 3 - IF SEC THEN ANALOGUE CHANNELS	3136	0211	1133	TAD CAD	
1. A. 1.	3341	VEILL BE SAMPLED, IF HESET UNCE PRUGRAMME	0137	0215	6333	LLCA	/LD COMPOSITE ALDR
والمحفظ فالمعاوي		THAS STARTED THEN SAMPLING WILL BE	9149	0213	6331	LNAD	ZEN MEM ALDR
	0 741		0141	0214	6332	LNFAD	VEN FIELD ALD:
	3:142	DI SCUVTI NULD	6142	0215	6141	LINC	
	0.343		3143			LADE	
er tele g	3344		3144	9516	1000	LDA	
	0345	VPHJGRAM HALTS AFTER DATA HAS BEEN CULLECTED					
	3 7 4 6	PRIFSS CONTINUE TO PROCESS AND STORE DATA-	0145		0105	FNA	
	9347	1	ð146		1560	PCL I	
	0050		7147	9551	0037	3037	
		SECT - LOCATION 101 CONTAINS FIELD COUNT	9150	0553	4135	STC EMA	
	3.351		0151	0223	0443	515 0	
	3352	/SLCT - LOCATION 192 CONTAINS LINE COUNT	9152	0224	6227	JXP •+3	
	0153	/CAD - LOCATION 193 CONTAINS COMPOSITE	0153	0225	0500	1.0.8	
.	0054	/AP:DRFS5		3226	6313	EVF C	VEN TV FIELD CT
$\sim N_{\odot}$	0355	ZEFA - LOCATION 104 CONTAINS END FIELD	0154				
	0356	/ALDRESS .	0155	0227	0441		
	3057	VEMA - LOCATION 105 CONTAINS END MEMORY	3156	Ø230	6233	J4P +3	
	3363	/ALERISS	3157		3533	IOB	-
		ACCERT - LUCATION 130 CONTAINS COUNT OF	0163	Ø232	6314	F124	ZEN SLAULATUR
	0061		3161	9233	6442	SVS 2	
	3/162	VVFRTICAL COUNDINATE ERRORS	0160		6233	J4P1	
	anea	MCERE - LOCATION 131 CONTAINS COUNT OF		3235	0500	100	
		VHURIZUVTAL COURDIVATE ERRORS	0163		6321	ENCG	ZEN COORD CEN
	3:64		0164			SNS 3	ZSAMPLE FORCE PLATE
	0164 0065						
	7765		0165	0237			
	0065 0066	/	0165 0166	0237 0243	6304	J.4.2 DA3	>30
	0065 0066 0367	/ /TFLK - LOCATION 134 CONTAINS INITIAL			6304		
	0065 0066 0367 0379	/ /TFLK - LOCATION 134 CONTAINS INITIAL /FLOCK NUMBER FOR TAPE TRANSFER AT START	0166 0167	3243	6304 3077	J.4.2 DA3	130
	1965 9366 9367 9379 3971	/ /TFLK - LOCATION 134 CONTAINS INITIAL /FLOCK NUMBER FOR TAPE TRANSFER AT START /OF PEUGRA4+ EACH TIME A BLOCK IS USED	0166 9167 3179	3243 C241 0242	6304 3077 3777	JAP DA3 SET I 17 3777	130
	1365 9366 9367 9379 9371 9372	/ /TFLK - LOCATION 134 CONTAINS INITIAL /FLOCK NUMBER FOR TAPE TRANSFER AT START /OF PROGRAMA EACH TIME A FLOCK IS USED /TFLK IS INCREMENTED-SET TO 100 WHEN	0166 0167 0179 0171	0240 C241 0242 0243	6304 3077 3777 0643	J.4P DA3 SET I 17 3777 LDF 3	▲ 30
	1965 9366 9367 9379 3971	/ /TFLK - LOCATION 134 CONTAINS INITIAL /FLOCK NUMBER FOR TAPE TRANSFER AT START /OF PEUGRA4+ EACH TIME A BLOCK IS USED	0166 0167 0179 0171 0172	3243 C241 0242	6304 3077 3777 0643	J.4P DA3 SET I 17 3777 LDF 3 PDP	V30
	1365 9366 9367 9379 9371 9372	/ /TFLK - LOCATION 134 CONTAINS INITIAL /FLOCK NUMBER FOR TAPE TRANSFER AT START /OF PROGRAMA EACH TIME A FLOCK IS USED /TFLK IS INCREMENTED-SET TO 100 WHEN	0166 0167 0179 0171	3243 0241 0242 3243 0244	6304 3077 3777 0643	J.4P DA3 SET I 17 3777 LDF 3	V30

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. Meretanilein	nices references	section and	the latitude according	den de la construcción de la constru	a an ann an a	and a second	an na historio en	en fan de ferste fan de ferste fan de ferste fan de ferste ferste ferste ferste ferste ferste ferste ferste fer En ferste fers	and the second		in a principalitie de la service	der sie der Seiner Staten einer Sterne Steine der Bestehlungen der Beiter der Steinen der Steinen der Steine St Steiner Steine Steine Steiner Steiner Steiner Steine Steine Steine Steine Steine Steine Steine Steine Steine Ste	a series and a series of the series of th
								a0a 4	8226	a = 0.0		IUR	
	3175		0246			CLLR	/RATE=STOP.MJDE=0	3274	Ø336	0500 6335		RCA	
	0176		0247	1350		TAD K0060	VEN INT ON EVI	0275 0076	0337	4137		STC CA	SAVE CURHENT MES AD
	0177		0250	6134		CLEN	/1/2 1	0276	0343	1020		LDA I	SHVE COMPLETE MAR HD
	0593		0251	6141		LINC		0277	0341			0020	
	9591				•	LAO DE		0300	0342	0020			
	0595		0252	8443		SNS 3	CONTINUE SAMPLING?	7391	0343	0004		ESF	
	9203		Ø253	6334		JMP DA3	/N0	0302	0344	0000		HLT	
	3234		9254	0392		PDP		0303	0345	6352		JMP INITI	ADE TOON
	0235					PAJDE		0394	0346	6030		JMP Ø	/RETURN
	9236		Ø255	6131	DA1.	CLSK	/SAM?	0305			/	54355	
	92.37	4	0256	5251		JAP 5	IN CR	0306				PMODE	
	0519		02.57	6141		LINC	/YES	0307	0347	7772	KN6.	-6	
a la de la	0211					LMODE		0310	0350	0060	K0060,	2063	
1	0212		9263	0113	DA2,	SAM 10		0311	Ø351	7772	SCTR	-6	
1.	0213		0261	1077		STA I 17		0312					
	0214	С.,	3862	0217		XSK 17		Ø31 3			1		
	3215		9263	0456		SKP		Ø314			/		
	0216		3264	6394		JAP DAS	/BUFFER FULL	9315			/	· · · · · · · · · · · · · · · · · · ·	
	1017	lan di ku Martin	0265	9032		PLP		9316				LMODE	
	3223					PAJDE	이 같은 것이 같은 것이 같다. 것이 가지 않는 것이 같이 많이	0317				INITIALISATION	
	1221	- 14 - 14 14	9266	6135	a de la companya de l La companya de la comp	CLSA		0320	0352	0068	INITI-	SET I 2	
	9228		0267	2260		ISZ DA2		Ø321.	9353	0030		0	
	3273		8270	2351		ISZ SCTR		0322	0334	1020		LDA I	
antina Sector	7224	백리는	9271	5255		JMP LAI		0323	0355	0540		REGIN1	•
	2225		3272	72.00		CLA		3324	7356	4141		STC BEGIN	
	A226		2273	1347		TAD KN6		Ø325	0357	1023		LDA I	
	3227		0274	3351		DCA SCTH		0326	0360	0052		CC1	
	3233		2275	1269		TAL LAR		0327	3361	1040		STA	
		an a	3276	1347		TAD KNG		9330	0362	1615		13	
	3231		0277	3260		DCA LAS	RESET SAM	9331	0363	1040		STA	
			0320	6141	•	LINC		Ø332		1620		14	
	0233		8300	0141		LMODE		9333		1949		STA	
	5234		00.01	6046		JMP DA4	TEST FOR END DATA	0334		1631		15	
	9235		0301	6396		PDP		0335		1043		STA	
	3236		0335	0008			· · · · · · · · · · · · · · · · · · ·	0336		1674		16	
	2237					PAJDE		0337		1 3 2 3		LDA I	
1.2	(1943		03.33	5255		JNP LAL		0349	0372			+ CCS	
	3041					LHODE.	TEST FOR END DATA	0341	0373	1243		STA	
	0545		03:34	6306	DA3.	JMP DA4	TEST FOR END DATA	Ø342		1696		II	
	0343		0335	6304		J.jP1		0343		1049		STA	·
	3244		3396	1000	DA4,	LDA		3344		1613		15	
	3245		3397	3333		Ø		Ø345		1629		LLA I	
	0246	•	0313	4346		STC DA5			9403	0031		1	
	0347		3311	::509		108		9346		4143		STC CC	
	7257		7312	€336		RCFA	READ CURRENT FLD AD	8347	6401				COMP ALDE TO AC
	3251		:5313	1443		SAL	/CFA=END FIELD ADDR ?	0350		1333		LDA	VOMP ADDA 10 AC
	2252		0314	0194		1FA	•	Ø351	0433	0103		CAD	
	3253		2315	6317		JMP •+2	1.40	0352		1560		FCL I	
	<u> 3254</u>		3316	6355	. *	JKP +4	/YES	Ø353	3435	7770		7770	
	9255		0317	0462		SNS I 2		0354	3436	0302		PUP	
	0256		9329	6346		JMP DA5	CONTINUE	0355				PRUDE	
	GP57		0321	6331		JMP ++10		Ø356	3437			CIA	/TWOS COMPLEMENT
	0260			0500		108		7357	3410			TAD CFA	
	0241		0323	6335		RCA	/READ CURRENT ADDR	336 J	3411			104 ++2	
	3262			1563		PCL I		0361	0412	5214		1%P •+2	
	0202			2037		0937		0362	0413	0330		0359	
	8264			1443		SAL		0363	0414	7006		RTL	/X4
	0265		9327	0105		ESA		2364	0415	6141		LINC	
				6346		JMP DAS	/ 10	0365				LEODE	
	0266		0330	8500	,	IUn	/115.	3366	0416	4110		STC NLF	
	3267					DISCG	/DISABLE CG	3367		1303	•	LLA	
	7273			6382		IUB		3373		0127		C4	
	3271		0333	3530		RCFA		0371		1120		ADA I	/DIV BY 1777 .
	0272			6336			SAVE CURRENT FLD AD	0372		6890		-1777	
	3273		1335	4136		STC CFA			0-1.10				

a contraction of	i na stalini	an alar on a survey and a survey	ويطعونهم فتستحد وتعا		n an		and the second	e antes en la construcción de la co	Hill action 2 short Solved National Sol	 KC. et al. Management that is an international state of the second state. 	Stand Standard States and States an	
	7373	0423	0451	APU	/REMAI VDER +VE?		9472	05	3 997	7.	SET 1 17	
	0374	9424	6427	JMP ++3	2.80		0473	051			3777	
	0375	0425	0222	XSK I 2	YES, INC QUOTIENT		3474	051			JHP AD1	
	337E	0426	6421	JMP5	/REPEAT		3475	051			LDA I	
	0377	3427	1120	ADA I			0476	051			2003	
	0430	3433	1777	1777			8477	1958			STC AD3	
<u>,</u> 1	0431	0431	4111	STC REM	SAVE REMAINDER		9599	052			JMP AD1	
	0402	0432	2032	ADD 2			0591	058		I	JMP TA1	VNEXT 2 BLKS
58	9473	0433	2110	ADD NLF		1	9502	052			LDA I	
	3434	0434	4110	STC NLF	STORE NO OF LINC		8583	05			2034	
	0405	0435	2103	ADL CAD	/FIELDS		0594	852			STC AD3	
	3436	0436	1563	BCL I			0505	052			SET I 17	
E Since	9437	2437	7773	7770			3596	Ø 5 8			3777	
	3410	0043	4442	STC ++2			0597	053			JAP ADI	
	3411	8441	6443	JXP •+2			3513	053			LDA I	
£	3412	3442	8333	0890	/INITIAL FIELD ADDR		0511	053			2035	
	3413	0/43	0242	RUL 2	184		0512	053			STC AD3	
	0414	0444	1120	ADA I			9513	053			JAP AD1	
	0415	8445	9643	8649	/LDF N		7514	053			JMP TAL	ZLAST 2 PLKS
23	9416	0446	4112	STC DFD1	SAVE INIT LINC FIELD		3515	953		MAINS.	PDP	
	9417	3447	3911	CUN	사람이 영국 관계에 관계하는 것이 같다.		0516				PAJLE	
	2421	0450	4050	STC 50		8	3517	053	7 4514		JAS I INIT2	
	3421	9451	4051	STC 51			0520	354		BEGINI.	JMS I START	
	3488	0452	4052	STC 52			3521	054			JAS I VOIEST	
	3423	0453	4253,	STC 53			0522	354			JAS I PHC	
	3424	0454	4054	STC 54	집에 집에 가지 않는 것 같아. 가지 않는 것 같아?		0523	054			JMS I CJUE	
	0425	0455	4855	STC 55			0524	054			CLA	
9	0425	0456	4056	STC 56			0525	054			TAD CAMCU	CAMERA CODE
	8427	2457	4357	STC 57			0526	054			CLL	
	3433	3463	4363	STC 63			0527	854			RAL	ZX1J CPINADYS
	3431	3461	4661	5TC 61			W530	355			TAD K2350	VISZ EURAED
	3432	3462	4062	STC 62			3531	055			DLA +4	
ч. <u>с</u>	9433	2463	4063	STC 63			1532	355			TAD ++3	
	3434	0464	4064	STC 64			9533	055			101-81	ZSAD ISZ
	3435	0465	4365	STC 65			3534	055			DC4 +3	
	3436	3466	4366	STC 66			0535	355			3333	/ISZ, CÓUNTS HC FOR
	0437	0467	4267	STC 67			0536			/		LACH CAMERA
	3463	9473	0002	PDP			9537	055	6 5361		J≾P •+3	
<u>)</u> (3441			PHODE			3540	055			3323 .	/OVERFLOW
	3442	9471	5513	JMP I MAIN	• •		3541	056			CLA	
	1043			A second state of the second sec second second se second second sec			0542	856			TAD CAMCO	
	0444			1			9543	05€			SZA	1663 32
	0445			1			3544	956			JAP +2	1.00
	3446			1			0545	956			JAS I STURE	/YES, STORE COORDS
	3447			MAIN PROGRAM			3546	056			LINC	
	3453	0472	6141	MAINI, LINC			0547				LAUDE	
	9451			LADDE			9553	056	6 7247		JAP HCP1	
	3452	0473	0443	SVS 3			%551	356			HLT	
	9453		6536	JAP MALN2	IND FP DATA TO STORE		0552	057		PASS2	PDP	
	3454	0475		LDA I			3553				PAULE	
	9455	3476		2308			:3554	357	1 4514		JES I INITS .	
	0456	0477		STC AD3			9555		2 4537		J4S I INIT3	
	0457		0377	SE1 I 17			3556	357		BEGI V2.	JAS I START	
	3463	3501	3777	3777			7557	357			JMS I VCTEST	
	3461		6614	JMP AD1			0560	057 057			J45 1 PHC	-
	0462	3533		LDA I			4561	357			JAS I CUDE	
	0463	0504		2991			9562 9562	357			LIVC	
	0463	0535		STC AD3			9563 9563	031	1 0141		LADE	
	0465	0596		JMP AD1			0564	360	3 1995		LLA	
		0590		JMP TA1	/XFER 2 BLKS					2	CAACO	
	3466			LDA I	e est both to Liberthed		J565	063			SAF	
	3467	0510		2002 2004			0566	063				
	0473	9511		STC AD3			0567	960 (44)			00 168 - 1 4	
	J471	3512	4523	SIC ADS			0573	NO ()	4 6613		JAP •+4	
	-											

	SECOND INITIALISATION ARTUEN JAP VT VYES UNT	•	/LDF N VVCEAR SET TO 5 VACEAR SET TO 5 VFFLAGI SFT TO 9
TA3 BCL 1 7603 STC TBLK JMP 0	JTINE FOR 840DE 840DE 840DE 1033 1033 1032 1032 1032 103 103 103 103 103 103 103 103 103 103	- 0 - 6 0 -	STC LFD 3333 3333 STC LFD STC LFD STC LFD STC FLACI STC FFLACI LDA I
1 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	/ SUBRUL		
8666 1569 4134 6000 6000	6141 6141 1006 6141 1006 6713 6713 6713 6713 6713 6713 6713 1028 1028 1028 1028 1028 1028 1028 1028	7776 1933 1933 1933 1933 1933 1933 3777 8361 8361 8361 8361 1033 3112 8363 9035 1033 1033 1033	6000 600 700 800 800 800 800 800 800 800 800 8
0671 0671 0672 0673	000 000 000 000 000 000 000 000 000 00	6471 64728 64728 64728 64728 64728 64728 64733 64736 64733 6	00725 0772 0772 0775 0775 0775 0775 0725 072
96779 96779 96775 96775 96775 9793 9793 9795 9795 9795	97116 977116 977117 977717 9777717 977777777	0735 0735 0735 0735 0748 0748 0748 0745 0745 0745 0755 0755 0755 0755 0755	9755 9755 9755 9755 9755 9755 9755 9755
		τ, μ	
STURE CP1 CP1	ADI. LDA LDA LDA LATE DATA ADI. LDA 0	-2 S TJ TAPE UN UNIT A4 A2 A2 /UNIT	0 1 1 1 3 0 3 1 1 3 0 5 1 1 1 3 1 1 1 1 1 3 3 1 1 1 1 1 3 3 1 1 1 1 3 1
PUP PAULE JAS I ST JAS I ST LINS I ST LASDE JAS HCP1 PAUDE PAUDE PAUDE PAUDE	MISE FUR LDA STC ADA STC ADA STC ADA STC ADA STC 10 STD 1 STA 1 STA 1 STA 1 JAP ADS JAP ADS JAP ADS JAP ADS JAP ADS JAP ADS STA 1 STA 1 ST		882 1000 1000 1000 1000 1000 1000 1000 1
PASS3	AD1. AD2. AD2.	Ар4. / / / ТА1. ТА1.	TA2. TA3.
00028 6 1 2 1 7 2 2 4 1 9 2 0 0 2 9 5 9 0 9 0 0 1 9 1 1 11111111111111	00000000000000000000000000000000000000	6637 6637 6637 6639 6639 6639 1038 11123 11123 1123 6531 10534 10534 10534 6531 10534 6531	0714 0000 1000 1100 1100 1100 1000 1001 1001 1001 1000000
00000000000000000000000000000000000000		000000 000000 000000 000000 000000 00000	80.80 80.000 80.000 80.000 80.000 80.00000000

2.49
and the street of	معمولا فصبي مؤموسة مدينون ال			ور من ور م	 Section of the section of the section	Construction of the standard state of the	er Mallana Dir Neumanna an an an an an Arabia Pro An anna Anna An Anna Anna Anna Anna Ann		and the construction of the owner		e daram meneral services and a service service service service service services and the service services of the	Anne a state of the second
	9767	0751	6471		APO I		1011	1 7 4 9				
	0773	0752	5417		STC M1		1966	1347			JMP END	
	3771	0753	1323		LDA I		1967	1353			CLR	
	3772	07 54	7757		-20		1970	1051			ADD DFD	
	3773	0755	5440		STC M2		1071	1952	1120		ADA I	
						•	1072	1953	3331		1	
	0774	2756	1390		LDA		1073	1354	5005		STC DFD	/INC DATA FIELD CNT
	3775	8757	2030		2030		1074	1055	7005		JMP DFD	
	0776	0760	4116		STC TVC	/INITIAL VC	1075	1056	0916	END.	NOP	
	0777	0761	0002		PDP		1376	1057	3911		CLR	
 	1999				PMJDE		1977	1969	2111		ADD REA	/REMAINDER
93.4	1031	6762	5675		JAP I SINITE	· · · · · · · · · · · · · · · · · · ·	1199	1061	3017		COM	MENHINDEN
ats.	1392			1			1101	1062	4005		STC COUNT	
1	1033	har an		1 I			1192	1063	1020		LDA I	
	1974	e dan dari sering. Kabupatèn kabupatèn k		1.1			1103	1964	7776		-1	
	1035			1.		and the second	1104	1965	4006			
2014	1936		1991				1105	1366	3005		STC FCOUNT	
Sec. 14	1037		1.54.54		*1000		1106	1067			ADD DFD	
	1710			/SUBBUI		VENTICAL COURDINATE	1197		1123		ADA I	
an a	1911	1000	0000	CUTEST	2848	/RETURN JMP		1073	0001		1	
े <u>दि</u> है	1312	1031	6141		LINC		1110	1071	5705		STC DFD	
1.00	1913				LAUDE		1111	1072	1023		LDA I	
÷	1814	1002	0225		XSK I COUNT		1112	1373	7 976		JMP •+3	
	1915	1 203	7005		J4P +2		1113	1074	5056		STC END	
-						1	1114	1975	7005		JAP DED	RETURN TO PROCESS
8 P.	1216	1994	7.345	DE D	JMP FCNT	VEND OF LINC FIELD	1115	1 376	1929		LDA I	/REMAINDER
n a lie	1017	1005	0644	DF De	6644	/LDF CURRENT DATA	1116	1077	7131	END1.	J:4P +2	
	1923					FIELD	1117	1139	5056		STC LND	
	1321	1996	1021		LDA I STAD	INEXT WORD	1123	1101	9966		SET I FCOUNT	PROCESS LAST
	1382	1097	1563		NCL I		1121	1192	7776		- 1	LINE OF LATA
	1023	1919	1777		1777		1122	1103	0:365		SET I COUNT	
	1024	1311	1463		SAF I	/VC 2	1123	1124	7776		-1	
	1025	1312	6933		6030		1124	1105	1020		LDA I	
	1059	1013	7153		JAP CATHC	0k \	1125	1106	7111		JMP +3	
	1027	1014	1039		LLA	/YES	1126	1197	5056		STC END	
	1939	1915	0391		STAD		1127	1113			JMP IADDH+1	
8	1031	1316	1153		ALA I		1130	1111	1020		LLA I	
	1332	1017	7775		-1		1131	1112			7777	
	1233	1323	1623	•	FSE I		1132	1113	4004		STC TVFCNT	
	1334	1321	2033		2393		1133	1114	0317		CO.4	
÷.,	1335	1022	1463		SAF. I	/ERROR	1134	1115	4117			
	1336	1923	3330	IADDR,	อฐาญ		1135	1116	0017		STC VC	
	1937	1924	7926		JMP ++2	1.00	1136	1117	4133		CO.4	
	1340	1925	7035		JMP +13	/YES	1137	1129			STC HC	
	1341	1096	1001		LDA STAD		1140		2134		ADD TELK	
	1342	1027	4116		STC TVC		1141	1121			ALA I	
	1 343	1033	1000		LDA			1122	0332		5	
	1944	1030	0031		STAD		1142	1123	5132		STC +7	
	1045	1032	5323		STC IADDR	•	1143	1124	0002		PDP	
				•			1144				PMU DE	
	1046	1933	0005		PDP		1145	1125	4527		JMS I STORE	
	1347	104.			PMUDE	245.1.00000000	1146		7200		CLA	
	1959	1034	2099		JMP I CVTEST	/RETURN	1147	1127	1134		TAD TALK	
	1051				LEODE		1153	1130	6141		LINC	
	1352	1035	3395		PTP		1151				LYODE	
	1353				PMODE	·	1152	1131	1460		SAL I	TARL EDARM STRICK
	1:354	1036			ISZ VCERR	/INC VC ERROR COUNT	1153	1132			3339	/TAPE STORE FULL ? /TFLK+2
	1955	1937			JWB •+5		1154	1133			JXP -7	/ NU
	1956	1343	7492		HLT	/Tuo Many Errors	1155	1134			JMP PASS2	/YES
	1057	1341	7240		STA	/SET AC=7777	1156			/	0.11 FH226	< 1 L3
	1063	1342	3132		DCA EFLAGI	SET ERROR FLAG	1157			,		
	1061	1043	6141		LINC	· · · ·	1160			1 5		
	1062				LMJDE		1161					
	1063	1044	7150		JAP CNTHC		1162			/		
	1064		0226	FCNT.	KSK I FCOUNT		1163			,		
	1365	1946			JAP ++2		1164			10.24	*1150	
							-			/ CUENT	HURIZONTAL COORI	DIVATES & SR. LOLD

يعزه وليز		وروب أوحارك وروار	سيونين والأستان وسيري				a Maria and Antonio Anno a channa an ann an Anna an Ann An Anna Anna	fering State States and States States and States States and states in growth and states and st States and states and st	والمراجع والمراجع والمراجع والمراجع			ander versen eine ersen er en	
	1165				0.10/10	LHUDE		1264	1244			STC LHC	/LAST HC
	1166 1167		1159	0 045	CNTHC.	PDP PMO DE		1265	1245	0311		CL ??	
	1173		1151	2115		ISZ HCNT	/ERROR?	1266 1267	1246 1247	4132	11001	STC EFLAGI	/CLEAR FLAG
	1171			5357		JAP ++5	/ ERRORT	1270	1250	3217	HCP1,	CLR Adu ad	
	1172			2131		I SZ HCERH	YYES, COUNT ERRORS	1270	1251	1120		ADA I	
	1173		1154	5356		JMP +2		1272	1252	7776		-1	
	1174			7432		HLT	TOU MANY ERRORS	1273	1253	1 949		STA	
	1175		1156	5541		JMP I BEGIN	RETURN TO START	1274	1254	1217		AD	
s.	1176		1157	6141		LINC		1275	1255	1460		SAL I	/LAST HC ?
	1177					LMO DE	. ·	1276	1256	0000	LHC.	0903	12327 OH 2030
	1233		1160	1231		LDA STAD	STORE CURRENT HC	1277	1257	7262		JMP ++3	CKN
n en de. Tester de	1231				/		IN APROPRIATE LOC	1300	1260	3005		PDP	/YES
	1202				TEMSTO,		/STC 30,31,32 ETC	1301				P4JDE	
	1233			3161		ADD TEMSTO		1332	1261	5541		JMP I BEGIN	
	1235	l es ll	1164	1120 0001		ADA I		1333	10/0	60/2		LMUDE	
	1636			5161		STC TENSTO		1394 1395	1262	5263 0000	•	STC ++1	
	1237			7342		JMP CVTEST+2		1306	1264	4133		0309 STC HC	AND LATEST HC
	1219				1.			1307		0002		PDP	
Villan Bir oʻ	1211				1			1310				PMODE	
	1212				1			1311	1266	5699		JAP I SPHC	
	1813				1			1312			1		
	1214					*1200	· · · · ·	1313	1267	0003	PH2,	0	
	1215				/SUBBOU	FINE TO PROCESS	HORIZONTAL COURDINATE	1314			1		
	1216					PMOLE		1315			/		
	1217		1293		SPHC,	02:00	/RETURN JMP	1316			/		
	1559	4. j	1291	6141		LINC		1317				TINE TO EVALUATE	
2.2	1221		1000	1.344		LMJDE		1329			SCODE.		ZETURN JAP
	1222 1223		1202 1233	1030 2115		LDA		1321	1271	6141		LINC	
	1223		1204			HCNT ALA I		1322	1070	0.311		LAJDE.	
	1825		1895			5		1323 1324	$\frac{1272}{1273}$	$0011 \\ 2136$		CLR ATAL CD	
	1226		1206			ADA I		1324	1274	3261		ADD SR RUL I I	
	1227		1237			2030	/ADD 1-7	1326	1275	4136			ZREPLACE SHIFTED SH
	1233		1213	5217		STC AD		1327	1276	2133		ALL HC	ALIGION DATFIL DA
	1231		1211			ADD HENT	FORM FOL N TO	1330	1277	0312		BUR 12	
	1232		1212	1663		BCO I	CONRECTLY ORIENTATE	1331	1330	0261		EOL I 1	
	1233		1213	0397		ð90 7	/SR WORD.	1332	13:01	1569		PCL I	
	1234		1214			ADA I		1333	1392	7773		7773	
	1235			3853		0253	FORMED	1334	1303	4123		STC CAMCO	ZCAMERA CODE
	1936		1216	5231		STC PH1		1335 1	1304	3 995		PDP	
	1237		1217	3203	AD,	0993	ADD HCN	1336				PADDE:	
	1240		1223	9263		RUL I 3		1337	1305	5670		JAP I SCODE	ZREIGEN
	1241			3472			/F_P?	1340					
	1242 1243			7231 5267		JMP PH1 STC PJ9	/ 10 / 17 ES	1341 1342			,		
	1243			2304		STC PH2 ALD TVFCNT		1343			,		
	1245			1620		BSE I		1344			ZSDRROD	TINE TO STORE COD	WI JATES
	1246		1906			4900		1345	1336	0033	SSTURE		ARTUNA JER
	1247		1227			STC TVFCNT		1346					
	1250		1230			ADD PH2		1347				LAJDE	
	1251					0303	/ROL N	1350	1310	9541		LLF 1	
	1252		1232			STC SR	SAVE SR WORD	1351	1311			LDA	
	1253		1233			ADD EFLAGI		1352	1312				TV FELL COUNT
	1254		1234				/FLAG SET ?	1353	1313	1063		STA I TRUE	
	1255		1235				1.10	1354	1314	0255	•	ASK I TONT	/TAPE BURFIE FOLL?
	1956		1236			LDA I	/YES	1355	1315				/ 3.)
	1257		1237			2433		1356	1316				/YES, STORE ON TAPE
	1263		1240			SIC LHC	ZLAST HC	1357	1317			LLA	
	1261		1241			JAP +4		1363	1320				VERTICAL COOLDINATE
	1262		1242			LDA I		1361	1321			STA 1 TRUE	
	1263		1243	6021		2327		1362	1322	9555		XSK I TONT	
	-							-					

oie Xini-	an a						na na sense da se	and the second	معديد وردي م رود معوره درونيار (منابعة وما والمعورة	n a chana ann an tao ann an tao ann an tao		
	1363		7325		MP .+2		1462			1		
	1364	1324	7450		ISP MIAPE		1463			1		
	1365	1325	1303		.DA (C	HORIZONTAL COORD	1464					
	1366	1306	0133			AQUITOATHE COOND	1465					
	1367	1327	1560		CL I 039		1466			·. ·	•	
	137.3	133.)	6003		TA I TBUF		1467			/		
	1371	1331	1963		SK I TCNT		1470 .			/SUBRUU		LE DATA ON TAPE
	1378	1332	8888		MP •+2		1471		1 4 4 4		LAUDE	
	1373	1333	7335		MP MTAPE		1472	1450	1333	MTAPE.	LDA	
an a' an a'	1374	1335	0302		EP		1473	1451	0000 550)		J	A PERSON AND A STREET A DESCRIPTION
	1375	1000	0006		AUDE		1474	1452 1453	5541 1020		STC RETURN LDA I	/SAVE RETURN ADDRESS
	1377	1336	5736		MP I SSTURE		1476	1454			1	
h.	1433						1477	1455			AXO CXA	
	1491	ر با میں		1			1590		1023		LDA I	
1017	1408	lan an taon 1990. Taona 1990 - Anna 1990		1.			1501	1457			-1909	
	1493			1	Section and the		1532	1460	4992		STC TCNT	/RESET TONT
	1434	a da ara	20 - C	1			1573		1930		LDA	4
	1435	i national da stan Ting ang padatang		/SUBROUTI	NE TO START PRO	CESSING	1574	1462	0134		TBLK	
의 이상 영화 이상 전	1436				1438		1505	1463	1120		ALA I	
	1437	1403	9909	STARTI, 0			1576	1464	0001		1	
19.5	1413	1401	6141		IVC	 The second process of the second s	1507	1465	1040		STA	
an an Ar Ar an Ar	1411				NJDL		1512	1466	Ø134		TRLK	
	1418	1432	1383		DA I		1511	1467	1100		ADA I	
	1413	1403	7771		6		1512	1470	3033		3030	
	1414	and the second	4115		TC HCNT	SET UP HC COUNTER	1513	1471	0451		apj	ZTAPE OVERFLOW?
	1415 .	1495	1020		LAI		1514	1472	3999		HLT	/Y ES
	1416	1436	4939	. 4	039 TC TEMSTO		1515		1333		LDA	Cr.V
	1417	1497	5161				1516	1474	0303 ·		TPUF	
	1423	1413	2116		DD TVC		1517		1123		ADA I	
	1461		1563 6393		330		1520		1000		1939	
	1422	1413	1049		14		1521	1477			APJ I	/LJWER HALF FULL?
	1424	1414			Ċ		1522		7506		JØP ++6	ATES
	1425	1415			DA I		1523 1524	1591 1592	1000 0134		lda Tplk	/NO, UPPER HALF FULL
с. н. П	1425	1416			473		1585		1123		ADA I	
	1427	1417	3471		PU 1		1526	1504	6000		6000	
	1433	1420	7146		AP A3		1527		7512		JMP ++5	
	1431	1421	0224		SK I TVFCNT	/INC TV FIELD COUNTER	1530	1596	1030		LDA	
	1432	1422	1039		LA		1531	1507	0134		TELK	
	1433	1423	0004		VECAT		1538	1510	1122		ADA I	
	1434	1424	1560	P	CL I		1533	1511	4333		4999	
	1435	1425	7433	7	400		1534		5514		STC +2	
	1436	1426	1460	S	AL I		1535	1513	0714		9714	ZwRC 1
	1437	1427	037 7		377		1536	1514		XFER1,	0090	
	1440	1435			MP MIA		1537	1515	1009		LDA	
	1441	1431	1003		DA		1549	1516	1514		XFERI	
	1442	1432	3034		VECNT		1541	1517	1120		ADA I	
	1443	17.33	1560		CL I		15//2		1.331		1901	
	1444	1434	9377		377		1543	1521	1043		STA	
	1445	1435			TC TVFCNT		1544		1540		XFFBS	
	1446		0311		LR		1545		1839		LLA	
	1447		1129		DA I		1546		1514		XFERI	
	1450		7757		20	AND ADD INST	1547		1560		ECL I	
	1451	1441	3417		DD 41	/ADD APO INST /REPLACE MUDIFIED INS	1550	1526	7000		7000	
	1452	1442			TC M1	ARECAGE SUDIFIED IND	1551		1123		ALA I	
	14:3	14/3	3443		DD M2		1552	1530	0001		1	
	1454	1444	3017		1014 TC X2	/APU I INS CHANGED	1553		1943		STA	
	1455	1445		-	TC M2 DP	ABLA T TWO OLUMOTO	1554	1532	8134		TELK	ZRESET TELK
	1456	1446	2692		MODE		1555	1533	1120	1	ADA I	·
	1457	1 4 4 7	56 40		MODE MP I STARTI	ZRETUEN	1556	1534	3000		3020	1 2000 A 10 10 10 10 10 10 10 10 10
	1463	1441	56.19		al I SIMALI	* 48 Aui 4 Suli - 7	1557	1535	0451		APU	/TAPE JVERFLUW?
	1461			•			1560	1536	0039		HLT	/YES

25.4

		2716		0714	/NO, WRC 1	a na ana ang ang ang ang ang ang ang ang	1660	1668	1020	an a	LDA I
1561 1562	1537	3714 3933	XFFR2.	0333			1661	1663	0091		1
1563	1541	0000	RETUEN		/RETURN JMP		1662	1664	1143		AD.4
1564			/				1663	1665	0140		CC
1565			1			•	1664	1666	1460		SAE I
1566			1				1665	1667	0396		6
1567			1		•		1666	1670	6570		JMP PASS2
1573		•	1				1667	1671	6611		J.4P PASS3
1571			1 .				1670	1672	0011	RET.	CLR
1572				*1600			1671	1673	1349		STA
1573				I VI TI ALI SATI ON, P			1672	1674	0052	16,	CC1
1574	1690	0000	SINIT3,		/RETURN ADDR		1673	1675	1000		LDA
1575				PADE			1674 1675	1676 1677	0140 0250		CC Rol 10
1576	1691	6141	a di shara	LINC	e a construction de la construction Construction de la construction de la		1676	1790	5703		STC 17
1577	1600	1020		LDA I			1677	1701	2004		ADD TVFCNT
1633	1602	\$573		PEGI 12			1700	1702	1620		BSF I
1638	1604	4141		STC REGIN			1701	1723		17,	0330
1633	1605	1223		LDA	1		1702	1704	4304		STC TVFCNT
1604	1636	0953	11.	CCS			1703	1795	0032		PDP
1€35	1637	3479		AZE I	· · · ·		1794				PMO DE
16 16	1619	7617		J4P T2			1705.	1706	5600	-	JMP I SINIT3
16'37	1611	0011		CLR			1736				
1619	1612	1040		STA			17 37			1	
1611	1613	0953	12,	CC2	/CLEAR CC2		1710			,	
1612	1614	1343		STA	101 100 001		1711 1712			,	
1613	1615	0352	13,	CC1	/CLEAR CC1		1713			,	
1614	1616	7672 1300 -	T2.	JMP RET LDA			1714			•	*1
1615	1629	0058	14	CC1			1715	0001	0000	STAD.	2
1617	1621	0451	· · ·	APU	/>2000 PTS 7		1716	0002	0000	TCNT.	Ø
1623	1622	7672		JMP RET	YES RETURN		1717	0003	0000	TBUE	8
1621	1623	1120		ADA I			1729	0334	0333	TUFC VT.	Ø
1622	1624	3400		3469			1721	0005	0000	COUNT	0
1623	1625	0451		АРО	/>256 PT5		1722	0006	0003	FCOUNTS	3
1624	1626	7672		JMP RET	ITES RETURN		1723	0007	0000	LFC.NT.	ø
1625	1627	9311		CLH	1.90		1724				•
1626	1633	1943		STA			1725			/	t
1627	1631		15,	CC1			1726 1727			,	*52
1630	1632	1320		LDA I			1733	0052	0309	CC1.	8
1631	1633	0092		2 AD4			1731	0053	0000	CC2,	ð
1638	1634 1635	1140 1606		II			1732			/	•
1634	1635	1020		LDA I			1733			1	
1625	1637	0002		2			1734			1	
1636	1643	1143		ALM	•		1735			1	
1637	1641	1613		12			1736			/	
1649	1642	1923		LDA I			1737				*130
1641	1643	0335		2			1743	0130	3203	DATA	200
1642		1143		AD4			1741	0101	0033	SFCT.	3
1643	1645			13			1742	0102	9236	SLCT.	236
1644		1329		LDA I			1743	6103		CAD.	3031
1645	1647	0032		2			1744 1745	0124 0195	0302 4003	EFA. EHA.	2 4 2 3 2
1646		1143		ADM			1745	0195		CFA.	3
1647	1651	1620					1748	3107		CA	0
1650	1652	1323		LDA I 2			1757	0110	9300	VLF.	9
1(51	1653	0302 1140		ADA			1751	0111		RFA.	ð
1652 1653	1654 1655	1631		15			1752	3112		DFD1+	õ
1654	1655	1929		LLA I			1753	0113	0472		MALNI
1655	1657	3332		2			1754	0114		INITS.	SINIT2
1656	1669	1148		AD4			1755	0115	3900	HCVT.	0
1657	1661	1674		16			17 56	0116	3209	TVC.	Ø

/INC CHAN COUNTER

	ويجددونه ومعاودته	ala di tana jinan nandi tana asar	oja managana katala	ala propositi negativa de la compañía de la compañí	فيستنبذ فستحصص ويرج ويشتدوه		······	and the second second			en da internet		and the state of the state of		al an an an aire
	1757	Ø11 ⁻		VC.	Ø			DF D	1005					6345	
	1763	012.		VCTFST.				DF D1	0115					1070 0351	
	1761	9121		PHC.	SPHC			DISCG	6355				SFGT	0101	
	1762	0182	2 1273	CODF.	SCUDE			EFA	0104				SIVITS		
	1763	Ø123	3 0000	CAMCO.	0			FFLAG1	0132				SI VITA		
	1764	0124	2053	K2353,	2050			EMA	0105				SLCT	3192	
· · ·	1765	0125	5 9931	K1.	1			ENAD	6331					1200	
	1766	9126	5 1247	HCP.	HCP1			FNCG	6321				SR	3136	
	1767	Ø127	1306	STURE	SSTURE			FND	1056				SSTORE		
	1773	3132	5 0933	VCLER	8			ENDRI	6343				STAD	3001	
	1771	3131	0000	HCERR	8			ENDI	1977			•		3135	
	1772	013	3 99999	LILAGI	0			FNFAD	6332				STAET1		
	1773	013.	5 0000		9			ENFC	6313					01.87	
	1774	9134	4 0011	IDGRA	(/ CTAUT1			ENMON	6391				SUPH	6346	
	1775	0133	0 1420	START	JINALI			FNSM	0314				TA1	0643	
÷.	1776	0130	5 0000 12/00	313	0 61 11 79			FONT	1045				142	0657	
	1///	0130	1000	CC-	1 1			FLOUNT	0000	•			T43	3666	
	K.9.0.5	0141	00001	DERIN	DICTAT		n e maile e con	110.00	0100	and the second second	· .		TA4	367.4	
e dispeditori A	6391	87141		J				noran	0131				TFLK	3134	
	0012							UCNI UCNI	0126				TEUE	9393	
	0336			1		a second and the second second second		0001	10/7			•	TCVT	0.132	
	00.35			1 .		a ta an an an an 🕴 💁 an ann an		TADDD	1993			•	TEMSTO	1161	
1. set 1.	6033				and the second second			14000	2250				TVC	3116	
a de la comercia de l La comercia de la come	43 FPR	185					1	10110	0110				TVFCVT		
								TUTTS	0137				15	1617	
ina Angelere	ar.	1217						11	1606				VC	2117	
	451	8614					· · · · ·	12	1613					3130	
	402	9621						13	1615				VCTEST		
	AD3	0623						14	1620					1514	
	AD4	2642						15	1631				XF EBS	1540	
•	PEGIN	9141						16	1674						
	PEGINI	9540						17	1703						
	FFGI V2	0573						3.46	1347						
	CA	0107						4.8960	3353						
	CAL	0133						K1	0125						
	CAGO	6333						K2050	Ø124						
	CAGUER	6305						LI)CA	6333		1				
	CANCO	0123						LDCAM	6302		•				
	CC	3143						LDFC	6311		÷				
	CCAFL	63.36						LILC	6312						
	CC1	3752						LFCVT	603 7						
	CCS	3053						LHC	1256						
	CDPF	6347						JAIN	0113						
	CDPI	6344	· .					MAINI	3472						
	CDP4	6342						MAI V2	0536						
	CFA	3136						MTAPE							
	CFC	6315	-					M1	1417						
	CLAD	6334						MIA	1436						
	CLCAL	63-14					•	38	1/43						
		1150							1446						
	COLE	0122						VLF	0110						
	COUNT							PASS2							
	CSM	6316						PASS3	2611						
	CUTEST							PHC	1121					•	
	DATA	01.55						PH1	1231						
	DATAL	0200						PHS -	1267						
	E41	1255						FCA	6335						
	IA2	0260	•					TCFA	6336						
	DA3	0334						EEM DET	3111	*					
	L-14	33.36						REI	1672						
	EA5	3346						EETURA							
	LBM	6341						SCAC	639 7						
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										_			
							9376			1.			
	3333		*		*20		9377				* 5/)		
	3331					C - CALIBRATION MATRIX ACQUISITION.	01 00	3050	0030		ø		/COURDINATE COUNTERS
	0005				/		0131	0351	0000		Ø		/FOR EACH CAMERA
	0003				/16-5-7	75	. 0102	ØØ52	0030	CC1,	0		/CHANNEL
	0334				/		9193	0253	<u> </u>	CC5°	9		
	8335				/d.0.JA	ARRETT.	8104	0354	8039		ø		
	2 326	•			/		0105	0055	0032		Ø		
	30.37				1		@1:96	0056	0003		Ø		
a ta da	0310				- 78 HODE	E I/O PRESET, START 20.	0137	ØØ57	0030		0		
	3311				1		0110	3369	0000		Ø		
	3312				1		2111	0 961	0000		ø		
199	0313				/PHJGRA	M OBTAINS THE CO-ORDINATES OF A	0112	0062	0999		Ø		
	3714			13 g - 4 - 1	/GRID O	F PJINTS AND STORES IN THE FORMAT	0113	3963	0000		3		
	3315				/VC+HC+	UN TAPE UN UNIT 1 STARTING AT TAPE	0114			1		•	
	8016				/FLUCK	HELD IN TRLK (LUCATION 2360) INITIALLY	3115			1			
ŵ, s	0317				/SET TO	200. THIS DATA IS THEN REDUCED TO	3116			1			
227	0323				/PROVID	of an averaged pair of co-urdinates for	8117			1			
tan ka Marina	0321				/EACH G	REL POINT, AND STORED IN A CALIBRATION	9123			1			
dr S	3.322	en en en			ZSATRIX	- FURMAT: -	0121				*100		
14 de 1944 1947 - 1944 1944 - 1944 - 1944 1944 - 1944 - 1944 1944 - 1944 - 1944 1944 - 1944	0013			S. 1997	1		3122	3130	0030	SFCT,	Ø		VIV FIFLD COUJT
	3724				VUC. VC	··· VC+K ···K+HC+HC ···HC+K ···K	Ø123 .	0101	0036	SLCT.	36	•	SIM LINE COUNT
	3925				1		0124	0102	9991	CAD.	3331		COMPOSITE ADDR
	2326				1.		0125	0103	0000	CFA.	0		CURRENT FIELD
	0327				1.		0126	0194	0300	CA	Ø		CULHENT ADDA
	2233				1.		8127	0195	2103	I VI TE.	SINITS		
	3 131				1		0139	0106	2643	VCTEST.			
1.1	3.132				ZUC, VC	••• VC+K •••K+HC+HC •••HC+K •••K	3131	0197	2434	PHC.	SPHC		
er per se se Tra construction	3.333					*** K+K ***K+ K+ K *** K+K ***K	9132	0113	2512	CODE	SCUDE		
	3334				1		3133	0111	0000	CAMCO1.			
8-1-1- 8-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1	3035				1.		9134	6112	2350	K2950,	2353		
· · ·	0336			1 A.	1.		0135	0113	0001	K1,	1		
	0.037		÷.,		1.		0136	0114	2542	STURE,	SSTORE		
	3343				1		0137	0115	2433	START,	STARTI		
	3041				/ K. K	••• Kod •••Ko Ko K ••• KoK •••K	3143	0116	3967	INIT3.	SI VIT3		
	3.14.9				1		0141	3117	0331	CC,	1		
	9343					K=3777; THE MATRIX OCCUPIES LOCATIONS	0142	0123	9832	PFG1N.	PEGINI		
	331.4					2777 JF A PAUDE DATA FIELD- FUR A	0143	9151	9233	CAL			
2.1	0345					ATION GRID OF 25X10 THE ACTIVE ELEMENT		0122	7403	CAN.	SCAL		1041
	3346					MATHIX WILL BE FOUND IN LOCATIONS	0145	0122	3474	DI SP.	7400		/CAL RH MARGIN
	3347				/3003 -		0145	0124			SDISP		
	3051				/ 5500 -	2011-	J147		7777	K.91.	-1		
	0951					THE IS STRUCT IN TABLE TO A DEALER		0125	7776	K41.	7776		
						THIS IS STORED ON TAPE IN 6 PLOCKS	0153	0126	3400	SCDA.	SSCDA		
	0459 3053					NG AT THE PLOCK NUMBER HELDLIN CTELK TON 5273) INITIALLY SET TO 22.	0151	0127		NELS.	9990 States		NO DATA WOLDS
					/	ION SEVEN INTIMULT SET TO 20.	0152	2133		INIT4.	SI VITA		
	3354 0755				,		0153	0131		TESP	2010		
	0755					LULSYM	0154	0132		INTI.	SENITI		
	3356					PAJ DE	0155	6133	4200	C04P.	SCUAP		
	3757				<i>c</i>	*10	0156	0134	4403	RE Do	Shr.D		
	3763			7777		1777	0157		4531	STOR.	SSTOR		
	0361		0911	9033	r VC+	ð	0163	0136	3777	K3777,	3777		
	0768						3161			MTX+	S4TX		
	2363				/		0162		5063	CHFCK.	SCHECK		
	0064					MTXV=GD	Ø163	0141	3337	K37+	37		
	0065					STXH=F VC	0164		0377	K77,	77		
	3366						Ø165		0137	K137.	137		
	0:46 7				/		3166	0144	5200	TAPL	STAPE		
	007.1					*20	3167			1			
	3071		0350	5521		JAP I CAL	8173			1			
	3:72				1		0171			1			
	1373				1		0172			1			
	.).) 4				1		0173				*200		
	3378				/		3174	0200	0000	SCAL.	0303		·
						·	-						

	and the second					an a	and the second	and the second se					a de la facta de la de la facta de la facta de la d
	0175	0201	6322		DISCG		0274	4 020	7 45	36		JMS I VCTEST	
	0176	0232			CLA		0275					JAS I PAC	
	3177	0233			TAD CAD		0276					JAS I CODE	
	9233	02.14			LDCA	COMPOSITE ADDR	0277					LINC	
- 191	0201	0205			CLA		3303					LMJDE	
	3535	02:06			TAL CAM		9301		3 100	00		LDA	
	0203	92.37			LDCAM	ARH MARGIN	9303					CAMCJ	
er ander Gegeneren	2034	0210			CAGO		03/33					SAL	
n an	9235	9211			EVAL	ILN ADER	9394					CC	
	3236	0212			LVFAD	/EN FIELD ADDR	0305					J4P +4	
	8237		7230		CLA		0336					PLP	
	0210	9214			TAD SLCT		0397					PADDE	
	3211		6312		LILC	/LD SIM LINE CNT	0310		1 451	4		JMS I STORE	
	9212	0216	6314	t spin	ENSA	/EN SIMULATOR	0311	. 030	2 614	1		LINC	
	0213	. 2217	6321		ENCG		0318					LADDE	
	0214	3223	63.37		SCAC	/CAL COMPLETE?	0313		3 060	51		LIF 1	
	3215	9221	5223		JMP1	/NJ	0314	i 033	4 647	2		JWD HC61	
	3216		6322		LISCG	/YES	Ø315		5 030	95 P	ASS3,	PLP	
	3217	0223			CCAFL	/CLR CAL COMP FLAG	0315					PMODE	
	6223	0224	6335		RCA		9317					JMS I INIT4	
	3821	0225			DCA CA	CURRENT MEM ADDDR	4329					JMS I COMP	
•	3888	0226		1	RCFA		0321					JMS I SIJR	
•	8223	9552	3103	1	DCA CFA	/CURRENT FIELD ADDR	0322				1.1	JMS I SCDA	
da Antonio en el	3224		1997 - 1997 1997 - 1997 1997 - 1997	1			0323					JMS I DISP	
	3225						0324				•	JAS I MTX	
	1226			/			0325					JAS I CHECK	
	2887			1.			0326					JAS I SCDA	
	2532						0327					JMS I DISP	
	2231			1			0330					JUS I TAPE	
	323.2			MAIN P			0331		0 740			HLT	
	3233	9539	4532		JAS I INITI		0332						
	3824	9231	4535	MAINL	JAS I INIT2		0333						
	3835	9232	4515	PPGINI.	JAS I START		0334						
	8936	3933	45.36		JAS I VOTEST		0335 0336						
	3237	0234	4537		JAS I PHC		3337						
	.4241	0235	4510		JAS I CODE		0349					. 4	
	0242	3236 3237	7293 1111		CLA TAD CARGON	AGAMERA COLE	0341					LHOLE	
10	0243	9249	7193		TAD CAMCOI CLL	ZAMERA CODE	0348					SEGANT 1	
	3944	6241	7334		RAL	ZK13 (BINARY)	0343			1	FIRST	INITIALISATION	
	0245		1112		TAL K2050	/ISZ FORMED	3344					*233	
	2046	3243	3:247		DCA ++4	VISC FORMED	0345					PADE	
	0247	9244	1247		TAL +4		0346		g g øe	o si	INITI.		
	2250		1113		TAD KI	ZND ISZ	0347					LINC	
	0255 0251	0246	3251	• .	DCA ++3	* U.S. L.	0353			-		LMODE	
n se de la composition Referencia	0252	3247	0000		0000	/ISZ, COUNTS HC FOR	0351		S 006	2		SET I 2	
	3253	0253	5253		JXP +3	ZEACH CAMERA	0352					3	
	3254	0251	0000		3000	/OVERFLOW	3353					LDF 3	
	3255	0252	7203		CLA	·	0354					LLA I	/SETS UP
	0256	3253	1111		TAD CAMCUL		0355					BEGINI	/LJC FOF
	1257	0254			SZA	/CAM 0?	0356		7 134			51 A	/PEUCESS
	9263	0255	5257		JMP ++2	///	0357		3 218			PEGIN:2000	ZPASS 1
	3261	0256	4514		JMS I STORE	YES. STURE COURDS	0360					LLA I	
	1868	0257	6141		LINC		9361					CC115939	/SETS QP
	0263				LMODE		0362					STA	/ເວລະນັບ
	3264	9263	9601		LIF 1		3363				•	13	/TO STAT
	3265	0261	6472		JMP HCP1		3364					STA	/CHANNEL
	3266	0268	9933		HLT		3365					I 4	/PASS 2
	3>67	3863		PASS2.	PDP		0366					STA	
	3279				PMJDL		3367				1	15	
	0271	3264	4505		JAS I IVITS		0370					STA	
	3272	0265			JMS I INIT3		. 0371					16	
	3273			PEGI N2.	JMS I START		0372					LDA I	
							· -						

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UP CHAN COUNTERS IART AT NL 1 FOR 2 PROCESSING

						A CONTRACTOR OF A CONTRACT		Contraction of the second s	A THE CONTRACTOR AND AND A SUCK STORE	WEINER CONTRACT		a na ann an Anna an Ann	the management of the second
	0373		0224	2953		CC212003		0472	0321	2050		5012000	/USED TJ CJUNT
				1043		STA		0473	0322	1040		STA	
	374		3825										VAO OF COORDS
	0375		3556	1077		11		0474	0323	2051		51!2000	/FRUM LACH
•	3376		0227	1040		STA		347 5	0324	1340		51A	/CAMERA CHAN
	0377		0230	1134		15		6476	Ø325	2952		52!2000	
	9439		0231	1959		LDA I	/CAMERA CHAN	0477	0326	1040		STA	
						1	/SET TO 1 FOR	3503	2327	2053		5312000	
· . • ·	8481		0838	3331									
	9482		3233	1 349		STA	/FIRST PASS OF	Ø5Ø1	0333	1043		STA	
	5433		0234	2117		CC12000	/PASS 2	0502	0331	2954		5412000	
1,224.20	9434		0235	1393		LDA	/COMP ADDR TO AC	0503	0332	1943		STA	
	2435		0236	2192		CAD12090		0504	0333	2955		5512000	
						BCL 1		0595	0334	1940		STA	
	0426	1993.	9237	1560									
	8437		0240	7773		7770		0506	0335	2056	•	5612300	
	8413		0241	3398		PDP		0507	0336	1940		STA	
in action	8411			19 Section	영상 문화 가지?	PAUDL		0513	0337	2957		5712000	
A 1.2	2412	5.5	8848	7041		CIA	/CALCULATE NO OF	0511	0343	1340		STA	,
	3413		2243	1103		TAD CFA	ALINC FIELDS IN	0512	0341	2060		6012000	
		12:03	2844	3846		DCA ++2	COMPLETE PHODE	0513	0342	1040		STA	•
and the second	3414	122	a that I a share a	18 Novali 1. La L									
	9415		2945	5247		JXP ++8	/FIHLDS	9514	9343	2061		6112333	
	9416	÷	2246	8830	이 집에 가슴을 가지?	0099	그는 것은 옷을 빼 안 안 하는 것이 없는 것이 같다.	0515	0344	1040		STA	
	3417		2247	1246		TAD1		2516	0345	2062		6515090	
K	0423	1	2250	1246	وی از میکند از میکند. از معارضه در این میکن در با در از از از ا	1AD2	같다. 한국 영화 성격에 다른 것이 많다. 같아요.	0517	0346	1049		STA	
	3421		2251	1246		TAD3	전성이 영양철 등 감사에서 가지 않는 것을 다.	0520	0347	2063		6312000	
		- 16-		1246		TAU4	/84	0521	0350	1230	· · · · · · · · · · · · · · · · · · ·	LDA	ZINITIAL TAPE
	3488		2252								1.00		Veluck NU
	3423		2253	6141		LINC		0582	0351	0360	•	TFLK	FELJUR NO
	3424					LEVER	혼다. 정기 같다는 것이 집에 많아?	3523	0352	4361		SIC ITPLK	
	3425		3254	4355		STC ALF	승규는 것 같은 것 같은 것이 없는 것 같아.	0524	0353	0002	1	PDP	
	3426		Ø255	1093		LDA	승규는 것은 것이 같아요. 이는 것을 많다.	0525				PAUDE	
	3427	1.	U256	2134		CA12030		0526	2354	5600		JMP I SINITI	
						APO I	/<2 LINC FIELDS ?	0527		0000	1	0	
	0433		0257	3471							' ,		
	3431		3260	6265	•	JAP +5	/YES	0530					
	3432		3261	1560		BCL I	GR.	0531				L'AU DE	
	3433 -		9262	4333		4933 .		9532			1		
	3434	•	9263	3062		SET 1 2		0533	0355	0000	NLF,	ø	
				-		2		0534	93.56	0000	REAL	0	
	3435		0264	9:):02			1511 BY 0044						
	3436		9265	1120		ALA I	/DIV BY 2000	0535	0357	0000	DF D1.	0	
	3437		0266	5777		- 5999		Ø536	0369	0177	TPLK,	.177	
	7440		Ø267	9451		APO	/REMAINDER +VE?	0537	Ø361	0177	I TELK,	177	
	3441		0270	6273		JMP +3	140	0540			1	1 <u>1</u>	
			3271	3288		KSK I 2	TYES, INC QUOTIENT	0541			1	<u> </u>	
	3442 .						/ELPEAT	0542					
	243		0272	6?65		JMP5	* 1.207 ADT 1				·.		
	-je- <u>4</u> 7.		0273	1123		ALA I		3543					
	3445		6274	S303		2633		9544			VSUBRJU	TINE FOR SECONI	D INITIALISATION
	0446		0275	4356		STC RE4	/Save Remainder	9545				*100	
	0447		0276	2302		ADD 2	/CALCULATE AND	3546				PHO DE	
						ADD NLF	STURE TOTAL NO	2547	2169	Ø00Ø	SI NI T2,		ZEETURA JMP
	3459		0277	2355			JOF LINC FIELDS		2131	6141		LINC	
	3451		3303	4355		STC NLF	AND FILLED	3553	6101	0141			
	3425		0391	1300		LLA		0551				LAUDE	
	24.53		3332	21:12		CAL12083		0552	0102	10.73		LUA	
)454		\$3.33	1560		BCL I		Ø553	2133	6355		NLF	
			3334			7770		0554	3134	9.417		COM	
	34:55					STC +2		9555	3195			AZE I	/NLF=G ?
	3456		0335										
	3457		Ø306	6310		JMP +2		0556	0136			J.1P + + 10	/ YES
	9469		3307	5333		3113	/INITIAL PMODE	Ø557	6137	4336		STC FCJUNT	SET UP LINC FIELD
	3461			2397		ADD1	VFIELD ADDR	0560	911 <i>8</i>	1020		LPA I	/CUDVIER
	3462			2397		ADD2		35(1	3111			1015	/SET END TO NOP
						ADD3		9560	9112			SIC END	
	0463			2337			1 5 1						
	3464		031 3	23.3 7		AUD4	/ 54	0563	3113			SET I COUNT	
	346.5		0314	1123		ada I		3564	0114		;	1777	
	3466			3643		3643	/LDF N	2565	:3115	6127	1	JEP +12	
	3467			4357		STC DFD1	/SAVE INIT LINC FIELD	0565	0116	1000	7	LLA '	/<1 LINC FIFLD
								3567	3117			14F.14	/JE TAINS SET
	3479			8011		CLR	THESE LOCATIONS						ZCJUNI IJ HEN
	3471		3383	1943		STA	VINEDE LUCHIIVAD	0570	0120	0:717		CO 4	FUSUAL IS MEN
	-							-					

Para la la Malaktaria di Sul sura da	A dela de la desta de la dela de la dela de la dela de la dela de			en e	ne na vezet na stranov se	n na an	an a	and the second	an a			a an
0571	9121	4375		STC CJUNT	AND LINC FIELD		0679	0414	0537		VC	
9572	0185	0366		SET I FOUNT	/COUNT TO -1		Ø671	0415	1123		ADA I	
0573	3123	7776		- 1			0672	0416	7307		-473	
3574	J124	1000		UDA	ISET FND TO JMP		Ø673	0417	4471	M1,	APJ I	INEW TV FIELD?
2575	0125	3677		F.VD1	/INST AT ENDI		3674	9429	6432		J32 ++12	
3576	3126	4656		SIC IND			0675	0421	0224		XSK I TVFCNT	/INC TV FIELL COUNTER
3577	9127	3965		SET I TONT	12 BLUCKS OF DATA		0676	2422	0011		CLR	
05.00	0130	6777		-1930			0677	0423	1129		ADA I	
06 71	0131	2963		SET I TRUF	/TAPE BUFFER SET			0424	7757	NO	-23	
	3132	3777		3777			9799			M5,	-	
0632				SET I STAD	START ADDR FUR		0791	0425	2417		ADD6	ADD APO INST
JE J3	0133	0361			/DATA		7792	0426	4417		STC -7	VREPLACE MJDIFIED INS
36 34	(1134	2909		2.112			0793	0427	2424		ADD •-3	
0635	2135	3.364		SET I TVFCNT	TV FILLD COUNT		97 44	0430	9917		COM	
96 36	0136	3333		9909			0705	Ø 431	4424		STC5	ZAPO I INS CHANGED
36.37	0137	1063		LUA			7796	0432	0002		PDP	
3619	0149	0357		DFD1			Ø7 07				PHJ DE	
3611	0141	1043	2 A A	STA			0710	2433	5600		JAP I STARTI	/RETURN
5612	8142	3144		•+8			0711			/		
3613	3143	4605	14 - 19 A. M.	STC DFD		· ·	0712			/		
9514	A144	0939	1. N. S. S. S.	3900	/LDF N		0713			1		
1615	3145	1020		LIA I			0714			1		
5616	\$146	23.13	-	2333			0715			ZSUBROI	ITINE TO PROCESS	HORIZUNTAL COURDINATE
7617	3147	4623		SIC IADDR	/INITIAL ADDR		0716 ·	2434	0230	SPHC.	0000	ZRETURN JMP
38 2.3	9159	4771		STC VCEER	VCERH SET TO 0		0717	2435	6141		LINC	
3621	3151	1773		STC HCERR	ACERK SET TO 0		0720	0.100	••••		LADE	
3688	0152	4772		SIC LFLAGI	/EFLAGI SET TJ Ø		0721	0436	1000	. •	LDA	
0683	0153	1923		LDA I			9782	0430			HCNT	
		6471		APU I	TTV FIELD COUNT				0773			
9624	0154			STC M1	ADUTINE SET TO		0723	0443	1120		ADA I	
0525	9155	4417			/INITIAL CONDITIONS		0724	2441	0005		5	
0626	3156	1020		LLA I	/INTIRG CONDITIONS		0725	0442	1120		ADA I	
3627	0157	7757		-23			9726	0443	2030		2030	/ADD 1-7
0633	3160	4424		STC N2			3727	9444	4453		STC AD	
3631	6161	1003		LDA			0730	3445	8773		ALL HONT	VEOEN HOL A TO
0632	9168	2900		2000			0731	3446	1663		BCO I	CORRECTLY DELENTATE
3633	2163	4774		STC TVC	VINITIAL VC		9732	0447	303 7		Ø33 7	/SR &JDE.
3634	9164	0002		PDP			3733	0459	1123		ADA I	
#635			•	PMODE.			0734	0451	0256		0256	AROL N. FOLMED
3636	2165	5733		JAP I SINIT2			0735	0452	4454		stc •+2	
- 34 37			1				0736	0453	0000	AD,	0000	ZADD HCN
1643			1				\$737	34:54	80.30		3939	ZHUL N
36.41			1				27 49	0455	4540		STC SR	IS AVE SR WORD
3642			1			•	9741	0456	2772		ADD FFLAGI	
2643			1				07 42	0457	0471		APJ I	/FLAG SET ?
0644			1				0743	0460	6465		JMP ++5	/ 10
			,									
0645			1		-		(1744 1744	3461	1920		LDA I	/ 7 E.S
36.46			-	LMODE	•		0745	3462	2030		2030	
2647			/CODD-1		DOCKSSING		0746	3463	4591		STC LHC	/LAST HC
36.50			× 50%R30	TINE TO START P	400203140		9747	3464	6470		JMP •+4	
76 51				*400			3 7 59	0465	1929		LDA I	
36 52				PAUDE		•	0751	3466	2227		2327	
0653		0000	START1,				0752 ₁	0467	4501		STC LHC	/LAST HC
06.54	2431	6141		LINC			07 53 (3473			CLR	
0655				LAJDE			07 54	3471	4772		SIC FFLAGI	/CLEAR FLAG
06.56	0408			LIA I			0755	3472		HCP1,	CLR	
16.57	3403	7771		-6			07 56	3473			ADD AD	
0663	3404	4773		SIC HONT	/SET UP HC COUNTER		37 57	9474			ALA I	
0661	0405	1029		LDA I			0769	9475			-1	
0662	3436	4320		4933			8761	0476			STA	
0663	3437	4762		STC TEMSTO	VRESET TEMSTO		0762	8477	0453	•	AD	
0664	3410		•	ADD TVC			0763	3533	1460	i	SAL I	/LAST BC 2
	3411	1560		BCL I						190		
0665				6900			0764	0501	0000	LHC.	03.99	12327 JA 2333
0666	3419	6009			INEXT VC STURED		0765	3592	6595		JAP +3	/NO
3667	5613	1049		STA	FARAI VU DIVAED		3766	0593	8935		PDP	YES, NETURN TJ .
-												

	a a tha a tha an an an an an an an a tha	in in the second second second									
3767				PMODE	/PROCESS NEXT	1066	Ø561 ·	0002		PEP	
3773	2534	5520		JAP I BEGIN	TV LINE OF DATA	1067				PMJDE.	
0771				LMODE		1079	2562	5742		JMP I SSTORE	
0772	0505	4506		STC •+1		1971			1		
0773	2 536	0030		80.00	ADD LATEST HC	1072			1		
3774	0537	4536		STC HC		1373			1		
3775	2510	8338		PDP		1074				LMODE	
3776				PHODE		1075			/SUBROU	TINE TO TEST FOR	VERTICAL COUEDINATE
3777	2511	5634		JMP I SPHC		1076				*600	
1389			1			1977				PMODE -	
1001	100 EC 100 E	1.1	1 .	1 Junio a		1100 .	2600	0000	CVTEST.	3300	/RETURN JMP
1302			1	· · · ·		1191	2601	6141		LINC	
1933	n an an shi ta ta shi ta sh	e e e e e e e e e e e e e e e e e e e	1		sector and approximately for	1195				LYODE	
1334	and set of the	y ta ta	/SUBROU	TIVE TO EVALUATE		1103	0602	Ø225		XSK I COUNT	
1035	2512	0000	SCODE	0330	/RETURN JMP	1104	0633	6605		J46 •+5	
1336	2513	6141		LINC		11/05	0604	6645		JMP FONT	VEND OF LINC FIELD
1937			, i	LMODE	an a	1106	0645	0644	DFD	3644	/LDF CUBRENT DATA
1913	0514	0011		CLR	and the second	1107	0696	1021		LUA I STAD	/FIELD
1311	9515	2540		ADD SR	•	1110	0697	1560		BCL I	/NEXT WORD
1012	3516	J261		ROL I I		1111	0610	1777		1777	
1013	9517	4540		STC SR	/REPLACE SHIFTED SR	1115	0611	1460		SAL I	/VC ?
1014	1253	2536		ALD HC	•	1113	8612	6000		6303	
1715	4521	0312		FOR 15		1114	3613	6751		JAP CNTHC	ON V
1916	3528	0261		FUL I 1		1115	0614	1000		LDA	/YES
1317	3523	1560		PCL I		1116	9615	0301		STAD	
1223	3524	7770		STC CAMCO	CAMERA CODE	1117	0616	1129		ADA I	
1021	0525	4541		ALD HC	CAMERA CODE	1120	0617	7776		-1	
1388	3526	2536		BCL I		1121	0620	1623		PSE I	
1323	0527	1560 6309		63.33		1122	3621	2333		2330	
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1325	9532	10002		PDP (1124 1125	0624	6626	THUDRU	0000 JXP •+2	1.50
1627	3 556	12 4 18		PAULE		1125	2625	6635		JMP ++10	/ NO / YES
1939	2533	1341		TAD CANCO		1127	Ø626	1001		LDA STAD	VUC FOR NEXT IV
1931	2534	3111		DCA CAMCOI		1130	0627	4774		STC TVC	LINE STORED
1032	2535			JMP I SCUDE	/RET URN	1131	0630	1009		LDA	LINE SIGNED
1033	2000		/	0		1132	0631	0301		STAD	VINITIAL ADDR
1034			•	LMUDE		1133	0632	4623		STC IADDR	ZEFSET
1235			1			1134	0633	0002		PLP	·
1036	3536	2230	HC.	0		1135		0000		PMODE	
1037	3537	3396	VC.	ā		1136 .	2634	5690		JAP I CVTEST	ZRETUEN
1043	3540	9930	SE.	0		1137		••••		LMODE	
1341	3541	3399	CA4CU,	0		1147	0635	0002		PDP	
1048			/			1141				PMODE	
1043				PHODE	•	1142	2636	2371		ISZ VCIKR	VINC VC EERDH COUNT
1344			1			1143	2637	5241		JAP +2	The to Print or Oak
1045				TINE TO STORE CO.	JRDI NATES	1144	2640	7432		HLT	ZTOO MANY EARDES
1046	2542	03:19	SSTURE		KETURN JMP	1145	2641	7243		STA	/SFT AC=7777
1347	2543			LIVC		1146	2642	3372		DCA EFLAGI	SET ERHUR FLAG
1053				LMJDE	•	1147 .	2643	6141		LINC	
1951	0544	9659		LDF 10		1150				LADE	
1952	3545			LDA		1151	0644	6751		JAP CNTHC	
1353	3546			VC	VERTICAL COORDINATE	1152		0226	FCNT.	XSK I FCOUNT	/INC LINC FIFLE
1054	3547			STA I TPUF		1153	0646			J4P ++2	/COUNT
1055	0553			XSK I TONT	/TAPE BUFFER FULL?	1154	0647				VEND OF L FIFLDS
1856	7551			JMP +2	1 40	1155	0650	0011		CLR	
1057	3552			JAP MTAPE	VYES, STORE ON TAPE	1156	9651			ALL DED	/INCREMENT CURRENT
1063	0553			LUA		1157	0652			ADA I	/LINC FIELD
1361	0554	0536		HC	ZHORIZ JNTAL COJRD	1160	0653		:	1	
1362	0555			STA I 1BUF		1161	0654		ļ	STC DFD	
1363	9556			XSH I TENT		1162	0655			JMP DFD	
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	1174						1274	27 55	5357		J-12 +2	
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3.00	1177	0672	1 3 2 0		LDAI		1276					
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an an ta	1208		6605	s.).	JMP DAD	VRETURN TO PROCESS	1391	0761	1001		LDA STAD	ISTURE COLREAT HC
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4.5	123	A CONTRACTOR OF					1333	0762	4030	TIMSTO,	4030	/STC 30,31,32 ETC
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			0002		PLP		1343	1013	9363		TRLK	
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4297 3073 6141 L14C 1525 1163 6463 JAP PASS2 7A3, REPLAT PASS 2 1247 3073 6141 Le3DE 1527 1165 6311 RET, CLR CLR 1231 171 3643 LDF 9 1539 1165 6311 RET, CLR CLR 1432 1372 1823 LDF 9 //LEF 9 1531 1167 2352 16. CC112330 1433 1373 0266 PRG142 /LOUDD PRIOCESSING 1531 1167 2352 16. CC112330 1434 1375 R124 PRG1422 /LOUDD PRIOCESSING 1534 3171 5667 JAP I SIAIT3 1443 1377 2333 11. CC212303 /ANY COUNDS 1536 / L3DE 1441 1131 711 JAP T2 /COURTPY 1537 / L3DE L3DE 1844 1843 1843 1843 1844 1844 1844 1844 1844 1844 1844 1844 1844 1844 1844 1844		1967	0333					15.24	1162	3006		6	
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1442 1132 0J11 CLk /fESCLEAR COMMENT 1541 /SUBRUTI W. TO INITIALIZE PASS 3 1443 1103 1044 STA /CAM CHAY COURD 1542 *1236 1444 1144 2053 12 CC12006 /COUNTERS 1543 *1236 1444 1105 1343 STA 1544 3236 0305 SINIT4, 0335 1445 1106 2552 13. CC112303 1545 3231 6141 Live 1447 11.07 0302 PDP 1546 1545 3231 6141 Live 1453 11.05 5667 JNP I SINIT3 1550 1293 5267 STC NB1 1452 111 1303 T2. LDA /CHECK LOW ORDER 1551 1234 4032 STC NB 1453 1111 1303 T2. LDA /CHECK LOW ORDER 1552 1234 4032 STC NB 1454 112 2552 14. CC112300 /HALF OF CNTH 1553 1205 1620 LDA		1131	7111		JAP T2	CUREENT CAM CHAN?		1540				L-1JDE	
1443 1103 1043 STA /CAM CHAN CODED 1542 *1238 1444 1164 2953 12, CC212303 /COUNTERS 1543 PMDE. 1444 1164 2953 12, CC212303 /COUNTERS 1543 PMDE. 1445 1105 1340 STA 1544 3230 0303 SINIT4, 0033 1446 1106 252 13, CC112303 1546 LAODE LAODE 1453 1137 0332 PDP 1546 LAODE LAODE 1451 3112 5667 JMP I SINIT3 1550 1293 5267 STC JBI 1453 1111 1373 72, LDA /CHECK LOW ORDER 1551 1293 S267 STC JBI 1454 1112 2352 14, CC1123006 /HALF OF CNTH 1553 1206 7653 LLF 13 1454 1112 2352 14, CC1123006 /HALF OF CNTH 1553 1206 7653 LLF 13 1455 1113 3451						/TES CLEAR CURRENT		1541			/SUBRJU	TINE TO INITIAL	IZE PASS 3
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						/>40 (OCTAL) PTS							
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	1561	. 19	214	0002		PDP			1657	1432	1320		LLA I	
	1562	•		0000		PMU DE			1660	1433	30.46		LIF 6	
	1563	30	215	1266		TAD KN4	/CALCULATE NO		1661	1434	5412		STC P1	
			216	2267		ISZ NBI	/OF LINC FIELDS		1662	1435	0011		CLE	
	1564			7540		SZA SMA			1663	1426	3364		SEI I RGL1	VIATA PULNIER
	1565		220	5215		JMP3			1664	1437	3717		3777	
	1566			7339		CLA CLL			1665	1410	0365		SEL I EGUS	VLISP BURFER
	1567					LINC			1666	1411	3777		3777	PUINIER, VC
	1570	31	222	6141		LMODE			1667	1412	3366		SF1 I RGL3	/LISP PURFFR
	1571	•		00/7		ADD NB1			167.3	1413	3777		3777	VPUINIEE+ RC
	1572		223	3267		CO4	/SET LINC FIELD		1671	1414	3646	PL.	L1F 6	
	1573		224	0317		STC LFCNT	/COUNT		1672	1415	1 9 2 4		LIA I RGD1	/ VC
	1574			4397		ADD I TRLK	7 CO (141		1673	1416	1463	•	SAE I	
	1575		556	2361		ADA I			1674	1417	7777		77777	
	1576		887	1120		4201	SET INITIAL		1675	1423	0456		SKP	
	1577			4991		STC A2	TAPE BLOCK NO		1676	1421	7472		J4P 84	VENL JE DAIA
, tas Car	1633			5236		LUF 10	FAFE Deven ive		1677		4537	•	STC VC	
	1691		138		Al,	SET I TTC	/SET TO XFER		1703	1423	1024	•	LIA I RGLI	74C
	1632		333	0361		-4	14 BLOCKS		17.71	1424	3341		SCR 1	
~ ~	16:33		234	7773	100	8719	/REC 1	· · ·	1772	1425	45.36		SIC HC	
	16:34		335	3713	40.	0993	MPLKNTBLK	*	1793	1426	2537		ALL VC	
	1635		336	0333	A2,	LDA I			1734	1427	1123		ALA L	
	1636		237	1929		1031	/INC MBLK & TBLK		1775	1/33	73 37		- 47 8	
	1697		340	1301		AD4			1786	1431	3471		APJ I	VOLL OR EVEN FIELD
	1610		241	1143		A2	e de la companya de l		1797	1/32	7444		JAP P2	
	1611		242	1236		XSK I TTC	14 BLOCKS?		1710	1433	1123		41/4 I	
	1612		243	0221		JMP A2-1	/ 10		1711	1430	3273		273	
	1613		244	7235		XSK I LFCNT	TYES, ANY MURE?		1712	1435	9017		CJ.4	
	1614		245	Ø227		SKP	ZYES		1713	1436	4537		STC VC	
	-1615		246	0456 7264		JAP A3	/NO, RETURN		1714	1437	1320		L14 I	
	1616					LDA I			1715	1443	4.333		43.3.8	
	1617		259	1323		1			1716	1041	1143		AUM	ISET HE FOR DISPLAY
	1623		251	9391		ALM	/INC CURRENT		1717	1442	0536		10	VUN CHANNEL 2
	1621			1140		Al	/LINC FIELD		1720	1443	7450		J.4P B3	
	1622		253	1232		LFA			1721	1444	1123	P2.	ALA I	
	1623		254	1353		A2			1722	1445	7577		-213	
	1624		855	1236		ADA I	RESET MELK		1723	1446	3317		CUM	
	1625			1120		-1	ALDET ALDET		1724	1467	1.531		SIC VC	/LISPLAY UN CHAN 1
	1625		857	7776		ALA I			1725	1450	361.4	B3+	LLH 4	
	1627			1123		4000			1726	1451	1393		LLA	ISTURE IN LISPLAY
	1633		261	4733		STC A2			1727 .	1452	3537		VC	ZPOFFFR
	1631		262	5236		JMP A1			1733	1453	1965		SIA I EGL2	
	1632		263	7232	43	PLP			1731	1454	0645		L19 5	
	1633	13	264	9635	A3,	PMO DE			1732	1455	1 300		L1-A	
	1634		0 / E	= ())		JMP I SINIT4			1733	1456	3536		'1C	
	1635	33	200	5603	1	UMP I DIWITH			1734	1457	1066		STA 1 REL3	
	1636				,				1735	1463	32.15		KSK BC12	/IISP PUR RULL!
	1637							•	1736	1461	3456		SKP	/ VJ
	1640	3	266	7774		-4			1737	1462	1412		JAP R4	1155+ FKI 1
	1641				1	1 40 00			1743	1463			KSK EGL1	/EVE JE & FIELD?
	1642					LMODE			17#1		7410		JAP PI	100
	1643		~~~	0000	301	a			1748		1323		LIAI	TYESPING Lin
	1644	1	267	9993		Ø			1743	1466			1	
	1545				/				1744		1143		ALA	
	1645				/				1745		1414		F1	VINC L FIFLD
	1547								1776		7414		JAP P1	
	1653				,				1747		3338	-P4.	51.5	
	1651					*1430			1753	1-10	1.1.1.6	4 - 4	5WALE EVE	
	1652					PHODE COOPE 1	N DICOLAY DUPPED		1751	3473	5673		JMP I SSCLA	
	1653						N DISPLAY BUFFER		1752	0-10	2007	1		
	1654			0033	SSCLA	00:00			1753			,		
	1655	3	431	6141		LINC			1754			1		
	1656					L MO DE			• • ···					

a de la compañía de			·····							an ingener waard an oor all all an oor all		
	1755			1			2354				RG11=TVFCV1	
	1756				TINE IN DISPLAY	GRTT:	2355				RGL2=COUVT RGL3=rCJUVI	
	1757 - 1763	3474	3333	SLISP.	3233		2356 2757				DH=LFCN1	
	1761		6141	52.5.	LINC		2364			1	DI-GI W.V.	
	1762	0-12			LAJLE		2361			1		
	1753	1476	1333		LIA	•	2362			1		
	1764	1477	9135		1018		2063			1		
	1175	1501	1567		PCL I		8760				SIGMNT 8	
	1766	1501.	6933		6333		2365			/		
•	149 1	1578	3317	•	COM		9 36 6				*534	
2017	17/7	1533	1120		A14 I		2 167			/		
	1771	1504	7776		-1 510 +2	a di su d	2373				SAME SANKER-	JUNDINATES BELUNGING
	1272	15.16	3363	C1.	SET I RGE	and the second	2371 2372			/ 10 142	2431 SAUVIN-	
	1716	1507	3943	•••	9333		2 373			•	PMULT	
1 - Er	1775	1517	3.365		SET I ROLR		2774	4232	0009	SCUMP.	0.111	
	1776	1511	3171		3171	a an	2375	4291	6141		LINC	•
	1177	1512	03 86		SFI I RG13		2.176				U401A	
	2131	1512	3777		3777	and the second second second	2372	4595	Ø073		SFI I SGD	
	83.11	1514		CS1	LIF 5	 Marchael Control (1996) Marchael Control (1996) 	2133	3:233	3777		3777	
	2.1.12	1515	1036		LIA I BGL3 SIC LK	/AC	2131	92.44	3335		PLP	
in Ein Sa	2332	1516	4337		L1+ 4		2107 2133	42 15	7333		PAULE CLA CLL	
	2035	1500	1025		LIA I RGES		2134	4236	1124		IAL KVI	
	8116	1521	5147		LIS LH		8145	42 37	3910		ICA GL	
$\mathbb{V} \in \mathbb{V}$	21.17	1522	1223		ASK I RGL	ZEND OF BUFFERT	2136	4210		C.) J.	CLA CLL	
	2313	1523	7514		JAP CP	L41	2127	4911	1213		141 +2	ZRESEI CJ2
	2111	1524	144 1		5NS 0		2119	4312	7113 .		SKP	
	2312	1595	7506		345 61	/1F2	2111	4213	3346		10A 401	
	0,113	1596	1.52.3		514 I		2112	4214	33.51		LCA CJ2	
	2314	1527	102.0	631	23		2113	4215	68.81		CD# 20	41 0 1 × A.
	2315	153 <i>4</i> 1531	1143		414 C3-3		2114	4216	1410 7040		TAL I GL CAA	ACC TO AC
	2016 2017	1538	1333		L1.4		2115 2116	4217 4223	7443		57.4	VEND OF DATAL
	5353	1533	1527		C3		2117	4221	5223		J4P +8	/ 10
	2321	1534	0317		CJ.4		2120	4222	5337		342 004	YYES, HEIUHN
	2102	1535	5587		510 03		2121	4223	7 943		C:14	
	2303	1 536	9938		515		2122	1.224	3337		LCA RVC	
	2324				5-01FF		2123	4225	1410		AAL I GL	VHC IJ AC
	2325	3537	5674		JAP I SUISP		2124	4226	7413		SZA	ALNEADI PRJCESSEL!
	2126			1.			2125	4227	7419		SKP	N3
	2327			1			8186	4233	5213		145 COS	1115
	2333 2331			,			£197 2130	4231 4232	3343 1343		LCA RAC TAL RAC	
	21.12			-	LAJDE	·	2131	4233	3344		LCA CHCI	
	2333			1			2132		1337		TAL RUC	
	2.130				*1		2133		1113		141 61	ZVC+1
	2335	3 3.51	8339	SIAL,	3		2134		3341		DCA CVC	COMPARISON VC
	2036		3333		3		2135	4237	1010		TAL GL	
	2337		9397		8		2136	4243			1CA EVC	15ET OP LAIA PUTVIEE
	2363			IVIC 11.			2137		1411	CO1+	IAL I FVC	NEKT VC IN COMPARE
	2341			CJUN1.			2140	1242			ICA CVCI	
	2342 2342			r CJU 41+ Lr C 41+			2141	4213			TAL CUCI	
	2043 2368	3931	24.27		U		21/2	4244			CMA 57.A	VEND OF LATA
	2345			1			2143 2144	4246			SKP	/vJ
	2346			1			2145	4247			J42 CJ3	TIES, ED AFLUCE LAIA
	2367			1			2146	4253			IAC	VIGUS COMPLEMENT
	2151			1		÷	2147	4251			TAL CUC	/000-00
	P 151				TIC=STAD		2153	4252	7443	ł	524	/しじ=じしじ?
	2352				VP=1CV1		2151	4253			SKP	/33
	6353				HGL=1RUr		2152	4254	5264		JMP CJ1A	1125
	-											

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215		4255	1124		TAL RUI		2252	0346	0373	HC1,	0	
215		4256	1103		SZA	/UC=CUC-1?	2253	0347	8113	HCS1	6	
215		4257	7413		SAP	C4.1	2254	0350	0100	HC3+	3	
2156		426 J	5264		JAP CUIA	/YES	2255	Ø351	0339	HC4+	ð	
2157	'	4261	5911		ISZ FVC	ZINC FVC	2256	0352	33.13	405.	3	
216	}	4262	7333		CLA CLL		2257	Ø353	0309	HC6+	0	
2161		4263	5241		JAP C01	/GEI NEXT VC	2260	0354	31/13	HC7.	0	
2165		4264	1411	CJ1A.	TAL I FVC	VUC=CUC+NJW	2261	0355	9390	HC10.	2	
2163		4265	3343		LCA CHC	COMPARE HC	2262	0356	0003	HC11.	ð	
2164		4266	1343		TAL CHC		2263	0357	3030	HC12,	3	
216:		4267	7941		CIA		2264	9363	3030	HC13.	2	
P166		4973	1344		TAL CHCI	/CHC1-CHC	8265	0361	8933	HC14,	ã	
2167		4911	7510		SPA	/+vE/	8866	3362	0000	HC15.	2	
		4272	7041		CIA	///	2267		6666	HCI6,	3	
2170					TAD KN15						2	•
2171	· .	4273	1336			/-15	2273	0364	2023	HC17.	-	
2178		A274	17.30		SHA CLA	/11+# >1151	2271	0365	0030	HC53"	3	
2173		4275	5241		JAP CJ1	YFS. GET NEXT VC	2272	,		1		
217/		4976	2345	stration -	ISZ NAC	AND COUNT HC	2273			1		
2175		4977	7340		CLA CLL		2274			1		
2176		4338	1343		14D CHC		2275			/		
2179		43.11	3346	COS.	LCA ACI	ISTURES HC FOR					*433	
2237		43.12	8331		ISZ CJ2	VEACH PUINT IN	2277				PADLE	
2031		4393	1911		TAD FUC	/HC1, HC2, E1C	2307.			/		
2232		A3:34	1124		JAL KNI	/FVC-1 /	2331			/SUPRJ	UTIAN TO RELUCE	LAIA TJ JNE
\$233		43/15	3411		LCA FVC	/REPLACES HC WITH 0	2322			/CUJRL	INATE PAIR PER	GRID PUINT
2234		4336	3411		LCA I FVC	/IJ INDICALE IT HAS	2343			1		
\$295		43.37	1342		THE CVC1		2304	4433	8939	SRED.	33.32	
2236		4313	7.301		CIA		2345	4431	6141		LINC	
2037		4311	1341		TAL CVC		2336				LMODE	
8213		4312	71.43		SZA		2397	3432	0011		CLR	
2211		4313	2341		ISZ CLC	/BEEN PROCESSED	2319	3493	4521		STC AHC	VAHC SET TO B
2212		4314	1033		102 0V0	TOLLY TROOLDDED	2311	0434	1393		LUA	And Still to S
2213		4315	1343		TAP CHC		2312	9495	1349		RHC	
2214		4316	3344				2313	9405 9496	3317		CJM	
2215		4317	5841		LCA CICI			3487				
2916		4223		C 13	JAP CU1	ADD TOUT TAILS	2314	9413	4529 2345		STC 4HC	
			4534	C731	JMS I RED	ZEFLUGE LATA	2315				AUL NHC	
2217		4321	4535	•••	JAS I STJR	STURE DATA	2316	0411	1463		SAF I	VONCY 1 PAIR OF
0001		4322	1303		CLA CLL		2317	3412	3301		41	COURDE ATTES?
5551		4323	1325		1AL ++5		2320	9413	0456		SKP	INJ, HELUCE
2222		4324	7410		SKP		2321	9414	6516		JMP R3	/XFS+SIJAE
1203		4325	3346		DCA HC1		2355		1123		AIA I	
5554		4326	3331		DCA CJ2		2323	3416	7767		-15	
2225		4307	5213		JAP COS		2324	3417	3451		4P)	/> 10 HC COURLS
2226		4333	7243	CJ4,	S14		2325	0423	€426		J32 ++6	C6.
0007		4331	3337		DCA RVC		2356	3421	1959		LLA I	/YES-MAKE VHC=13
2233		4332	7243		STA		2327	3422	9.11.3		10	
2231		4333	3340		DCA RHC	•	2333	3423	1043		51A	
5555		4334	4535		JAS I STOR		2331	1424	0345		14C	
2233		4335	5600		JAP I SCUMP	•	2332	0425	6433		JAP +3	
8931	•		• • • •	1			2333	0426	1123		ALA I	
2235				/			2334		3010		10	
				1							404 I	
8636 8039		4226	7447		-15		2335 2336	3433 3431	1120 2520			
2237		41.130	7763		-15						2036+R14B-2	/FORA ALL INST
824.3				/			2337	9432	4433		SIC ++1	VIJ GET APPRJPRIATE
2241				DI (0	LAULE		P343	3433	3316			/reciphocal
2242			0933	RVC.	0		2341	9434	4465		SIC RLIV	
2243		0340	03.13	ннс.	0		2342	8435	2345		APL VHC	
2244		3341	2303	CVC.	Ø		23/3	3436	0317		CUA	
2245		3342	3339	CVC1.	3		2344	3437	4311		SIC CTR	/SEL HC CUUVIER
2246		3343	3953	СНСи	3	•	2345	3443	3231	GVE.	KSK I CTR	
2247		3344	3333	C-IC1.	3		2346	9441	0456	:	SAP	
2250		3345	4333	VHC.	Ø .		2347	3442	6455		JXB BS	/LIFE SUMMER
8251				1			2350	9443	1993		LIA	/CALCULATE SUM
•							-					•

1982 B. 1997		in godiera						a a superior and a superior of the			e a construction and a construction of the con	مربع بر مربور می <u>م</u> رور م		
	2351		9644		RI	HC1	/OF DIFFERENCES		2450	41.01	a		PMULE	
	2352		6445	2520		ALL MHC			2451	4531		SSTOR-	0383	
	2353		3446	1143		ALM			2452	4532	6141		LINC	
	2354		9447	0521		AHC			2453				LMUDE	
	2355		3453	1020		LIA I			2454	2533	9646		LLF 6	
	2356		0451	0001		1			2455	(1534	1033		LIA	
	2357		3452	1143		ALM			2456	0535	9337		RVC	
	2360		3453	3444		k1	/INC R1		2457	0536			STA I SGD	
	2361		1454	6443		JAP AVE	· 130 m		2463	0537	1000		L14	
	8369		8455	1338	80.	LIA			2461	0540			RHC	
					ng)				2462	Ø541	1370			
•	2363		0456	0521		AHC							SIA I SGD	
	2364		0457	Ø241		RUL 1	/K10 (BINARY)		2463 .	0542	1023		LDA I	•
	2365		0463	1563		BCL I			2464	0543	3 3 3 1		1	
	2366		9461	3381		1			2465	0544	4345		STC NHC	
1.14	2367		9462	1240		et UL	/FRACTIJNALY		2466	0545	1023		LIA I	
	2373		3463	4465		• + 4032	/MULTIPLY		2467	3546	0346		HC1	
	2371		3464	9456		SKP			247.0	0547	4444		STC R1	
	2372		3465	0:337	EDIV.	3333	/MULTIPLIER		2471	0550	0435	• •	91 :P	
	2273	19 A.C	3466	3381	u Nordelle	RJR I 1	/DIV BY 10		2472				PADDE	
	2314	6 (S.C.	3467	3451		APJ	/-VE JR +VE!		2473	4551	5731		JMP I SSIJR	
	2375		3473	6476		J.IP +6	-VE-ROUND DOWN		2474			1		
14	2376		0471	3472		LZE I			2475			1		
11		1999 (M. 1997)					V+AF*BOND Obs		2476			•	LAJLE	
	2377		8472	6502	1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -	JAP ++10								
	2433	- S. A	3473	1159		ADA I			2477				*603	
	2431		9474	0 341		1 .			2593				PAOLE	
	24.35		0475	6532		JAP ++5	•		2581			/		
	24:13		3476	3452		L21.	NROAD DOMNS		2502				TIJE TJ RUILD	CALIBRATION MATRIK
	2434		3477	6532		J4P +3	LNJ CK		2593			/		
	2435		3533	1123		ALA I			2594	4633	0030	SMTX,	3333	
•	24.35		0531	7776		-1			2535	46/11	7243		STA	
	24.97		3532	1100		ALA			2596	4692	3010		DCA GD	
	9413		35 13	3343		K-IC			2537	4693	6221		C11 23	
	2411		3534	4340		SIC RAC	AVERAGED HC		2513	4634	3131		LCA TEMP	
	2412						AVERAGED HC		2511	46:45	1136		TAL 83777	
			3535	2337		ALL HVC			2512	4636	3413			
	2413		3536	3317		CJM	1						LCA I GL	
	2414		2507	23#1		ALE CVC	CUC-RVC		2513	46 37			ISZ TEAP	
	2415			1248		MIL	/DIV BY 2		2514	4610	52 35		JX2 •−3	
	2416		9511	4513		•+4302			2515	4611			514	
	2417		0512	9456		SKP			2516	4618			LCA TEMP	
	2420		0513	2003		2033			2517	4613	7243		SIA	ISET OF MIK FOR
	2621	•	3514	2337		ADL RVC			2520	4614	5213		LCA MIXV	/VC
	2492		0515	4337	_	STC HVC			2521 .	4615	1141		TAD K37	ISET UP ATK FUR
	2423		0516		E3.	PDP			2522	4616	3011		LCA MTXH	1-1C
	2424		,,,,			PRODE			2523	4617			LINC	
	2425		4517	5600		JAP I SRED			2524				LAJIE	
			4317	2000	,	USP I DAEL		•	2525	9623	0070			
	2426								2526	3621	3777		SET I SCD	
	2427				/								3777	
	2438		<u>.</u>			LADDE			2527	9682	96.46	4112	LIF 6	
	8431		3523	0033	MHC+	0			2534	3683	1333		LLA I SCL	
	2432		9251	0333	AHC.	3			2531	3624	1463		SAF I	TEND OF LATA!
	2433				1				2538 ,	J625	7777		7777	
	2434		3522	8933	BTA9.	2939	/RECIPROCAL OF 2		2533	3626	9456		SKP	/ 43
	2435		0523			1252	/3		2534	3627	€751		JAP AT4	TYES, MIK BUILT
	2436		3524	1303		1 3 3 3	14		2535	7630	4761		SIC VEL	
	2437		0525	3631		2631	/5		2535	\$631			LLA I SGL	
	2643		0526	0526		Ø526	16		2537	3632			SAF I	ZAUREADY PROCESSEL!
	2441								2541	3633			3-3-F 1 2)	FROMEMON FROOFSDEDI
			0527	3444		3444	17							4 3 3
	2442		3533	9499		3430	/10		2541		0456		SKP	NO
	8443								2542	0635			JAP ATI	/YES
	2266				/				2543	0636			STC HE1	
	2445				/				2544	0637		:	ELA .	
	2446				/SUPROU	TINE TO SIGRE RE	DUCED COURDINATES		2545	96.49	3313		SGL	
	2447				/				2546	3641	1040		SIA	
	-								-					

		and with the second second second			neer eine an			SCHOOL STOLEN					والمرافق والمراجع وا
	2547	8642	3765		ADLR		2646	3741	1333		LEA	1115	
	2559	0643	1312		51C FCJ		2647	3742	0764		415		
	2551	116 44	1.32	M12,	LLA I PCU		26 59	0743	4763		STC HEL		
	2552	3645	1463		SAF I	/END OF DATA!	26.51	3744	2762		ADD VES		
	2553	31.46	7777		7777		26.52	3745	4761		SIC VEL		
	2554	31 47	34: 6		5KP	CKV	26.52	0746	2012		ADL FCO		
		3659	6674		JAP AT3	ITES							
	2555		1040		SIA		2654	8747	4765		SIC ADDR		
	2556	9651			rt5 214		2655	3753	6705		JAP MI3+11		
	2557	3658	3752				2656	0751	3495	M14.	PDP		
	256-1	9653	3 31 7		CUA		2657				PAJIE		
	2561	3654	2761		ADD VE1		8663	4752	5690		JAP I SMTX		
	2562	36.55	1120		ALA I		2661				LAJIE		
	2563	3656	9319		1.1. State 1. State 1		8668	3753	1933	M15,	LDA		
	2564	0457	3471		APJ I	/ <ve1+107< td=""><td>2663</td><td>\$754</td><td>3761</td><td></td><td>VEL</td><td></td><td></td></ve1+107<>	2663	\$754	3761		VEL		
	2565	3663	6663		JMP +3	1125	2664	2755	5057		STC VE		
	2566	0661	0232		XSX I FCJ	(8)	2665	0756	2763		ADI: HEI		
	2567	3662	6644		JAP ATE		2666	3757	5260		STC HE		
	257 3	7663	1332		LLA I FCJ		2667	3760	7333		JAP MT6		
	2571	0664	1463		SAL I	/ALRIADY PROCESSED	2673			1			
	2572	3665	0.183		3		2671			1			
	2573	960E	0456		SKP	180	2672			/			
	2574	G667	6EhA	•	STR AND	/YES	2673	3761	0333	VF1.	0.		
	1575	3673	4763		SIC HEL		2674	3762	3332	VFS'	3		
	\$576	0671	8762		ALD VIS			3763	0110	HE1,	Ø		
la de la	F577	3672	4761		SIC VEL	•	2675		0330	HFS.	2		
	2533	3673	6644		J .P 412	ZNJ . CRN	2676	0764			2		
	2631	9674	1340	MT3.	LUA		2677	0765	0373	AUDRo	ð		
				11107	SGD	•	27 70			/	51223		
	3692	3675	3519		A)A I		2701				*1000		
	26.13	3676	1123				27 32	1 302	90.95	M16,	PUP		
	26.34	3677	7775		-2		27 13				PAULE		
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	PE 16.	67.31	2313		8033		87.05	5.142	2131		ISZ TEMP	ZEIESI CUJE	RD1
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	3151				LMODE			3250	9313	3777	SGL	3777
	3152	1232	1929		LDA I			3251	0011	0000	CTR.	Ø
	3153	1233	9659		LDF 10			3252	0912	0993	FCU	3
	3154	1234	5216		STC TAL			3253				
i. Di se	3155	1235	3371		SFT I CTR			3254			1	
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- ¹ 1	3167	1217	9714		0714	/WRC 1		42	3236			
	317.3	1553	9293	TA2,	0323	/MALKNIBLK		A3	3864			
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	3230	1230	3331		1			CA	1104 .			
	32.31	1231	1143	•	ADM			CAD	0192			
	3202	1238	1216		TA1			CAGO	6303			
	3273 .	1233	0372		SET I FCU			CAGOFR	6395			
	32.74	1234	7773		-4			CAL	9121			
	32.75	1235	1000		LDA			CAM	9122			
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	3257	1237	1120		AUA I			CAMOUL			•	4
	3813	1243	7776		-1			CC CCAFL	0117 6206			i.
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	3213	1243	0231	TA3,	KSK I CTR				6347			
	3214 3215	1244 1245	7216		JAP TAI				6344			
	3216	1246	1323		LLA I			CLIPM	6342			
	3215	1247	3659		L17 13	•		CFA	0133			
	3223	1250	5216		SIC TAL				6315			
	3201	1251	3223		ADL TA2			CHC	4343			
	3222	1252	1129		ADA I			CHC1	4344			
	3223	1253	7776		-1				0143			
	3224	1254	1563		PCL I			CH1	5134			
	3885	1255	79.33		7030			C45.	5110			
	3226		1 34 9		STA				5123			
	3287	1257	1270		CTPLK			C-14 CLAD	5142			
	3230	1263	1120		ALA I				6334 6334			
	3231	1261	7737		-73 APJ				2751			
	3638	1262	3451		SKP				3113			
	323 3 3234	1263 1264	3456 3333		HLT				Ø133			
	3232	1264	3355 3011	;	CLR				2335			
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3335	6351	7177	KV1.	-1				0134	3431	2657		CALHC!2000		
0336	0052	3024	K24.	24	•			0135	0432	1000		LDA		
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Ø356	3373		LI'ATA	STVF - SLDATA				0154 0155	0447 0450	64378 0633		JMP M2		
0357	0 97 1	4227	VCC.	SVCC				Ø156	0450 0451	6929		LIF 3 JMP 20		
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i s e i se	0177	0295	0062		SET I GTR			0276	0271	1001		1001	
14	0200	0296	7771		-6			0277	0272	1140		AD4	
	0231	9237	3363		SET I FCTR			0323	0273	0267		LDAT1	
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	22.13	9211			LDA			03:32	0275	6266		JMP LDATI-1	/NJ
	3234	1212		k.	CTRLK	/START BLUCK FOR		0333	3276	1003		LDA	
	0235		1125		ALA I	/CAL MTX		0304	Ø277	0267		LDATI	
	0296	0214			4033			0305	0300	1120		ADA I	
	9237	3215			STC MTX2			3336	0391	7776		-1	
신전문문	3213	0216	1920	2.1	LDA I	•		0307	0398	4307		STC DTBLK	SAVE START BN
	9211	0217	3653	ي في	LDF 10			0319	0303	0362		SET I CTR	
	9212		4221	2	STC MTX1			0311	0334	2377		2377	
	8213	9221	3653	MTX1,	LDF 13	en en el en constante de la constante de		0312	2305	0395		PDP	
	0214		3710		9713	/RDC 1		0313				PHODE	
	0215	9883	0110	MTX2.	0000	MBLKN TBLK		0314	2306	5651		JAP I SLDATA	
	7216	0224		Q	LDA I			0315			1		
	0217	0225	1001		1301	/INC MELKNTELK		0316				LAUDE	
	0220	0226	1140		ALM			Ø317			1		
	8821	Ø227	0223		MTK2			0320	0307	0200	DTBLK.	200	
	8228	0230	0223		XSK I FCTR	/END OF L-FIELD?		0321			1	•	
•	3223.	0231	6244		JAP MTX3	Ck \		0322			1		
- -	0224	0232	1323		LUA I	TYES, INC L-DATA		9323			/SUBROU	TINE TO GET COJ	EDINATE PAIR AND
1	3925	0233	3331		1	/FI HLD		0324			/CALCUL	ATE CALIBRATION	ADDHESS+
14.1	3226	0234	1140	ž.	ALM			0325				PMODE	
	8227	0235	0221		MTX1			0326	2310	0000	SGC.	0000	
	9233	0236	0363		SET I FCTR			0327	2311	6141		LINC	
	2231	0237	7773		- 4	and the second		0330				LMJDE	
1	9232	2243	1323		LDA I			Ø331	0318	0651		LDF 11	
	0233	3241	3777	•	3777			3332	0313	1 324		LDA I HD	/vc
5	3234	3242	1143		ALM	. * · · · · · · · · · · · · · · · · · ·		0333	Ø314	1460		SAL I	VEND OF CURRENT
1.50	0235	. 0243	3223		MTKP .			0334	0315	7777		7777	/TV FIELL?
	3236	0244	0555	MTX3.	XSK I CTR	VEND OF CAL MTX?		9335	2316	6321		JMP +3	 C.V.
	0237	0245	6281		JMP MTX1	64.1		0336	0317	6512		JMP SNFLD	/YES LOAD NEXT FIELD
	3243	3246	0932		PDP	YES EXIT		3337	0320	6312		JMP •-6	
1.1	0241				240 DE			0340	0321	0643		UDF Ø	
	3545	2247	5600		JHP I SMIX			0341	9322	1940		STA	
	3243			1				Ø342	0323	2061		VC12000	
1.00	3204				LAJDE			9343	0324	9345		SCR 5	/LEFT HALF JF ADDH
s	3545			/			•	0344	0325	1343		STH	
(1,2,2,2)	3546	3250	0029	CTBLK,	20			0345	0326	2063		ALDR12000	
	3247			1				0346	Ø32 7	9651		LDF 11	
	2253			1		•		0347	3333	1024		LLA I RD	
· · ·	9251			1				0350	0331	3643		LCF Ø	
11 - A A	0252				TINE TO LOAD 3	BLUCKS OF DATA		0351	Ø332	1949		STA	
	0253			/				0352	0333	S 965		HC15003	
÷.	3254				PHODE			0353	0334	Ø 345		SCR 5	/RIGHT HALF JF ALDR
	3965 -	2251	9233	SLDATA.				0354	0335	1343		S1H	
`~	3856	2252	6141		LINC			Ø355 j	9336			ADLN:6000	
	3257				LMODE			Ø356 ¦	0337			CLR	
	0269	0253			SET I FCTR			Ø3 57	3 340	0302		PDP	
	3261	3254			-3			0369				PMODE	
	9363	0055			LUA	CURRENT 1K START		3361	2341	5710		JMP I SGC	
	9263	0256	33 07		DTFLK	VBLUCK NU.		9362			/		
	9264	3257	1120		ADA I			Ø363			/		
	3965	3260	5003		5039			0364			/		
	0266	0261	4267		STC LDAT1			3365				LMJDE	
	02 67	3595	1023	\$	LDA I			0366	,		/SUBROU	TIVE TO GET 1 T	V FIELD OF DATA
	0273	3263			1			036 7	•		/ 1	1	
	0271	3264			AXJ			3370				*439	
	0272	0265	0653		LDF 13			0371				PHOLE	
	02 73	026 6	0710		0719	ZEDC 1		0372	2409	0000	STVF.	0000	
•	-							-					

and a table of the state of the	a de la Section de la composition de la Composition de la composition de la comp		and the second secon								antalian an Calabara (C. Sarahara) an Constantin	
0373	24.31	6141		LINC			0472				LADDE	
	2401	0141		LMJDE			0473	347-3	0002	TVF2.	PDP	
9374								(1-17)		1 11 67		
0375	0432	0653		LDF 13			0474	0471	c		PAUDE	
3376	3403	1088		LDA I CTR	/FN		0475	2471	6221		CDF 20	
0377	3434	1460		SAE I	/END OF DATA?		1476	2472	7243		STA	
9433	0405	7777		7777			3477	2473	3410		DCA I PTR	
2491	0406	6411		JMP +3	·		0503	2474	7243		STA	
9492	8437	4531		STC FLAG			95:11	8475	3410		DCA I PTR	
(1) 1973 (4)	3413	6470		JAP TVF2	/HETURN & PROCESS		0532	2476	6141		LINC	
0473					SAVE TY FIELD NO.			2-110	••••		LADDE	
3434	0411	4507		STC FN	A DEAL IN LIERD NOT		35-33	9499	AACA			
3435		1022		LDA I CTR	the second se		0574	0477	0064		SET I RD	
3496	0413	4510		STC TVC			0535	2503	2777		2777	
34 37	0414	1 022	1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -	LDA I CTR			0536	0531	1623		LDA I	
9413	0415	4511		STC THC	and the second		0507		7776		7 1	
3411	3416	0202		XSK CTR	VEND OF DATA?		0510	0503	1143		AD4	
0412	3417	6423		JAP +4	A AND THE THE REPORT OF THE		9511	0504	0008		СТН	
3413	9423	0.102		PLP			0512	0535	0095		PDP	
0414			art.	PAJDE			9513				PMODE.	
	6401	6693		JES I LDATA	TYES, LOAD MORE DATA		2514	2.536	5600		JAP I STVF	
0415	2421	4470	14		TESTERNO NORE DATA		2	2.000	2000	an start and a start and a start and a start a	0 1 0.00	
3416	2422	7410		SKP			2515				LMODE	
2417	いがい ほうとう	and the second second	· .	L 1J DE			0516				LMODE	,
0420	8423	9395		9U9	1		0517		· · ·	/	-	
Ø421				PHODE			0520	0537	0030	F.N.	Ø.,	
3422	2424	6221		CDF 23		-	3521	0510	0000	IVC.	ø	
1423	2425	1227		140 .+2		1	0522	Ø511	0903	THC.	0	
6424	2426	7413		SKP			0523			1		
7425	2427	2777		2777			0524			ZSUBBOU	TINE TO ASSEME	BLE NEW TV FIELL-
		3319		DCA PTR	/SET PTR TO STORE		3595	0512	1000	SNFLD	LDA	
1426	2433				CURRENT TV FIELD			0513	3093	5	3	
7427	2431	1310		TAL TVC	CORRENT TV FIELD		0526					
3433	2432	3413		DCA I PTR			0527	0514			STC NF1	
3431	2433	1311	•	TAD THC			0530	Ø515	2531		ADD FLAG	
3432	2434	3410		LCA I PTH			Ø531	Ø516	1460		SAF I	lend of Lata?
3433 .	2435	6141		LINC			3538	0517	7777		7777	
3434	•			LIJLE			3533	0520	Ø4:56		SKP	
3435	0436	9653	TVF1.	LDF 13			3534	9521	6527		JEP NE1+1	/YES
		1322		LEA I CTR			0535	0582	0935		PLP	
3436					LAD OF DATA?		0536	0.0111	0000		PHUDE	
7/37	3443	1460		SAL I	VEND OF DRIM.			0000	1.1.67			
3443	3441	7777		7277			0537	2523	4467		JAS I TVF	
3441	0442	6445		JAP +3	/NU		0540	2524	4466		JAS I COMP	
7442	9443	4531		STC FLAG	/YES		2541	2525	6141		LIVC	
1443	3444	6473		JAP IVE2		,	2542				LAUDE	
34.44	3445	144.3		SAL	CURRENT TV FIELD?		3543	0526	9033	NF1.	3333	VRETURN JEP
1205	0446	3537		FI			851.4	6527	0633		LIF Ø	
32.46	3447	6473		JAP TUFE	/ NJ, RETURN		0545	9532			JAP END	
	9450			LDA I CTR			0546		•	1		
3447 .	. –									,		
2453	0451	4513		STC TVC			9547	21.21	2010	11 40	a	
0451		1 322		LDA I CTR			9553	0531	0000	FLAG.	Ø	
2452	0453			SIC 1HC			a551			/		
3453	0454	ØJJ2		5U5			3552					JURDINATES RELONGING
1. A. S. A.				PADDE			2553			/TO THE	SAME MARKER.	
3455	2455	6221		CDF 23			3554 /				*633	
3455	2456		•	TAD TVC			3555				PAJDE	
				LCA I PIR			0556	5633	0390	SCOMP,	8303	
54.57	2457									500007	CLA CLL	
0460		1311		TAL THC			0557	26:31				
04 61	***61			LCA I PTH			9563	SC 35			TAD +2	
0462	2462	6141		LINC			Ø561	2633			SKP	
3463				LYUDE			Ø562	56 14	3353		LCA HCI	VRESET CJ3
3464	3463	9808		XSH CTH	ZEND OF DATA FIFLD?		Ø5(3	2605	3395		DCA CU3	
3465		6436	i	JAP TVF1	/ 30		0564	26/36		:	1AD ++2	
		00002	1	505 000	· · · · ·		3565	2607		1	SKP	
3466	2405	0308					0566	2610		1	2777	
3467				PADDE.	AND I SATE MITTER TATA							
347 3		4473		JAS I LDATA	VYES-LJAD MJRE DATA		0567	2611			LCA PTH	
)471	2467	5235		JAP TVF1-1			0570	5615	6141		LINC	

	0571				LMODE		0670	2710	1347		TAD CVC1	
	0572	0613	0364		SET I RD		Ø671	2711	7341		CIA	
	3573	3614	3377		3377		0672	2712	1346		TAD CVC	
	3574	3615	0032		PDP		0673	2713	7443		SZA	
	0575				PAJLE		• 0674	2714	7413		SKP	
	3576	2616	6221	CO1.	CDF 20		2675	2715	2346		ISZ CVC	
	3577	2617	1419		TAD I PTR		0676	2716	1350		TAD CHC	
	0693	2623	7 143		CHA		Ø677	2717	3351		DCA CHC1	/REPLACE CO.4P HC
9	3631	26.21	7443		SZA	/END OF TV-FIELD?	3703	2720	5242		JWB C05	
	9692		7410	star in the	SKP	UK1	0731	2721	4465	C04,	JMS I RED	
10	3633	2623	5331	di se	JAP CUS	/YES	37 32	2722	4464		JAS I SRD	
e ; ;	3£ 34		7:343	· •	C.4A	「「「「」」、「」、「」、「」、「」、「」、「」、「」、「」、「」、「」、「」、	07.33	2783	7303		CLA CLL	
. j ⁴	3675	2625	3344	eg e de je	DCA RVC	Property and the state of	0734	2724	1326		1AD +2	
ġ.	36 36		1410		TAU I PTR	the state and second second	0735	2725	7413		SKP	
2	36 37		7443		SZA	ALREADY PHOCESSED?	07.36	2726	3353		DCA HC1	
	3613	2630	7410		SKP	ORV	9707	2727	3392		DCA CO3	
	9611		5216		JMP CU1	/YES	0710	2730	5216	•	JAP CUQ	
	2618	2638		2000 - C	DCA RHC		0711	2731	7243	CU 5,	STA	
	CE13		1345	1	TAL RHC	1	3712	2732	3344		DCA RVC	-
	3614	2634	3351		DCA CHCI	and the second	07.13	2733	7240		STA	
	3615	2635	13/4	A	TAD EVC		9714	2734	3345		DCA RHC	
	6616		1059		TAD KI		0715	2735	4464		JMS I SRD	PUTS 7777 AT END
Т.,	0617	2637	3346		DCA CVC		0716	2736	6141		LINC	/OF FIELD
	0629	2643	1013		TAD PTR	i	3717				LMODE	
	3621	2641	3311		DCA FD		0723	0737	0364	· .	SET I RD	
	C622	2642	1411	C05.	TAD I FD	•	0721	0740	3377		3377	
	3623	2643	3347		LCA CVC1		0722	3741	3305		PDP	
	3624	26.44	1347		TAD CVCI	and the second	0723				PMUDE	
	3695	2645	7348		СИА		0724	2742	5600		JMP I SCOMP	
	3628	2646	7440	•	57.A	ZEND OF DATA?	0725			1		
	3687	2647	7410		SKP	INU	9726			1		
	2630	2659	5321		JAP CJA	TYES, GU REDUCE DATA	0727	2743	7743	KN35.	-35	
	9631	2651	7991		IAC		0730			/		
		2652	1346		TAD CVC	•	0731				LMODE	
	3633	2653	7410		SZA	/vc=cvc?	3732	0744	0093	RVC.	0	
	9633	2654	7/10	•	SKP		0733	0745	8000	RHC.	3	
	3634	2655	5265		JAP CJ2A	/1ES	9734	9746	3333	CVC+	0	
	3635	2656	1051		TAD KN1		Ø735	0747	9999	CVC1.	ø	
	3636	2657	7443	•	SZA	/VC=CVC-1	9736	0750	0000	СчСэ	Ö	
	3637	2660	7413		SKP	CV.	0737	0751	3890	CHC1.	3	
	3643	2661	5265		JAP CU2A	/YES	9743	0752	0031	VHC.	ĩ	
•	3641		2011		ISZ FD		0741		0.70.	/	•	
	3642	2662			CLA CLL		3742	0753	0333	HC1,	Ø	
	3643	2663	7303 5242		JAP CJS	GET NEXT VC	9743	0754	0000	HCS.	3	
	0644	2664		CJ2A.	TAD I FD		3744	9755	0000	HC3.	9	
	3645	2665	1411	CUZHJ	DCA CHC	•	0745	9756 9756	00003	HC4,	2 0	
	3646	2666	3353		TAD CHC		37 46	0757	0100	HC5	ÿ	
	0647	2667	1350		CIA			9769	0000	RC6,	3	
	0653	2673	7941		TAD CHC1	CHC1~CHC	37 4 7 37 5 3	3761	3309	HC7.	L) (A	
	0651	2671	1351			Z+VE?		,		чен.	2	
	0652		7510		SPA	AND WAKE +AF	0751			HC11,	3 3	
	JE 53		7041		CIA	7-35	0758				0	
	06.54		1343		TAD KN35	/DIFF>1351?	0753	0764		HC12	0 3	
	7455	2675	7793		SAA CLA	/res.gei next vC	0754	0765		HC13,	8	
	3656	2676	5242		1%5 CUS	AND. COUNT HC	9755	9766		HC14	a	
	Ø6 5 7	2677	2352		ISZ NAC	NUNCOUNT GO	9756	3767	0000 0020	HC15,	0 a	
	3663	2733	7333		CLA CLL		0757	3773	0000	4016,	2	
	30.61	2731	1359		TAD CHC		0760	3771		.HC17>	0	
	9668	27.02		C03,	DCA HC1	•	0761	3772	9323	HCS0	5	
	3663	2733			ISZ CO3		0762			/		
	0664	27 44	1311		TAP FD		0763			1		
	3665	2735			TAD KNI		3764			/		TATA 70 345
	0665	87.36			DCA FD	AUDUR 601 140 147 TH (2	0765				UTINE TO REDUCE	
	3667	2737	3411		DCA I FD	IREPLACE HC WITH 0	3766			1000BD	INATE PAIR PER	CIVE FOINT

					n an						
3767				*1300		1366	1974	3301		1	
3773				P.⊴J DŁ		1067	1075	7102		JMP ++5	
3771	3930	3939	SRLD.	0000		1273	1076	Ø452		LZE	VEORND DOWNS
0772	3301	6141		LINC		1071	1 377	7132		JMP •+3	/NO
0773				LMODE.		1072	1100	1120		ADA I	
0774	1392	JO11		CLR		1973	1101	7776		-1	
0775	1003	5121	• • • •	STC AHC	AHC SET TO D	1074	1102	1120		ALA	
3776	1334	1339	a a t	LDA		1075	1193	0745		RHC	
3777	1025	0745		RHC		1076	1134	4745		STC HHC	VAVERAGED HC
1438	1006	3317		COM		1977	1105	2744		ADD RVC	
1791	1 207		er ada de 1	STC MHC		1100	1106	9317		CO.4	
1938	1313	2752		ADD NHC	•	1101	11.97	27.46		ADD CVC	/CUC-RUC
1723	1911	146.0		SAL I	/ONLY 1 PAIR OF	1102	1110	1240		MUL	VDIV BY 2
1304				1.4.1 St. 2.18	/CUURDINATES?	1193	1111	5113		•+4002	
1385	1913			SKP	AND, REDUCE	1104	1112	0456		SKP	
1006	1014	7116	1997 - A. A. A.	JHP R3	YES, STORE	1105	1113	2300		8930	
1897	1015	1129		ALA I		1176	1114	2744		ADD HVC	
1313		7757		-29		1127	1115	4744	e e de la come	STC RVC	
1311	1 +17	0451		APJ FREE	> 20 HC COURDS	1110	1116	0002	-R3,	PDP	
1015	1020	7026		JMP +6	CN	1111				PMU DE	
1313	1321	1320		LDA I	TYES, MAKE NHC=20	1112	3117	5600		JMP I SRED	
1014	1022	0020		29		1113			1	· · · · ·	
1715	1023	1843		STA		1114			1		
1916		3752		NHC	$\frac{1}{2} = \frac{1}{2} $	1115				LMODE	
1317	1025	7930		JMP +3	and the second	1116	1120	0303	MHC,	0	
1023		1123		ADA I		1117	1121	0.309	AHC.	Ø	
1021		0329		20	· · · · ·	1123			1		
1355	1039	1129		AUA I		1121	1122	2030	RTAB1,	2000	/ RECIPROCAL OF 2
1723	1931	3120		2000+RTAB1-2	FURM ADD INST	1122	1123	1252		1252	13
1324	1032	5033		STC ++1	TU GET APPROPRIATE	1123	1124	1090		1999	14
1025	1933	3316		ACK	/HECI PROCAL	1124	1125	0631		0631	15
1025	1034	5065		STC RDIV		1125	1126	0526		0526	16
	1 135	2752		ALD NHC		1126	1127	0444		3444	17
1927	1336	3317		COM		1127	1133	0432		8400	/10
1331	1937	4995		STCHCTR	SET HC COUNTER	1133	1131	0343		0343	/11
1 132	1343	0225	AVE	XSK I HCTR		1131	1132	0314		9314	/12
	1341	0456	HYL	SKP		1132	1133	9272		0272	/13
1.033	1042	7:055		JMP B2	/DIFF SUMMED	1133	1134	0252		Ø252	14
1.734	1042	1333		LDA	CALCULATE SUM	1134	1135	0235		0235	/15
1935	1344		R1.	HC1 .	/OF DIFFERENCES	1135	1136	0222		9885	/16
1036	1344	3129	n17	ADD MHC	or birreactors	1136	1137	0213		0213	/17
13379		1140		ADY AND		1137	1143	0200		0230	189
0.1343	1046	1140 1121		AHC		1140			/		
1341	1347	1020		LDA I		1141			1		
1.)40	1050			1		1142			/ SUBROT	TINE TO STORE	E REDUCED DATA
1043	1351	0001		AIM		1143				PMODE	
1044	1952	1140		HI HI	/INC R1	1144	3141	0009	SSRD.	8900	
1945	1353	1044		•	71.40 MI	11/15	3142		001.00	LINC	
1346	1054	7343	50	JMP AVE		1146				LUJDE	
1347		1339	R2,	LDA		1147	1143	9651		LDF 11	
1059	1056			AHC	AVIA (DI MADY)	1153	1144			LIA	
1 751	1057			HJL 1	7X10 (PINARY)	1151	1145			RVC	
1.752	1060			RCL I		1152	1146			STA I RD	
1053	1961	9331		1	CONSCRETE ON ALL Y		1147			LDA	
1.354	1962			MUL	/FRACTIONALY	1153 1154	1153	0745		EHC	•
1055	1663	5965		• + 4002	/MULTI PLY		1155	1064		STA I RD	
1356	1964	2456		SKP	AND TTOLTER	1155	1152		•	LDA I	
1057	1365	9909	RDI V.	3933	/MULTIPLIER	1156				1	
1368	1366	9321		ROR I 1	ZDIV BY 10	1157	1153			STC NHC	•
1361	1967	9451		APJ	V-VE OR +VE7	1160	1154		i	LIA I	
1062	1 37 3			J42 ++6	V-VE HOUND DOWN	1161	1155			HC1	
1363	1 37 1			LZE I	1+VE BOUND UP?	1162	1156			STC R1	
1064	1.372			JAP +10	•	1163	1157	5344		PDP	
1365	1 37 3	1159		ADA I		1164	1169	3002		• 271	
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-411-1211			and the second s				ana ina mandrina na kana na ka							
	1165					PMODE			1264	3456	1 763		TAD ADD:	
	1166		3161	5741		JAP I SSRD			1265	3457	1057		TAU K130	
	1167				1				1266	3460	3963		DCA ADDR	
	1173				1	•			1267	3461	5234		JMP SAAVC+1	/REPEAT
	1171				1				1874	0404	5204	1	0	
	1172				-	LMODE			1271					
	1173				ZSIIBR-)II		ADDR ACCORDING TO					,	LMJDE	
						OF DATA HC.			1272				*2	
	1174		· · ·		VALUE	*1409			1273	0000	0.300	CTD.	+ c Ø	
	1175					PMO DE.			1274	0002	0300	CTR.		
τę.	1176		0400	8404	CMATEO				1275	0003	0000	FCTR	0	
1	1177		3430		SMAHC.	0309	•		1276	0304	0000	RDø	0	
	1235		3491	6221		CDF 20			1277	9992	0393	HCTR.	ð	
с. Ч	1831		34.18			CLA CLL			1339					
	13.32		3493	1963		TAD ADDR			13-31			/		
	1233			1.356	i i	TAL K40			1308			_	SEGANT 2	
	1234		3405	3538	i.	LCA MAHCI			1333			l na si na		
	12,15	en de Sector de		1.362		TAD HC			13 74				LAJDE	
34 ⁻	1076	1. A. A. B.	3437		4	CIA			13.95		1 F			TE CORRECTION FACTOR
	12.34		3410	1632	÷ .	TAL I MAHCI	/HC(CAL)-HC(DATA)		1306			VFOR VI	RTICAL COURDINA	TE
	1513	111	3411			SPA	/+UE3		1307				*233	
÷.,	1211		3415	5222	1	JAP WAHCS	140	•	1310				РИЈЪН	
	1212		3413	1055		TAD KN30	TTES		1311	4200	0000	SVCC.	3933	
	1213		3414	7710		SPA CLA	/DIFF>307		1312	42.31	6581		CDF 59	
•	1214		3415	5600		JAP I SAAHC	/NU.ADDR OK		1313	4238	7309		CLA CLL	
	1215	•	3416	1363		THE ALLA	//es.modify addr		1314	4233	1 561		TAD VC	
	1216		3417	1.351	۵.	IAU KVI			1315	4204	7041		CIA	
	1217		342.1	3363		LCA ADDH	•		1316	4295	1463		TAD I ADDR	/VC(CAL)-VC(DATA)
	1923		3421	5201		JAP SHAHC+1	/RLPEAT		1317	42.36	3974		DCA DIF	
	1221		3402	1354	MAHC2,	TAD K30			1329	4207	1074	•	TAD DIF	
	1222		3423	7719		SPA CLA	/ DI + F<- 30?		1321	4210	7710		SPA CLA	/VC(DATA) <vc(cal)?< td=""></vc(cal)?<>
	1223		3424	7413		SKP	/YES		1320	4211	5837		JAP VCC2	LYJ
	1224		3425	5693		JMP I SMAHC	/NJ.ALDR OK		1323	4212	1363		TAD ADDR	ITES
	1195		3426	1363		TAL ALLE .	MULIFY ALDR		1324	4213	6141		LINC	
	1026	•	3487	1050		TAL KI			1325	4610	C		LAUDE	
			3433	3363		DCA ALLA				0214	1560		BCL I	
	1927		3431	5201		JAP SAAHC+1	ZREPEAT		1326		0977		-00 7 7	
	123.3		3431	2001	,	Unit Danielo I	F BLEI LATE		1327	0215			SAE I	
	1231				1				1333	0216	1469			
	1232								13319	3217	0000		0 (640	
	1233			2.2.20					1332	3883	0456		SKP	Am 5 12 11 - 2 (5.1.1) - 2 (5.1.1)
	1234	•	3432	3930	HAHC1.	0			1333	9221	6261		JAP ACC3	VTAKE YGN1-YGN9
	12:45				/				1334	0555	1443		SAF	
	1956				1				1335	Ø22 3	0331		CALIM2	
	1237						ADDR ACCORDING TO		1336	0224	9456		SKP	
	1243					JF DATA VC-	-		1337	Ø225 ·			JAP VCC3	TAKE YGN14-YGN13
	1241		3433	3990	SMAVC.	9919			1349	0226	0005	VCC1.	PhP	
	1948		3434			CDF 23			1341				PAULE.	
	1243		3435			CLA CLL			1342	4227	7309		CLA CLL	
	1244		3436	1061		TAD VC			1343	4239	1963		TAD ADDR	
	1045		3437	7)41		CIA			13/6	4231	1560		TAD XV100	
	1226		3443	1463		TAD I ADDR	/VCCCAL)-VCCDATA)		1345	4232	3277		DCA ADIES	
	1267		3441	7513		SPA	/+VE2		1346	4233	1677		TAD I ADDR2	
	1253		3442	5252		JAP MAVCI			1347	6234	7341		CIA	
	1251		3443	1053		TAD KN24	/YES		1350	4235	1463		TAD I ADDR	/Y GDN-Y GD(4-1)
	1252		3014	7713		SPA CLA	/ LIFF<24		1351	4236	5600		JMP I SVCC	
	1253		3045	5633		JAP I SMAVC	lyes, addr ok		1352	4237	1363	VCC2,	TAD ADDR	
	1254		3446	1363		TAL ALDR	/NJ.HODIFY ADDR		1353	1240	6141		LINC	
	1255		3447	1063		14D 89100			1354				LAJDE	
	1256		3453	3 363		LCA ADDin			1355	6241	1560		BCL I	
	1057		34:51	5234		JK2 S%4VC+1	ZELEPEAT		1356	0242	0077		3277	•
	1087			1058	MAVC1.	TAD K24				0242	1443		SAL	
			3453	7713	1173 Q U I P	SPA CLA	/ DI FF>-24		1357	0243 0244	0300	1	CALIMI	
	1261			7410		SKP	AND MODIFY ADDR		1363				SKP	
	1962					JMP I SMAVC	TYES ALDR OK		1361	0245	84.56			ZTAKE YEN12-YEN11
	1263		3433	5633		GULL DUMAN			1362	V-740	6271		JMP VCC4	· • • • • • • • • • • • • • • • • • • •
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									20.07	8210		7700	
	1363	024 7	1440		S4E.			1462	0327	7730			
	1364	9259	3302		CALIM3			1463	0330	1460		SAL I	x
	1365	0251	0456		SKP			1464	Ø331	0.900		9	
	1366	0252	6271		JMP VCC4	/TAKE YGN25-YGN24		1465	0332	0456		SKP	
	1367	3253	9002		PDP			1466	Ø33 3	6360	•	JMP HCC3	TAKI XGN1-XGN0
	1373				PMJDE		•	1467	0334	0332	HCC1.	PDP	
	1371	4254	7339		CLA CLL			1479				P.1.J DE	
		4255	1074		TAD DIF			1471	4335	7300		CLA CLL	
· .	1378	4256	1051		TAD KN1	/MAKE ONES COMP		1472	4336	1372		TAD HADDR	
	1373				DCA DIF			1473	4337	1051		TAD KNI	
	1374	4257	3374					1474	4340	3371		DCA HADDR2	
Se,	1375	4263	7413	Salar S. S.	SKP	· · ·		1475	4341	1771		TAD I HADDR2	
	1376	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	2201		LAUDE				4342	7341		CIA	
a.)	1377	9591	9935	VCC3,	PDP			1476					/XGDN-XGD(N-1)
	1433	and the second			PMODE			1477	4343	1772		TAL I HADDR	> XEDN=XGD(N=1)
	1431	4262	1063		TAD ALOR			1500	4344	5704		JMP I SHCC	
S	1493	4263	1857		TAD KI00			1501 -	4345	1074	HCC2.	TAD DIF	
	1433	4264	3277		DCA ADDR2			1522	4346			CIA	
	1434	4265	1463		TAD I ADUR			1593	4347	3074		LCA DIF	
	1435	4266	7041		CIA			1504	4350	1363		TAD ADDR	
	1436	4267	1677		TAD I ADDR2	/YGD(N+1)-YGDN		1505	4351	6141		LINC	
	1437	4273	5630		JMP I SVCC			1536		1.11		LMUDE	
	1413		17557	$\Phi_{i}=\frac{1}{2}\left(-\frac{1}{2} + \frac{1}{2} \right) \left(-\frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} \right) \left(-\frac{1}{2} + \frac{1}{2} + $	LMJLE			1597	1352	1560		PCL I	
	1411	3271	0332	VCC4.	PUP			1510	0353	7700		7700	
	1412				PHUDE			1511	0354	1440		SAL	
		4272	7309		CLA CLL			1512	0355	0393		CALIM4	
	1413		1074		TAD DIF			1513	0356	2456		SKP	
	1414	4273			TAD KNI	•	•	1514	0357	6334		JMP HCC1	ZTAKE XGV31-XGN39
	1415	4274	1051		LCA DIF			1515	0360	0000	нссз,	PDP	
	1416	4275	3074			·		1516	0000	0.000		PADDE	
	1417	4276	5239		JMP VCC1+2				4361	7390		CLA CLL	
	1420							1517					
	1421			/				1523	4362	1372		TAD HADDR	
	1422				LNODE	• •		1581	4363	1050		TAD KI	
	1.423			1 and a				1522	4364	3371		DCA HADDR2	
	1424	8277	0000	ADDR2.	Ø			1523		1772		TAL I HADLR	
	1425	0303	1230	CALI41,	1200		•	1524	4366	7941		CIA	
	1426	9391	1302	CALIM2,	1309			1525	4367	1771		TAD I HADDR2	/XGD(+1) -XGD)
	1427	0302	2530	CALIM3,	2503			1526	4370	5704		JMP I SHCC	
	1433	0303	0031	CALIMA.	31			1527			/		
	1431			1				1530			/	·	
	1432			/				1531				LMODE	
	1433			ISUBROU	TINE TO CALCULAT	E CORRECTION FACTOR	•	1532	0371	0000	HADLR2,	0	
	1434				RIZUNTAL CUURDIN			1533	0372	0000	HADDR.	Ø	
				Fon no.	PMODE			1534			1		
	1435	40.34	0333	SHCC.	0000			1535			1		
	1436	43:14	0333	SHOUP			•	1536			ZSDBROIT	TT JE TO COMPUTE	AND SCALE CURFECTION
	1437	43.15	6221		CDF 20			1537			/FACTUR		The sense sense senters
	1443	4306	7303		CLA CLL	•		1540				*490	
	1441	43.57	1363		TAD ADER							PAULE	
	1442	4310	1056		TAD K43			1541	6630	0000	CDI		
	1443	4311	3372		LCA HADDR			1542	4400	0630	SDI V.	6303	
	1444	4312	1962		TAD HO			1543	4431	6141		LINC	
	1445	4313	7941		CIA			1544				LWODE	
	1445	4314	1772		TAD I HADDR	/HC(CAL)-HC(DATA)		1545	9492			ADA I	
	1447	4315	3374		DCA DIF			1546	9403	2425		233J+RTAB-25	
	145)		1074		TAD DIF			1547	9494	44:05		STC •+1	
	1481	4317			SPA CLA	/HC(DATA) < HC(CAL)		1555	04.35	8699		3033	ADD RECIPROCAL
	1452	4320	5345		JAP HCC2	180		1551	9496	4435		STC DIV3	
		4321			TAD LIF	TYES		1552	0407	3911		CLR	
	1453				CMA			1553	9419	3649		LDF 0	
	1454	4382		:		JONES COMP		1554	3411	1330		LUA	
	1455	4323	3374	•	LCA DIF	تهديدون وسيدهدون	÷	1555	3412		1	DIF:2000	
	1456		1063		TAD ADDR		•	1556		0451	•	APJ	Z+VE LIFF?
	1457	r325	6141		LINC							JMP DIVI	
	1463				Laude			1557	3414				/YES
	1461	3326	1560		BCL I			1560	0415	1953		LDA I	r
								-					

		.										
	1561	0416			NOP		1669			/SUBBOI	TINE TO CALLER	ATE VERTICAL COURSINATE
	1562	0417			STC DIV4		1661				*630	
	1563	0429			LDA		1662				PAJLE.	
	1564	9421			di F 12000	•	1663	4600	0000	SCAVC.	0000	
2	1565	0425	6431		JMP DIV2		1664	4601	7300	JUNVUP	CLA CLL	
	1566	3423	1020	DIV1,	LDA I		1665		1063			
	1567	0424	0317		COM			4602			TAD ADDR	
	1579	0425	4447		STC DI V4		1666	4603	6141		LINC	
	1571	9426			LDA		1667				LMOLE	
	1572	6427	-		DIF12000		1670	Ø694	9346		SCR 6	
	1573	0430		3 (K.19)	CUM		1671	0605	1120		ADA I	
	1574	0431	0246	DI V2.	RUL 6	· · · · ·	1672	0696	7765		-12	
	1575	0432		DIVES	그는 그는 그는 것을 수 있는 것이 같아. 가지 않는 것이 없는 것이 없 않이 없는 것이 없 않이		1673	0637	3471		ΔΡΟ Ι	JODL OR EVEN TV FIELD
	1576	8433	4435		MUL		167.4	0610	6615		JMP ++5	
	1577	3434	- F		•+4002		1675	9611	1120		ADA I	ZMAKE ORIGIN ABOUT
	1633	• #100 000			SKP		1676	0612	0305		5	/CENTRE FOR A GRID
	1631	0435	09.30	DI V3.	0000		1677	0613	3017	a ser e ser e	COM	/JF II(LEC) VERTICAL
19 - 19 A.		0436	1243		MUL	the state of the second st	1700	0614	6620		JAP +4	/POINTS
	1692	9437	4441	÷	•+4392		1731	0615	1123		ADA I	AS APOVE FUR
	16.13	0440	9456	1.	SKP		1792	3616	7771		- 6	/OTHER FIFLD
3 A.	1634	0441	0620		8620	Standard Williams State	1703	3617	0017		COM	
	1605	3442	0321		BOR I 1		1734	3623	1269		MIL I	/SCALECKI DOMAD
	1636	0443	0472		LZE I	•	1705	0621	0144		0144	 www.sue.com/relation/citization
	16.37	9444	6447		J4P +3		1766	0622	4656		STC CALVC	
	1613	9445	1129		ALA I		17-97	2623	0395		PDP	
alan da sa	1611	3446	0331		1 5 6 6 5		1713		0001		PMU DE	
	1612	3147	0316	DI V4,	AOB.		1711	4624	4471		JAS I VCC	ACAL CHE AND A THE CONT OF
	1613	8450	0002		PLP		1712	4625	4473		JAS I DIV	CALCULATE AND SCALF
ing and the second s	1614		1		PMODE		1713	4626	6141		LINC	CORRECTION FACIOR
5 A	1615	4451	5600		JAP I SDIV	· • •	1714		01-1		LMJDE	
1.1	1616			1			1715	0627	1140			(Carried Cont. Cont. Cont. Cont. Cont.
	1617			1		,	1715	0630	0656		AL4	CORRECT CALIBRATED
0	1523 :				LMODE		1710				CALVC	ZVERTICAL COUND
	1621			1				Ø631	9905		PLP	
	1622	0452	3030	RTAB,	3030	/RECIPROCAL OF 25	1720	44.00	5100		PMUDE	
8 C	1623	0453	2721		2721	/26	1721	4632	5600		JMP I SCAVC	
	1624	3454	2354		2054	/27	1722			1		
	1625	0455	2525		2525	/30	1723					
	1626	3456	2436		2436	/31	1724			•		
	16:27						1725			/SUBRJU	TINE TO CALIBRA	TE HORIZONTAL CUORLINATE
		- 14:57			2354	/ 32						
	1630	3457 (3463	2354		2354	/ 32	1726	4633	0030	SCANC.	0900	
1.1	1633	6463	2354 2875		2275	/33	1786 1787	4634	7393	SCAHC,	0900 Cla Cll	
	1631	0463 3461	2354 2275 2222		2275 2222	/33 /34	1726 1727 1730	4634 4635	7390 1063	SCAHC,	0900 Cla Cll Tad Addr	
	1631 1632	0463 0461 0462	2354 2275 2222 2151		2275 2222 2151	/33 /34 /35	1726 1727 1730 1731	4634	7393	SCA4C,	0900 Cla Cll	
	1631 1632 1633	0463 0461 0462 9463	2354 2275 2222 2151 2194		2275 2222 2151 2104	/33 /34 /35 /36	1726 1727 1730 1731 1732	4634 4635	7390 1063	SCANC,	0900 Cla Cll Tad Addr	
	1631 1632 1633 1634	(1463) 3461 9463 3463 3464	2354 2275 2222 2151 2194 2041		2275 2222 2151 2104 2041	/33 /34 /35 /36 /37	1726 1727 1730 1731 1732 1733	4634 4635 4636 0637	7399 1063 6141 1569	SCA4C,	N900 CLA CLL TAD ADDR LINC	
	1631 1632 1633 1634 1635	0463 0461 0462 0463 0463 0465	2354 2275 2222 2151 2134 2341 2333		2275 2222 2151 2104 2041 2000	/33 /34 /35 /36 /37 /40	1726 1727 1730 1731 1732 1733 1734	4634 4635 4636	7390 1063 6141	SCA4C,	0900 CLA CLL TAD ADDR LINC LMODE	
	1631 1632 1633 1634 1535 1636	0463 0461 0462 0463 0463 0465 0465	2354 2875 2222 2151 2134 2041 2033 1740		2275 2222 2151 2104 2041 2000 1740	/33 /34 /35 /36 /37 /40 /41	1726 1727 1730 1731 1732 1733	4634 4635 4636 0637	7399 1063 6141 1569	SCA4C,	0900 CLA CLL TAD ADDR LINC LMODE FCL I	
	1631 1632 1633 1634 1535 1636 1637	(1463 3461 9469 9463 3464 3465 0466 3467	2354 2875 2222 2151 2194 2041 2000 1740 1703		2275 2222 2151 2104 2041 2000 1740 1703	/33 /34 /35 /36 /37 /40 /41 /42	1726 1727 1730 1731 1732 1733 1734	4634 4635 4636 0637 3643	7399 1063 6141 1560 7769	SCA4C,	0000 CLA CLL TAD ADDR LINC LADDE PCL I 7700	ZMARE UNIGIN AT CENTRE
	1631 1632 1633 1634 1535 1636 1637 1643	0463 3461 8468 9463 9464 9465 0466 3467 9479	2354 2875 2222 2151 2194 2041 2000 1740 1703 1650		2275 2222 2151 2104 2041 2.00 1740 1703 1652	/33 /34 /35 /36 /37 /40 /41 /42 /43	1726 1727 1730 1731 1732 1733 1733 1734 1735	4634 4635 4636 0637 3640 0641	7300 1063 6141 1563 7709 1120	SCA4C,	0000 CLA CLL TAD ADDR LIVC LADDE FCL I 7700 ALA I -15	VEARE UNIGEN AT CENTER
	1631 1632 1633 1634 1635 1635 1635 1637 1643 1641	0463 0461 0462 0463 0464 0465 0466 0466 0467 0470 0470	2354 2222 2151 2194 2041 2003 1740 1793 1650 1616		2275 2222 2151 2104 2041 2000 1740 1740 1743 1652 1616	/33 /34 /35 /36 /37 /40 /41 /42 /43 /44	1726 1727 1730 1731 1732 1733 1734 1735 1736	4634 4635 4636 0637 3640 0641 3642	7300 1063 6141 1563 7760 1120 7762	SCA4C,	0000 CLA CLL TAD ADDR LIVC LADDE FCL I 7700 ALA I	
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e de la	1777	1936	1262		STA I CBUF	/TV-FIELD NO		2976	1073	1462		SAE I	TRANSFER UKT	
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6.1.1	2633		0063	1992		LLA			2277	0162	7767		
1.1	22:11		9964	0175		UCTAC			2330	0163	0471		APU I
	8595	- 1	0365	0641		LDF 1			2301	0164	6174		JMP XIT
									2302	0165	1399		LUA
-	5633	1. 1. j. j. j.	0366	1343		STA	•						
•	22.34		3367	2307		DIDLKI2000			2393	0166	0175		JCTAC
	2205		3273	3376		SET I 16		4	2304	0167	1260		MUL I
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			6072		+6001			2345	0170	3919		10
	CS 36		9371										ADD NUM
	8337		3472	7338		JMP QAINIT			2316	Ø171	2176		
	2810		0 373	3652		MFSS3	/CDTBLK		2307	0172	4175		STC JCTAC
	8311		0074	3503		ANSWER			2310	3173	6137		JMP PM1
									2311	3174	6016	XI T.	JMP 16
	2212		9975	7953		JAP QARFSH				0114	0.010		ONF TO
	2213		0376	8077		SET I 10			2312			/	
	2214		3977	0500		AJSWER			2313			1	
						JMP PM			2314	0175	0390	OCTAC,	0
	2215			6133									
	2216		0131	1390		LDA			2315	0176	0000	NUM.	۵.
. . .	2217		01.02	3175		JCTAC		•	2316			/	
	2023			1123		ALA I			2317				*500
					•					ar a a	9999	ANCHER	
	8831		3134	7331	•	-776	· .		2323	0500	0000	ANSVER.	
	8888		9135	3471		APJ I			2321			/	
	2223		0106	6174		JAP XIT			8355			1	•
													*600
	2554		31.37	1930		l da		_	2323				+000
	2225		9113	0175		UCTAC			2324	0507	3643		
	2826		0111	2642		LLF 2			2324	6601	0301		
						STA			2324	0672	1440		
	P987		3112	1949									
	8230		0113	3114		CLIBLK!2000			2324	0603	1524		
	2231		3114	9976		SET I 16			.2324	0634	3040		
	2232		0115	6116		• + 6 0 3 1	-		2324	0605	2324		
						JMP GALVIT	•		2324	3606	3122		
	2233		3116	7000		•	100000 C 70 C	TADT					•
	0234		3117	3733		MFSS4	PRESS S TO ST	a (14) à	2324	3637	2440		
	2835		0120	0599		AJSVER			2324	3610	0214		
						JAP QARESH			2324	0611	1703		
	3936		9121									MECCI	TEYT 75 CAL MEY STARE DE OCT
	223 7		0122	0073		SET I 10			2324 /			MESS1.	TEXT ZF CAL MTX START BLUCK
	2943		J123	9500		ANSWIR			2325	0612	1343		
			0124	1339		LDH I 10			2395				
	2241								8326	0613	4743		
	5545		3125	1423		SHD I	(A.1. C.3.						
	2243		3126	2304		2309	/AN S?		8386	0614	4347		
	2244		9127	0456		SKP	/YES		2326				
						JAP XIT	INO REPEAT ME	SS	2327	0615	4343		
	2245		0130										
	2246		3131	3600		LIF Ø			2327	0616	9649		
	2247		0132	64.53		JMP 400		•	2327	9617	4943		
			2133	0355	PX.	5k1 15			2327	3623	4033	:	
	2250								2327		2432	i	
	2251		0134	0003		9				2621			
	2252		0135	0011		CLH			2327	3622	1413		
	88.53		3136			STC OCTAC			2327	Ø623	4074		
			0.00						-				
	•												

C. 0555.40

		•			-				
	2327	0624	6334		2341	0711	6134		
	2327			F CTBLK <3NZ	2341		• -	MESSA, TEXT ZETYPE S T	O START <1NZ
	2330	7625	0640		2342			/	
7					2343				
	8330	0686	0401					VOANDA SUBROUTINE FOR T	11 L
	8330	0627	2401		2344				
	2333	Ø633	4023		2345			/PDP-12	
	8330	9631	2431		2346			/REMOVE *1000 BHLOW IF	
	2333	0632	2224		2347			VINSERTING SOURCE DIREC	
	2339	2633	4332	The Barrier of Adams A state	2350			/INTO YOUR PROGRAM SOUR	(CE
h = 1	2339	Ø634	1417		2351			*1000 / REMOVE, IF DESIRE	2D
	2330			MESSE, TEXT ZF DATA START BLOCK	2352			1	
	2331	0635	3313		2353	•		/TO HERE TO INITIALIZE	THE ROUTINE
	2331	2636	4347		2354			1	
	2331				2355	1000	1020	QAINIT, LUA I	/SAVE JMP RETURN
	2332	8637	4943	and the second	2356	1001	0202	2	
	(1) C. P. M. (1999) 11 (1999) 14	0031		the second s	2357	1002	2030	ADD Ø	
	2332	2643	4743		2360	1003	1060	STA I	
	8333	19 A.	10 · · ·	and the second	2361	1074	0030	QAB. Ø	/JMP +3
51 (19 ¹⁷)	2333	9641	4347					ADD GAL+3	V Bail 0
1.1.1.1.1	8333		المركز مركز		2362	1035			ADTU TO STUCH DADAM
	2334	0642	4243		2363	1936	4001	STC 1	PTH TJ FIRST PARAM
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	2334	9643	0643		2364	1 0 0 7	1031	LDA 1	/GET FIRST PARAM
	2334	0644	4943		2365	1010	3264	ADD GAQ+1	PTR TO HALFWORL-1
•	2334	0645	4384		2366	1011	5857	STC OAG-3	
1 	2334	9646	2492		2367	1918	1 32 1	LDA I I	
	2334	3647	1413		2370	1013	5052	STC OARFSH-1	
	2334	0659	4374		2371	1014	4006	STC 6	/XR6 USED AS A SWITCH. = J
	2334	3651	6334					IF NO ANSWER FIHLD, =17	77 IF YES
100 100	2334			F DTELK <3NZ	2372	1015	0943	QACA, SET 3 /XR3 TO	PTR TO ANSWERS
	2335	06 52	0649	[1] The second s Second second s Second second s Second second s Second second se	2373	1016	1052	QARF SH-1	
1.2	2335	0653	0391		237.4	1917		SET 4	ZXR4 TO PTR TO OUESTIONS
					2375		1057	QAG-3	
·* .	2335	0654	1443		2376	1020	1001		ZTO HERE IF FIRST TIME THAT
	2335	0655			2319			OUGH OR FOLLOWING A CR	To null if finds that the
. · ·	2335	0656	8431			1.001	ØØ41	SET 1	•
1.1	2335	3657			2377	1021		4	
	2335		2491		2499	1022			
1	2335	Ø661	2224		2491	1923	7270	JMP QAT	4-
	2335	3662	4932		2402	1924	3016	.005	/F
Sec. 2	2335	0663	1417		2423		1324	LDH I 4	7H. BUMP PTR IF H OR F
1.5	2335	•		MESS3, TEXT ZE CAL DATA START BLUCK	2434	1986	7231		
	2336	9664	0313		2435	1927	7935	0+• 4MC	/74
· · · · ·	2326	8665	4347		2436	1039	7050	JMP QAE	/34
	2336		1.1.1		2407 .	1031	1460	SAL I	/CR?
	2337	0666	4943		2419	1932	0943	43	
	2337				2411	1033	7 0 2 6	JMP QAD	(1)
	2343	3667	4740	•	2412	1934	7921	JMP QACA+4 /EXA	MINE NEXT CHAE
14 July 14	2343	3673	4306		2413				/INITIALIZE ANSWER BUF:
		3671	4343		2414	1035	1343	STH 3	74 TO ANSWEES
	2343			•	2415		1324	LDH I 4	/NEXT HALF WORD
	2340	3672	4943		2415		1123	ADA I	
	2343	3673	3334						
	2343	3674			2417		7717	-60	
	2343	0675			2420 ;		0317	CO.4	
	2340	0676			2421		40.16	STC 6	
	234ð	3677	6334		2422		1363	STH I 3	VØ IN AC
	2349			F CDTBLK <3\Z	2423	1344		XSK I 6	
	2341	27 33	3624		2424	1945	7643	JAP2	•
	2341		3120		2425	1 346	1323	LDHI3	ZEUAP PTH. TO ANSWERS
	2341		3540		2426	1047	7326	JEP QAD	
	2341		2343		2427				ZANSVER BURK IS INITIATED NO.
	2341		2417		2439	1250	1343	QAE STH 3	ά Ω
	2341		4323		2431	1951		SET I 4	ZXR4 13 PTR TO LAST TYPE: 0
			2401					CHAR IN ANSWER BUFR	
	2341				2432	1952	3003	3	
	2341	37:37			2433		0	-	/RF-ENTER HEME TO MEEK
	2341	3113	4074		-				
					-				

			ALCONOM PARTY	Concerning Sector of Sector Sector	and a second	and the share of a contract of the production of the second s		10.101				
							05.04	1176	7521	QAJ,	JMP GETKBD	ATO HEAR IF DISPLAYED BURE .
				FS4		AT NETTER & DICE TO IN	2520	1120	1 361	ER	our ournob	
	2434		1323	QARFSH.	LDA I	VINITIAL Y PUSITION	0501	1100	0100	£-43	A75 T	
	2435		3277	277		•	2521	1137			AZE I	
	2436	1955	5113		STC QAH-1		2522	1147			JMP OAB /NOTHING	SITTED + EALL
	2437		0063		SET I 3	/XR3 TO PTR TO HALFWORD QU	2523	1141	0062 ·	х.	SHT I 2	
	•			ESTI UNS-			2524	1142	1412		QAY	
	244.3	1057	4.20.2		0		2525	1143	1402			/LF?
		1957				/XR5 TO PTR TO LAST DISPLA	2526	1144				/YES. EXIT
1	2441	1000	004D	YED OUA	R IN ANSWER BUFR		2527	1145				/CR?
			ن مربع	IED CHA			2530	1145			JAP QAN	
ž.	2442	1 761			QARFSH-1							VIS THERE AN ANSWER FIELD?
	2443		3341	WAG.	SET 1	· · ·	2531	1147	3206		JAP OARFSH	
	9444	1363			3		2532		7853			/ </td
iy e.	2445	1964			JAP QAT			1151			••••	r > ;
	2446		7374			/F		1152			JMP QAL	1-2
	2447	25 Sec. 5	1323			/H. BUMP PTR	2535		1423			/>?
	2459	1967				INEITHER ASSUME HALF SIZE	2536	1154			JAP DAK	
an sa	£451	1379			NCL I		8537	1155	1422			/ALT?
	2452		5103	in dia ka	STC 0AM+2	SET INSTR TO CLEAR FF FOR	2543	1156	7915		JAP GACA /REINIT	
	an a	· · · · · · · · · · · · · · · · · · ·			LZE STATES		2541		1422		SHD I 2	ZBACK SLASH?
•0 	2453	197.2	361.9		ADD QAW	INJP IN AC	2542	1169			JMP QARESH	/IGAURE
		1573			JAP OAM		2543	1161			SHD I 2	/HURJUI?
	2454			•	LDH I 3	VOUMP PTR	2544	1162				/IGVJLE
	2455	1374		1. K. S. S. M. S. M.			2544		1422			/TAB?
, ", ¹	2456	1075			LDA I	· "你是我们,你要算你了。"你是你你的吗?	2546	1164				/IGQUIE
	2457	1976		and the second	ESE 1	/		1164				ACCEPTADLE CHAN
	2463		5103			SET INSTH TO SET FF FOR F	2547					VIEST JEXT CHAR
	a sinte			ULL SIZI		and the second	2550	1166				
te esta	2461	1103		i ja kusti		VADD 9U IN AC	2551	1167				/74 BACK PIR UP BY 1
	2462	1101		QA.S.	STC DAP+3		2552	1173			• • • • • • •	/34 1 ////////////////////////////////////
	2463	1192				/ EAD CONTROL REGISTER	2553	1171	1929			VOK. STORE IT
	8464	1103		· • • •	ESE I	/THIS INSTR CHANGES. EITHE	2554	1172	00.10		0	
	• - • • • · · · · ·			R PSE &	UE BOL &		2555	1173			STH 4	
	2465	1104	0233		230		2556	1174	7053			/REDISPLAY
		1195			450 4	AC TO CONTROL REGISTER	2557		1334	QAL,		VIO HERE IF LUPBOUT OR <
	2465		0004			/KR1 TJ INITIAL & POSITION		1176			JMP DAD+1	
	2667				193		2561	1177				/74 IGNURE
	2473	1137				AY COOMSTRATE MIN TIDI S	2562		1775		-6332	-
	9471	111.5			LDA I	Y COUNDINATE MULTIPLE		1231	1332			TEST THE CHAR
	2472	1111			-43	AV MANDER JAME	2563 2564		1332			ZEUBOUT?
	2473	1112			· • · · · ·	YY COURDINATE	2564	1202			54E 1 37	
•	2474	1113			A		2565	1203	0037			
	2475		1323	OAH.	LDH I 3		2566	1234	7263			IND. BACK PIR UP BY 1
	2476	1115			J4P 0A0+1	· ·	2567	1205	6945		SET 5	
	2477	1116				174 BUMP PTR TJ NEXT CHAR.	257/1	1596	0004		4	
				PUT 43			2571	1237	0343		SET 3	
	2503	1117	7136			/34	2572	1213	0004		4	
	ຸກສະອ - ຂຽງ1	1123			SHE I	/NEITHER	2573	1211			J%P •+2	
					4300	· • • • • • • • • • • • • • • • • • • •	2574	1212				ZBUMP Pin
	2572	1121			43.70 JAP QAG	ZCR. MOVE X AND Y COURDINA	2575	1213				/GET NEXT CHAR
	2573	1155		an t	UNF UND	ATTA PART IS BRED T DAOTDTIAN	2576	1214			JAP 100+1	
				TŁ.	1.1.3 0.4.3	TODENY MAND		1916	3916			/IF 74 OR 34, HEPLACE CUM
	2534	1123				VISPLAY CHAR	2577	1610	9010	LUT OTA		
	2535	1124			• • • • • • • • • • • • • • • • • • • •	VPICK UP NEXT CHAR	04.7.7	10.0			R WITH Ø	
	2536	1125	7248			/TO HERE IF DISPLAYING ANS	8000 }		0311		CLH	
				WER PUFI	R		5631		1345		S1H 5	
	2507	1126	1520		SHO I /SWITCH	TU DISPLAY CORSUR- EITHER	2632	1553				ZWAS IT 74 JE 34?
				3033 OR			2693		7218			/NJ. CONTINUF
	2513	1127	\$ 3.2.1		ð	/IFAR4=KR5, THEN SWITCH=77	26.14	1555	7263			ZBACK 2TH UP BY 1
	- 010	1161		77	*	· · · · · ·	2675					ALD REDE IF CH
	01.1.1	1	7511		JMP QAF		8696	1553	0206	QA.V.	X54 6	
	2511	1133	1010		UTE UNE	ZOURSTINJ MIDE	2637	1224				VEXIT HOUTINE IF NU AUDURE
	2512					AQUESTION MODE		*		FILD		
	2513		1325	(JAI #	LDH I 5		0417	1005	1001		JAP DAN	84
	2514		7232		JHP 0A0+1	471.6	2613	1225		;		
	2515		7114		JAP DAY	/74	2611	1550	7053	700		/74 MJVF PTR TJ NEKT OUESI
	2516	1134	7114		JAP QAH	/34				ION FIE		
	2517		7125		JAP GAI-4	INEITHER. DISPLAY IT	2612	1227	7051		JMP QAL+1	/34 END OF PORCH AJVE PIL
		-					-					

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Sec. 19. 10	and the second	Same and the second state	a sea a se a se a se a se a se a se a s	And the second	Alexandration Conference in the second s						-			
enceione														
							2677		7263	JMP QAQ	YES. ICADEE			
	2613	1230	7225		J.1P QAN+2		27 33	1310	7 424	JAP GAX	ANOVE DUT FORWARD			
	2614		. –				2701				VTO HERE 10 EXIT WITH			
	2615	1931	1324	040.	LDH I 4	/S\R				SKIP				
			1423		SHD I	/ +1 74 BEGINO	27 0 2	1311	1323	LDA I				
	2616	1636	1460	FILD	5021	•	27.33	1312		1				
			-	FI EL U	2492	/ +2 34 END BU	2734		1140	ALM				
	2617	1233	7439		7430	7 72 34 610 50	2735		1004	NAB				
	and the second second	1.1.1.1	2	FR	· · · · ·									
	2629	1234	6009		J.4P 0	+3 NEI THER 7	27:36	1315	7004	JMP QAB	ARTANA ARTA DI DA 117 A CAL			
		1.1.1		4 VJR 3	34		27 37				/CHARACTER PATTERNS			
1.1	2621	1235	1463		SAE I		2719	1316	61 91		/KBU 3. ILLEGAL. USED			
· .	2622	1236	0334		.34					AS MARKER				
	2623	1237	0220		XSK I Ø		2711	1317	91 91	0101				
		1249	0220	2.1	KSK I Ø		2712	1329	4477	4477	/1:A			
	2624				JAP 0	en e	2713	1321	7744	7744				
	2625	1241	6200			SAR TO DISP LINC CHA	2714	1322		5177	/2: B			
	2626	$= \sqrt{y_1^2 + y_2^2}$			<u>a 8</u> % a		2715	1323		2651				
		1.2.2.3.4		R IN AC			2716		4136	4136	/3:0			
- 11	2627	1242	9241	QAP.	RUL 1	MULT BY 2 FOR INDEX					, 310			
			28.67	TO ADLE	RESS OF TABLE	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	2717	1325		2241	14.55			
1.1	2630	1243	3430		ADD QAX+4		2721		4177	4177	/4:D			
	2631	1244	4302		STC 2	ADDRESS OF CHAR TO D	2721	1327		3641				
				ISP IA	XH2		8788		4577	4577	/5:E			
	2632	1245	3546		ADD QAU	/THIS INSTR CHANGES.	2723	1331	4145	4145				
	2044 G		0000	ST THER	UP JR ADD 90		2724	1332	4477	4477	/6:F			
÷	0120	1064	2536	Br	ADD QAU	· · · · · ·	2725	1333	4344	4:344				
	2633	1246			ALD 1	ADD 4 TO XRI TO SPAC	2726		4136	4136	/7:6			
÷.,	2634	1847	50.91			VADD 4 10 KAI 10 SING	2727		2645	2645				
		a genera	$(1-\varepsilon)^{k_{1}} = a_{1}^{k_{1}} + a_{2}^{k_{2}} + a_{3}^{k_{3}} + a_{3}^{k_{3}$	Ł CHAR		•	2730		1977	1377	/13:4			
	2635	1253			STC 1	· · · · · · · · · · · · · · · · · · ·					- 1			
	2636	1251	2935		ADD 5	/GET ADDRESS OF ANSKE	2731		7710	7713	* * * * *			
				R BUFR			2732	1340		7741	/11:1			
	2637	1252	0317		CJ.1		2733	=	0.141	Ø341				
	2643	1253			ALL 4		2734	1342	41,42	4142	/12:J			
	the second se	1254	0453		AZ E		. 2735	1343	4376	4076				
	2641				CLR		2736	1304	1 377	1077	Z13:K			
	2642	1255				/SWITCH=Ø OR 7777	2737		4324	4394				
	2643	1256	5127		SIC QAI-2		2743		0177	8177	/14:L			
	PEAD	1257	3113		ADD OAH-1	VY COURDINATE IN AC								
	2645	1263	1742	•	ISC 2	-	2741		03.51	9391				
	2726	1261	1762		LSC I 2	/ DISPLAY CHAR	2742		3077	3077	Z15:M			
	2647	1262	6333		JAP Ø		2743		7733	7730				
	2653			640.	LDA I	/BACK UP PTR BY 1	2744	1352	3077	3.377	/16:N			
	2651	1264			-4300	· · · · ·	2745	1353	77:36	7796				
	8652	1265			ALA		2746	1354	4177	4177	/17:0			
					4		27.67	1355	7741	7741				
	2653	1846				A GENERAL COLLAN	2753	1356		4.677	124:P			
	2454	1267	1353		JAP QARESH	REDI SPLAY	\$751	1357		3,544				
	2655						2752		4276	4276	/81:0			
	2656		1321	QAT.	LEH I 1	ZSNR					* *5± + 12			
	2657	1271	1423		SHL I	/ +1 F	2753		3376	0376				
	2663	1272	9633		0690	/ +2 н	2754	1362		4477	/22:ic			
	2661	1273			JSP Ø	/ +3 NEITHER	2755	1363	3146	3146				
	2662	1274			SAE I	•	2756	1364	5121	5121	/23:S			
					10		2757 1	1365	4651 -	4651				
	2663	1275					8769	1366	0040	4 543	/24:T			
	2664	1076	0203		XSK I Ø		9761	1367	4077	4377				
	2665	1277	3223		XSX 1 0		2762	1373		9177	/25:0			
	2666	1333	6723		J.42 Ø	_			7731					
	2567					/	2763	1371		77:51	400 - 1			
	267.3	1301	1323	QAZ,	LDH I 3		2764	1372		2176	159: A			
	2671	1332	1320		LDA I		2765	1373	74.32	7432				
	2672	1333	004:3		49		2766		0677	- J677	187:1			
	2673				JMP QAI-4		2767	1375		77.51				
						/TJ HERE IF >	2773	1376		1463	/30:4			
	2674	13.36	1204	QAK.	LDH I 4		2771		6314	6314				
	2675		1324	ALLER R.		/IS CURRENT CHAR BLAN	2772	1433		8773	/31:1			
	2676	1336	9473		AZE I	AD CONTRACTA COMPANIES	2773	1401		7037				
				К?			-		1007					
3.949.0920.00	Contrast Revenues			and the second			A CONTRACTOR OF STREET	and the second	and a state of the second s	Addition of the second	an faller fan fan fan fan in m	ya hakaze ini se s	 An and the property of the second se Second second sec second second sec	1 1 A
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	0224	1 6 4 9	4543		4543	/32:2	3067	1471	Ø651		0651	•		
	2774	1402					3979	1472	1576		1536		/66:6	
	2775	1403	6151		6151									
	2776	1494	4177		4177	/33:/	3971	1473	4225		4225			
			9333		0000		3372	1474	4443		4443		/67:7	
	2777	1-100	9.1.9.5		0000	/34: BACKSLASH IGNORED	3973	1475	6050		6353			
	3733					7 34. DRUKSCHOR I GOOKED						/70:8		
				1. VU	NPUT		3374	1476	5126			/ 10.0		
	3 3 7 1	1436	0030		3	INOT USED	3375	1477	2651		2651			
					0	VAJT USED	3076	1530	5122		5122		/71:9	
	3332	1437	3333					1501	3651		3651			
	3333	1413	0 0 33		3309	/35:1	3377							
112.0	3134	1411			7741		31-30	1532	S530		2200		/72::	
11.	en en la secta de la secta	1-1-1-1	11-7-1	e e		CODES 36: ALT. 37: RUB	3101	1533	0300		0030			
	3395			5	e si e su a	CODES SUCHAID STUDD					4691		/73:;	
en e				OUT N	OT LISPLAYED		3132 .	1504	4631				/ 13.7	
	3736	1412	4543	9AY.	4543	/LF, CK	3193	1535	0930		4338			
1.1		1	1			14, 2000 244 244 244 2000	3104	8 g					/CODE 74: <nut displat<="" td=""><td></td></nut>	
1940	3137	1413	7476		7476			1.1.1		FD				
	3313	1414	3634	1.1.1	3634	ALT, BACKSLASH			·		-		4	
	3311	1415	3747		3747	/RUBJUT, TAR	31:25	1506	0935	QAU>	5		/CJNSTANT	
					0999	/ 40: SPACE	3196	1507	0300		Ø	INOT US	ED	
	3412	1416	0939				3107		1212		1212		/75:=	
	3113	1417	8333		9994									
i al l'	3314	1423	1500		7598	/41:***	3119	1211	1212		1212			
	3015	1421	9803		3333	•	3111						/CODE 76:> NUT DISPLA	
100		 	- 2.85 - 17			/485 P. C. S. H. Marker	•			YED				
	3316	1422	7300			/481 ************************************	2110	1610	9316		NOP			
	3317	1423	1373		0378	•	3112	1512		(CHW)		•		
						/CODES 43:, 44:, 45:L	3113	1513	3506		ADD QAU			
<u>,</u>	3723	1.8 Mg		e	DT COL AVEN AND ST		3114	1514	4323		4023		/77:?	
	1. 1. 1. 1. 1.				DISPLAYED				2055		2055			
	3321	1484	7238	QAX,	JMP QAU+1	and the second	3115	1515	6495		6423			
	3322	1425	7263		JMP GAQ	•	3116			1				
							3117	1516	1760	QAF .	DSC I			
	3 323	1426	7263		JMP GAG	•		1517	6000		6339			
	3324	1427	7 53		JMP QARFSH	- 1 S A	3120							•
:	3325	1435	1316		QAV	an shakar ƙwaran ƙwara 👷 👘 🖓 👘	3121	1520	7131		JMP QAI			
					0	/NOT USED	3155			1				
	332€	1431	0000				3123						ZEND Q+A	
	3327	1432	5166		5166	/46: &							7 BVD 1218	
	3 13 1	1433	0526		7526		3124		•	/				
		1400				CODE 47: TAB NUT DI SP	3125			1				
	3331						3126			1				
				LAYED										
	3032	1434	2393		Ø	INUT USED	3127			<i>!</i>				
					J	/ VOT USED	3130			/KEYBUA	RD INPUT	HOUTINE		
	3333	1435	0900				3131			1				
	3734	1436	3600		3600	/50:(abe	1000 0	1.34 /01	
	3135	1437	0341		0041		3132			QAKRB=6	036	PDP-8	IOT KBL	
				1.	4130	751:0	3133			0AT5F=6	341	/TSF		
	3,336	1440	41:03				3134			QAILS=6	946	/ILS		
	3337	1441	0036		0036					/	040			
	3343	1442	2359		2050	/52:*	3135							
	3341	1443	0059		2353		3136 .	1521	1003	GETKBD,	LDA			
						169+1	3137	1522	0000		Э			
	3942	1444	3434		0424	/53:+					SIC GALA	1144	/SAVE RETURN	
	3343	1445	9437		0437		3149	1523	5643			11+0		
	3364	1446	3533		0530	/54:,	3141	1524	2001		ADL 1		/SAVE KRS 1 AND 2	
							3142	1525	5643		STC OALA	17+3		
	3045	1447	0036		3006	155.	3143	1526	8008		ALD 2			
	3346	1453	34,34		3404	/55:-								
	3347	1451	3434		3404		3144	1527	5642		STC OAFX			
					0931	/56:•	3145	1530	5636		STC OALK	11+1		
	3953		0391				3146		0415				METHING TYPED?	
	3051	1453	0000		0398	•								
					3621	/ 57: \	3147,		6699		JWB Q		ZNU: EXIT	
	3352	1450					3157	1533	8533		IOR			
	3352	1454			1:334									
	3753	1455	4030		4333			1524	6336		OAXBB	/GET TT	Y CHAR, CLEAR FLAG	
		1455			4536 /60:0		3151		6336			/GET TT	Y CHAR, CLEAR FLAG	
	3353 3354	1455 1456	4030 4536				3151 3152	1535	1363		STA I	/GET TT	Y CHAR, CLEAR FLAG /SAVE IT	
	3353 3354 3355	1455 1456 1457	4030 4536 3651		4536 /60:0 3651	/61:1	3151	1535	1363	QATY,		/GET TT	/SAVE IT	
	3353 3354 3355 3356	1455 1456 1457 1463	4030 4536 3651 8191		4536 /60:0 3651 2191	/61:1	3151 3152 3153	1535 1536	1363 3933	QATY,	STA I J	/GET TT		
	3353 3354 3355	1455 1456 1457	4030 4536 3651		4536 /60:0 3651 2131 - 0177		3151 3152 3153 3154	1535 1536 1537	1363 3333 1120	QATY,	STA I J ADA I	/GET TT	/SAVE IT	
	3353 3354 3355 3356 3356 3357	1455 1456 1457 1463 1461	4030 4536 3651 8191 9177		4536 /60:0 3651 2191	/61:1	3151 3152 3153 3154 3155	1535 1536 1537 1540	1363 3333 1120 7549	QATY,	sta I J Ala I -237	∕GET TT	/SAVE IT	N
	3353 3354 3355 3356 3356 3357 336 3	1455 1456 1457 1463 1461 1462	4030 4536 3651 8191 0177 4523		4536 /60:0 3651 2191 - 9177 4523		3151 3152 3153 3154	1535 1536 1537 1540	1363 3333 1120	QATY,	STA I J ADA I	∕GET TT	/SAVE IT /Detween 203 and 237?	28
	3353 3354 3355 3356 3357 3363 3363	1455 1456 1457 1463 1461 1462 1463	4030 4536 3651 2191 0177 4523 2151	·	4536 /60:0 3651 2191 9177 4523 2151	165:5	3151 3152 3153 3154 3155 3156	1535 1536 1537 1540 1541	1363 3933 1120 7549 3451	QATY,	5ta I J Alia I -237 Apd		/SAVE IT /Detween 203 and 237?	286
	3353 3354 3355 3356 3357 3363 3361 3361	1455 1456 1457 1463 1461 1462 1463 1463	4030 4536 3651 2101 9177 4523 2151 4122	į	4536 /60:0 3651 2191 9177 4523 2151 4122		3151 3152 3153 3154 3155	1535 1536 1537 1540 1541	1363 3333 1120 7549		STA I J AIJA I - 237 APO JNP QACV		/SAVE IT	8
	3353 3354 3355 3356 3357 3363 3361 3361	1455 1456 1457 1463 1461 1462 1463 1463	4030 4536 3651 2191 0177 4523 2151	ż	4536 /60:0 3651 2191 9177 4523 2151	165:5	3151 3152 3153 3154 3155 3156 3157	1535 1536 1537 1540 1541	1363 3933 1120 7549 3451	OR CR.L	STA I J AIJA I - 237 APO JNP QACV	Tił	/SAVE IT /Detween 203 and 237?	8
	3353 3354 3355 3356 3357 3363 3361 3361 3362 3363	1455 1456 1457 1463 1461 1462 1463 1464 1465	4030 4536 3651 8101 9177 4523 2151 4122 2651	2	4536 /60:0 3651 2131 9177 4523 2151 4122 2651	165:5	3151 3152 3153 3154 3155 3156	1535 1536 1537 1543 1541 1542	1363 3333 1120 7540 9451 7634		STA I J Ala I - 237 Apo Jyp Qacv F. Tab		/SAVE IT /DETWEEN 203 AND 237? /CONTROL CHAR. CHECK F	8
	3353 3354 3355 3356 3357 3363 3361 3361 3362 3363 3363 3363	1455 1456 1457 1463 1461 1462 1463 1464 1465 1464	4030 4536 3651 2101 9177 4523 2151 4122 2651 2414	2	4536 /60:0 3651 2131 3177 4523 2151 4122 2651 2414	/62:2	3151 3152 3153 3154 3155 3156 3157 3160	1535 1536 1537 1543 1541 1542	1363 3333 1120 7540 9451 7634	OR CR.L	STA I J AIJA I - 237 APO JNP QACV	Tił	/SAVE IT /Detween 203 and 237?	8
	3353 3354 3355 3356 3357 3363 3361 3362 3363 3364 3365	1455 1456 1457 1463 1461 1462 1463 1463 1464 1465 1466 1467	4.030 4536 3651 2101 0177 4523 2151 4122 2651 2414 5477	3	4536 /60:0 3651 2131 3177 4523 2151 4122 2651 2414 9477	/62:2 /63:3 /64:4	3151 3152 3153 3154 3155 3156 3157 3160 3161	1535 1536 1537 1543 1541 1542 1543	1363 3333 1129 7543 3451 7634 3361	OR CR.L	STA I J ALA I -237 APO JMP QACM F.TAB SLT I 1	TH	/SAVE IT /DETWEEN 203 AND 237? /CONTROL CHAR. CHECK F	8
	3353 3354 3355 3356 3357 3363 3361 3361 3362 3363 3363 3363	1455 1456 1457 1463 1461 1462 1463 1463 1464 1465 1466 1467	4030 4536 3651 2101 9177 4523 2151 4122 2651 2414	3	4536 /60:0 3651 2131 3177 4523 2151 4122 2651 2414	/62:2	3151 3152 3153 3154 3155 3156 3157 3160	1535 1536 1537 1543 1541 1542 1543	1363 3333 1120 7540 9451 7634	OR CR.L	STA I J Ala I - 237 Apo Jyp Qacv F. Tab	TH	/SAVE IT /DETWEEN 203 AND 237? /CONTROL CHAR. CHECK F	8

- 10-	Sector Sector Sector	most subject		and the second second	an a	THE REAL	Constraint of the second second second	in the second			et in the state of the state of the state of the	and all store it is a second		1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1			
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	3163		1545	9068		SEI	r 1 2			3261	1634	7637		JMP QAL	XTT+2	/EXIT: LONT	ECHO
	3164		1546	7779		- 7				3262			/	Uni GHL			2000
	3165		1547	1933		LDA											
										3263	1635	1920	QALXIT.	LDA I	GET 6-	BIT ASCII	
	3166		1550			QAT	Υ.			3264	1636	0030		U			
	3167		1551	1461		SAF	I 1			3265	1637	0061		SET I 1		/RESTORE AR	c.
	3173		1552	7554		JMP	•+2									·	0
	3171			7635			-	-	~	3266	1640	0000		ø			
	3171	x	1999	1035		0.36	QALXIT	VILLEGAL CHAR. DONT E	C	3267	1641	0062		SET I 2			
					НЭ					3270	1642	0330		ø			
	3172	1.254	1554	0855		XSK	I 2 /CHECKI	D THEM ALL?		3271	1643	6000		JAP		ZEXIR SNR G	STYDE:
	3173			7551			4					0.0.00	10.0.00			PLAN LAN U	C IND
		1			1	w				3272				PRINT C	CACI		
	3174	Č								3273	1644	0500	QATPE.	IOR			
ie te	3175	2.49	1556	1150		ADA	i I			3274	1645	6946		QATLS	/PDP-8	IOT TLS	
	3176		1557	7440		- 33	7	an an tha an		3875	1646	1900		LDA			
far í	3177		· · · · · ·	8451		APU		/BETWEEN 240 AND 3377									
										3876	1647	3330		Ø			
مىنى مىنى	3293			7.57.5	100 A.M.	JUL	OALLGL	ITES. LEGAL CHAR		3277	1650	5654		STC •+4	/SAVE R	ETURN	
	3591		() - sel 73	8 - 19 - 19 - 19 - 19 - 19 - 19 - 19 - 1	1 1 1				•	3329	1651	0503		IUB			
	32.38	$b = (a_1, \cdots, a_n)$	1562	1461	1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -	SAL.	. I 1. 1988	140. CHECK FURTHER.		3391	1652	6841		DATSF	/WAIT F	AN FLAG	
· · · ·	3293	S. Asart		7572	1		++7		· · ·							UN FERG	
							A CONTRACT OF A	A MARINA MARINA		3398	1653	7651		JMB5			
	3224	1 N. 1 N.		1989		LLA		/RUBJUT		3303	1654	6930		JWb	/ Exi t		
	3205	ang ng n	1565	0334		334				3384			1				
	32.16	(1566	7644		JMP	QATPE	FCHO BACKSLASH	1.11	3375	1655	0243	QACHAR,	243	/HASH		
	32:37	a Bria	1567	1020	•	LDA	- •			3396	1656		4.10.11111			STON	
							· •					0244		244	/DJLLAR		
÷.,	3210		1570	3237		37				3307	1657	ð245		245	IPER CE	4T	
416	3211	1 - A - A	1571	7637		JMP	QAEXI T+2	/LEGAL EXIT		3310	1663	0247		247	ZAPUSTE	JEHE	
	3212		and free		1				,	3311	1661	03.30		300	AT SIG		
	3213		1578	1461		SAL	. 1 1										
			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1							3312	1662	0336		336	109 And		
÷.,	3914	1	1573	1033		0.12	OALXIT	/ILL EGAL		3313	1663	0337		337	/BACK A	HRO&	
	3215	de de la composición de la composicinde la composición de la composición de la composición de la compo	1.1.1					ALT	,	3314	1664	0340		40	/RUBJUT		
	3916	2	1574	7637		JM₽	QAŁKI T+2	/EXIT, LONT ECHO		3315	1665	0036		36	/ALT		
	3217				1				,		.005	0000	1515 05				
	3229	· ·	1575	1/000				4. · ·	5	3316	•		VEND OF	SIN GEL	עמא		
		1997 - A. A.		1000	gal egl,												
	3221		1576	1536		QAT	1 Contraction of the second seco			NO ERR	ORS						
	3555		1577	7644		JAP	QATPL	ZECHU CHAR									
	3223		1693	3536			QAIY			ADDD	0.36.3						
	3224		16.11							ADDR	0363						
				1569		RCL		STRIP IT TO 6-BIT		AD1 F2	4277						
	3225			7730		773	3			AHC	3121						
	38.56		1693	7637		JMP	OALXI T+2			ANSWER							
	3227				ZTO HER		CUNTROL CHA	B · · · ·					1				
	3230		16.10	1463				••		AVE	3049						
			16.14		QACNTR,					CAHC	31 33						
	3231		1635	7755		7755	5			CALHC	4657			•			
	3838 +		16:36	7621		JAP	QACKLE			CALIMI							
	3233		1607	1 323		LDA		/CR									
• •	3234		1619	3343			-	· •••		CUPINS							
						43				CULIN3							
	3235		1611	5636			QAEXI T+1			CALI 44	43 73						
	3236		1612	1323		LDA	I			CALVC						· · · · · · · · · · · · · · · · · · ·	
	3237			0215		215											
	3240			7644			OATIOL			CAVC	3977						
							QATPL			CRUF	4092						
	3241			1020		LĽA	I			CDIPLK	5114						
	3242		1616	3212		212				СНС	2753						
	3243		1617				OATPL										
									•	CHCI	2751						
	3044		1723	1635		0.26	qaeki t			COAP	9366						
	3245				/					C-)1	2616						
	3246		1621	1460	QACKLF.	SAL	I			CUS	2642						
	3247		1682			7752											
	3254		1623			JAP				C054	2665						
										C03	2702						
	3251			1950		lla	I	/LF		C04	2721						
	3252		1625	0045		45				CJ5	2731						
	3253			7611			QACNTR+5										
	3254									CIPLK	2259	•					
				1469		SAL				CTP	839S						
	3255			7751		7751				CVC	2746						
	3256		1631	7635		JMP	CALKIT	/ILLEGAL		CVC1	2747		1		,		
	3257			1323		LDA											
	3260		1633			47				DIF	0374						
	Sec. S		1033	0041		47	•			DIV	6073						
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	DIVI	4423		M1	0411				3433
	DIVI	4431		WS.	Ø437			SMAUC	
				MB	3146			SMIX	2200
	DI V3	4435		NF 1	2526			SVFLD	2512
	LIV4	4447		NHC	2752				. 0064
	DIPLK	2397		NUM	6176			SRED	3930
	END	0428		OCTAC	6175		•	SSRD	3141
	FCTR	2003		PM	6133			SSTUR	5000
	FD	0911		PM1	6137			STAPE	5024
	FLAG	2531		PTR	0910			STOR	0101
	F.S.	2537		GAP	7034	•		STVF	2430
9. ¹ . 1. 1.	GC .	0076						SVCC	4203
	GETAPD	7501		OACA	7015	•	· · ·	TAPE	9138
	HADDR	4372		QACHAR				T41	5040
	HADDER	4371		OACKLE				143	5072
	HC	8368		QACNTR				TA4	5103
	HCC	0072	• • • • • • • • • • • • • • • • • • •	04D	7 8 26			THE	2511
	HCC1	4334		QAE	7050			TVC	2510
	HCCS	4345	ether and the second second second second	QAEXIT				TVF	0067
8 - S S S S S S S S	HCC3	4360		QAF	7516			TVF1	2436
	HCTP	2175		QAG	7962			TVF2	2473
	401	2753		0AH	7114			VC	0361
	HC17	2762		041	7131			VCC	0071
	HCTI	2763		GAINIT	7033			vcci	4226
	HCIS	2764		NAJ	7136	•	•	VCCS	4237
	4013	2765		DAK	7385			VCC3	4261
	HC14	2766		QAKEB -	6936		1	VCC4	4271
	HC15	2767		GAL	7175			XIT	6174
	HC16	2779		OAL EGL				,	V114
	HC17	2771		QAM .	7101	•			
	HCS	2754		QAV .	1883				
	4020	2772		041	7231				
	903	2755		042	1848				
	HC4	3756		000	7263	•			
	HC5	27.57		OARESH	7953				
	406	2769		DAT	7273				
	HC7	2761		041LS	6 146				
	K 41	0951	· · · · · ·	GAIPE	7640				
	K4109	0060		OATSF	6341				
	K 184	3953		OATY	7536				
	1435	0355		040	7536				
	K135	2743		DAV	7316				
	K1	2353		DAW	7512				
	K102	0057		94K	7424				
	424	8952		241	7412				
	833	0054		042	7301		•		
	K40	3056		ED	2734				
	LEATA	337 2		1:DI V	3365	•			
	LLATI	2267		EED	0 165				
	XARC	0104		1:HC	2745				
		3432		1148	4452				
	MARCI			PIAB1	3122				
	MAHC2	3422 9430		EVC	2744			1	
	MAL			1:1	3:344				
	MAUCH	0103		1.2	3955				
	MAUC1	4452		1.3	3116				
	XFSS1	6633		SCARC	4633				
	XLSS2	6625		SCAVC	4607				
	41.553	6652		SCUMP	2633				
	AFSS4	6730	<u>.</u>	SDIV	4493				
	44C	3123	•	SGC	2313		•		
	MTX	3375		SHCC	4304				
	MIXI	2221	. ·	SLUATA					
	3175	8533		SHAHC	3400				
	\$173	2244			2.00				
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											(TA)
							3376	02:36	1040		STA
	1111				*23		0.377	0297 0217	9451		
	3311				/LISPLA1	CALIPRATED DATA WITH CURSUR -	3199	0210	4410		SIC LUAII Set I lpir
	3339				/DISC-C4	NL .	0101	0211	3264		-
	3313				1		31 32	0212	3777		3177
	3336			1.1	$\mathcal{F}_{\mathcal{F}} = \{ f \in \mathcal{F} \}$		0103	0213	9935		PDP
	7775		17.59		/16-6-7	5 - ¹	3134				PMJLF
	3.136				1	and the second	3195	3214	4530		JAS I LIATA
	3337		が長め	1.50	🖈 share h	particular de la construcción de la	0196	3215	4571		JAS I DSJAT
	3313		3 ¹		1		0107	Ø216	4530	· · · ·	JAS I LIATA
	3111		, in the	S. Brick S.	14.3.341	(BE11-	311.5	0217	4531		JMS I ISORI
	3112	- - -	法资料公开		1		3111	0559	4533		JIS I LLAIA
	3313		13.5× 21		/LISPLA	S LAIA FRUM TAPE CUNTAINING	3112	0221	4591		JAS I ISJAT
	7170		$(\bar{u}_{1},\bar{v}_{1})^{(1)}(\bar{u}_{1},\bar{v}_{1})$	1.424	/CALLDR/	THE LATA IN UNIT 2.A LISPLAN	0113	0288	4500		JAS I LLAIA
	3715		1404	Set a Sec.	/JE 644	FRA CHAINEL VUMPERATE FIELD	0114	0223	4531		JMS I LSJE1
- C.	7716		$\leq z_{1} \gtrsim -1$	s si k	ZNUAREIG	OFFITCAL CUDENTALE HURIZUNTAL	0115	0224	4582	DSP,	JAS I LISP
÷.,	3717		$(1 - 1)^{-1}$	1.46	ACALLY.	SATE AVE AV INDICALIUN AS IJ	0116	0225	25554		JMP 1
	3723		28 A.S		/6db14b1	R THE FUNCE PLATE (FP) LAS SAMPLED	0117				
	3 121		$= \sum_{i=1}^{N} \sum_{j=1}^{N} \sum_{i=1}^{N} \sum_$	8, 4°		J-PRUGEDED.	3123				
	3322	. Š.		1 general	1		0181		4 ··· .		
	3 723		1. 18	1. 18 (March 1997)	1		0122				IINE TO LOAD 3 PLOCKS OF DATA
	3758		7232		/LATA T	J BE LISPLATEL IS PLACEL IN A	0123			/	
	1325			1997 B	/1324 8	JINT FURPERS AND A MOVING WINLOW	9124				LAJLE
	1106				/1) DIS	PLAY THE DATA IS CONTRUCTED BY	9125				*433
	3 127			11.12	IPJT di	A CURSUR IS CUNTRULLED BY PUT 4	3126	·			PAJUE
	0 33 3				1TU PRJ	VILE A REALJUT JE LATA AS DESCRIBED	3127	0400	0302	SLLAIA,	
	Ø 331				/ATJVI+		9139	9491	6141		LINC
	3132				/	★	9131				LAULE
	1333				1 2 1 1 2	パート みんみ しない ほんてんない しげや モリシュー	0132	3472	3367		SHI I FOTR
	3336				18-X311	I/J PRESET-START 20 TU START	0133		7174		- 3
	3135				/		A134	3434	1 30 3		LLA
					1	• · ·	0135	. 3485	0436		LIPLK
	3336			- 4	ZLOCATE	UN 3436 CUNTAINS INITIAL TAPE BLUCK	9136	0436	1129		414 I
	3337				/ JUKR+R	. 12 BLUCKS ALE LUADED.	0137	0437	5033		5033
	0343				/		3140	3410	4416		SIC LDATE
	3361		1 - F		181-514	RTING THE PROGRAM LOADS THE VEAT 12	0141	3411	1020		LLA I
	11742				/PLJCKS		0142	9412	9331		1
	4343			•	/		7143	0413	03.51	i	CXA
	3344				,		3144	0414		LEAT1,	L1+ 13
	9745				,		3145	0415	37.33		RIC
	7376				,		3146	Ø416	ゆううう	LDAT2,	0.1.10
	3347				-	PAJLE	8147	3/17	1 3 2 3		LLA I
	0050					*20	0153	3423	1331		1031
	0351 7 N 0		a 10 1	6141			9151	J421	1143		AL4
	3352		0323	0141		LAJIF	9152	9455	3416		LIATZ
	3153			6233		JAP MAIN	9153	0423	3227		XSK I FCIR
	3354		3981	01.00	1		3154	3484	6415		JMP LUATI+1
	9355					PAJIE	0155	3425	1030		LIA
	3356					*133	Ø156	9426	3416		LIATE
	2257		41.93	0430	LLAIA.	SLLAIA	0157	3427	1123		ALA I
	9363		3193	30.70	I SURT.		7167	3433	7776		-1
	3361					S1.1 SP	3161	3431	4436		SIC LIPLK
	3362		9192		LISP	LSP	0162	0432	3366		SFI I TPTR
	3163		6193	7224	ISPL,	Dat.	9163	0433	2377		2377 .
	3384				,		0164	3434	0338		P1-P
	9365				,	L4J11	Ø165				PNOTE:
	3366						3166	0435	5600		JAP I SLUAIA
	3367					+530	3167			1	
	3373		3593	1020	MAI V.		0170				LMODE
	3 37 1		9201			LLF 10 51A	3171			1	
	3372		32.32	1040		514	0172	2436	3839	L'IFLK,	213
	3773		3233			LS1	3173			1	
	0374		3234			514	0174			1	
	3375		1235	3415		152					
	-										

0175		SUPRJUTIVE TO SURA D		0274	0636	9645		LIF 5
8176		/1V FIELD NUMBERS-VER	TICAL AND HURIZUNIAL	0275	3637	1335		LIA CURS
@177		/CJJRHINA1ES		9276	0640	0061		SFI I 1
9233		/		0277	3641	1106		LCT
0231	w	PACEF		0334	3642	7021		JAP BUI
9212	8437 8838	SLSURT, ØJØJ	· .	0371	3643	0363		SET I 3
. 0 233	8449 6141	EINC 🐁		0392	0644	1302		DCRUF+25
. 3234		LAJDE		0393	2€45	7116		JAP GLCS
Ø235	8441 9650	US1. L1. 10		0334	3646	3644		LDF 4
3: 3236	3442 1326	LLA I TPTR		0395	- 0647	1035		LLA CULS
ap:37	3443 3644	1	. ,	9396	8653	1560		PCL I
Pro \$213	8444 1864	SIA I LPTR		3397	9651	7400	S	7433 SFT I 1
8P11	8445 2652	LS2, LI+ 10	• · · · · · · · · · · · · · · · · · · ·	0313	0652	0361 1106		DCT
0212	9446 1926	LUA I TPTR	•	0311	0653 2654	7321	4	JAP PL1
0213	3447 3645	LIF 5		0312		0963		SET I 3
9214	0450 1344	STA LPTR		8313	0655	1260	1999 - 1990 - 19	LCRUF+3
ae15	0451 0653	DS3- L1+ 10		7314	9656 8657	7116	1 . S	JMP GECS
9216	3458 1826	Color Cas LLA I TPTR		2315 2316	0657 0660	0363		SFI I 3
0217	0453 0646	LLr 6		0317	3661	1263		1.0301+3
0223	9454 1944	STA DPIR	•	0320	0662	1005		LLA CURS
·	0455 0206			0321	3663	0313		EJR 13
0.55	9456 6441	JAP US1		0322	9664	1560		PCL I
* 9P23	0457 0032	PLP		Ø323	0665	7770		7770
9074	A478 5794	PHU1/E		0324	3666	1123		ALA I
3225	8463 5637	JMP I SUSORT		9325	0667	1178		CIAP+20
8224 8227	in the second			0326	0670	4672		510 +2
3233				1327	0671	1993		L14
0231		SUPROUTINE TO DISPLA	V STO PUTITS AS A	0330	0672	1333		1100
3232			024 PUINTS, WITH CURSOR	0331	0673	1363		SIA I 3
9233		y		0332	0674	1930		L1:A
223A		*603		1333	6675	3672		•-3
1235	9600 0333	SLISP, Ø		0334	3676	1120		ALA I
8236	631 6141	LINC		0335	0677	3343		40
3237		LMJDE		0336	4733	4702		510 +2
3243	0632 9133	NEISP. SA4 3	/SET UP START	9337	07:01	1000		LIA
0241	3623 1123	ALA I	/LUCATION OF MOVING	3340	0732	4933		1 3333
3242	0604 1039	1334	/WINDOL	0341	ð7 93	1763		STA I 3
3243	0635 0341	SCH 1		0342	37 34	1305		LIA CURS
3244	3636 3450	AZE		2343	37 35	9261		, rol 1 - 1
1245	06.37 6612	J9P +3		3344	97 36	3478		LZE I
3946	3613 1623	PSF I		7345	67.37	6725		JWS III
3947	7611 1777	1777		Ø 346	3713	90£3		SF1 I 3
3253	3612 1623	PSE I		3347	3711	1343		LCPUF+63
3251	3613 2333	2330		3 353	3712	3365		SEI I 2
3252	6614 1943	STA		0351	0713	1844		C1AB1-1
ØP53	Ø615 3334	LPIR		0350	0714	0 16 1		SET I 1
3254	3616 0134	SAM 4	/CURSJR	0353	0715	7772		-5
3255	3617 1123	ALA I		9354	0716	1988		L14 I 2
3256	3623 1333	1333		0355	9717	1363		· 51A I 3
3257	0621 . 3341	SCR 1		3356	0780	9221		KSK I 1
326.3	3622 2934	ALL LPTR		0357	0721	6716		1.4.2 -3
3261	3623 1629	PSE I		036.7	3722	2 176		SFI I 16
0262	0624 2033	2939		9361	3723	7726		-71
3263	M-25 4335	SIC CURS		9362	0724	6727	•.• •	J46 •+3
3264	3626 0646	LLF 6		9363	0725	0:176	DI 1.	SF1 I 16
1265	JE27 1335	LIA CURS		3364	M726	7714		- 63
3266	9633 - 3861	SF1 I 1		2365	0727	3224		SFA
3267	0631 1136	101		0365	3739	1563		PCL I
127.3	9632 7921	JAP BII		3367	0731	3233	1	234
3071	DE33 0063	SFT I 3		3373	3732	0394 0477		FSF Chart 17
3272	3634 1324	LCRUF+47		9371	Ø733	6377		SF1 I 17
8273	0635 7116	JMP GLCS		0372	0734	1254		LCBUF-1
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	10.101.001		in the second													
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	3375		3723	9377		377					9475			/D.J. VI		
	3376		0741	1777		LSC I 17				-	3476			/UNIV-	WISCONSIN	
	3433		3742	3236		KSK 1 16					3477			/		
	3431		07 43	6741		J4P 2					0509			/SIGNED	12-PIT BINARY TO LECIMAL CONVERSION	
	34.72		3744	6751		JAP LOUR					0501			/		
	3473		\$745	6777	• •	JAP LLAI					9532				VIA: JMP RUI	
2.12	3476		0746	6751		JAP DOUR				· ·	3593		et al composition de la compos		BIJARY NUMPER IN ACCUMULATUR	
	36 35		37 47	3338		PUP					7534				IR 1 PRESET	
	14.76		1.1.20		and a second second	_P4J1.F					9505				L 6-RIT ASCII COLL STURED VIA IRI	
	3097		1723	5674	13,2 3,70 ····	JAP I SLISP		·			0576	5 5 <u>5</u> 5	. · .		ING ZEHUFS SUPPRESSED	
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	9411		an an An Stairte		1						0510			/USES I		
	8412			1. 1. A. 2. A. 1.	1010	LAJDE					0512	•		/		
	3413		3751	1333	LCUR.	2					9513	1021	0361	PD1.	SCR I 1 /SIGN 10 LINK BIT	
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10	2415 2416		3754	3646		LLF 6					0515	1 1 2 3	3471		APJ I ZAAKE NEGATIVE	
121	3417	al de la composition de la composition Composition de la composition de la comp	3755	1:525		LLA CURS			•		9516 -	1024	3317		CJ.4	
	1077		3756	3343	11 a a	SCH 3					2517	1025	5065		SIC NURUI /SAVE II	
	1021		37.57	1121		ADA I	· · ·				0520	1026	5993		ALD Ø /SAVE RETURN	
	3672		9763	2433	M = 1/2	430				•	0521	1 327	51.01		SIC P9BD1	
	1423		3761	4371		SIC 1		•			0522	1030	1 323		LIA I /LOAD PUSSIPLE SIGNS	
2 (F) 2 (K)	3424		3762	3377		SEI I 17					9523	1031	5540	K98D1+	5540 /*** *	
	9425		3763	7773		-4					3524	1932	3452		LZF /GFT CJRHECT SIGN	
	30.25		0764	1645	•	LDr 5					7525	1333	9346		RJR 6 Sth I 1 /ANL Stjre It	
	3427		9765	1915		LIA CURS					0526	1934	1361 3362		SET I 2 /SET ADLENE PULVIER	
	3423		7766	3342		SCR 2					.0527 0539	1936	1131		Q9PL1-1	
	3431		3767	1123		ALA I					7531	1037	7354		JAP MORLI ZCUNUERT A LIGIT	
	11432	•	3770	9334		4 DIS 1					8532	1840	8453		AZE ZIS IT A LEALING ZELDE	
	7433		3771	3141 1123		ALA I				•	0533	1341	7050		JAP LOBLI INJ	
	3434			0.331		1					3534	1042	3 3 3 1		ALL ROBDI //ES: MOVE SIGN HIGHT 1 PLACE	
	8435 8436		3773 3774	3237	•	KSK 1 17				,	0535	1943	1341		SIN I VSTURE A SPACE JVER THE SIGN	
	3437		1775	6771		J.4.24					0536	1344	0452		LZE /GFT HE COMMECT SIGN	
	366.3		3776	6303	DCU1.	JAP 3					7537	1945	0336		KOH 6	
	3641				/					•	9543	1046	1361		STH I I ZAVE SIGKE IT	
	3442				1				·		0541	1347	7 137		JMP 10 / IHEN CONTINUE CONVERTING	
	3603				/						3542	1952	3:177	L9PD1-	ALL PORDI-2 MAKE ASCII	
	34.44		3777	1033	LUAT,	LDA					1543	1/051	1361		STH I I /STORE A LICIT	
	9045		1.333	3830		3		•			0504	1052	7054 7950		JAP M9BL1 /CONVENT NEXT DIGIT JAP LSRL1 /AND STORE IT	
	3216		1201	5123		SIC LEA2					0545 0546	1053	1020	/1.1111.5	SUPPOULATE STORE IT	
	3417		1008	3317		SET I 17		Ŧ			0547	1054	1938	M9BL1	LDA /SAVE EFILEN	
	3453		1 1 33	2777	11.4.1	2777					0553	1355	33-33		0	
	3451		1 1 74	3646	1-LA1-	LDF 6 LIA I LPTR			•		2551	1056	5375		STC P9PL1-4	
	1452			1324		SCR 3					2552	1057	3763		SET I 3 /SET DIGIT COUVEER	
	0453		13.16	0343		ALA I					9553		1777		1777	
	3451. 3455		1313	0433		433					3554	1361	0222		XSK I 2 /4JVE ADLENI PJINIEH	
	3456		1011	4931		S1C 1					3555	1362	3065		ADI NOPDI ZUJAL THE VALUE	
	3457		1012	3645		L1.F 5					3556	1 363	0223		XSK I 3 ZPUMP CJUNIEL	
	3463		1.313	13.34		LIA LPTR					3557		1363		STA I ZSAVE REMAINING PART	
	3441		1.414	1342		SCI. 2					9563		3338	19 FD1+	3	
	3462		1315	3141		LIS 1					7561				ADA 2 /IMAL ALD	N.
	3463		1916	9237		KSK I 17					0562	1367	3451		APO /STILL VEGATIVE?	2
	3464			7334		JAP DIA1					0563		7363		JAP 5 //ES:CJUNT AND ADD AGAIN	
	3465		1 323	6333	PLA2,	JAP U					056A 3565		1333		LLA / VJ: GET THE CJUNTER. 3	
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	0570	1075	6223		JAP 8	NO: BACK TO THE SUBROUTINE		0667	1162	3393		ø	
	3571	1076				YES:MAKE ASCII		0470	1163	0333		Ø	
								0671	1164	3031		õ	
	3572	1377			3363	14 m 1 m						0404	/-
	Ø573	1198			STH I 1			0672	1165	3434			/-
	0574	1131	6033	P9BU1.	JAP N /	AND RETURN TO CALLING PGM		0673	1166	0030		0	
	3575	with the second s		/ADLE VL	TAPLE			9674	1167	ゆうりき		3	
	3576	1102	1753	Q9FL1.	1750			3675	1170	4136		4136	13
8	3577	1133			144		•	0676	1171	2101		2131	11
				194	12			0677	1172	4523		4523	12
4. j. j.	3633	1134		A. A	16							4122	/3
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ef. j	8411	1112	2733	14 년 (국)	0	and the second		0710	1203	0000		8	
	3612	1113	9933	- ಕಟ್ಟರ್	0			8711	1204	03:10		-	
	3613	1114	0003	1. S.	3	and the second		0712	1235	9339		2	
	3614	1115	9333		1 🔞 - 1 - 1 - 1 - 1 - 1	and the second second second second second		9713	1236	0339		0	
	0615		5 M M M		LMODE	•		9714	1237	0333		9	
	2616		1. N. 1997	1				9715	1213	0000		0	
٠	9617			1.				0716	1211	0005		2	
1 g 1.		261 C 1112	1.1.2.2	GLCS.	LDA			3717	1212	0003		0	
	9693	- 1116 		01031	0				1213	0303		2	
- 10 A.	31.21	1117						0723				<i>v</i> .	
		`e∛e : 11₽9			SIC GL2			0721	1214	0013		0	
	*623	1121	3361	1.5	SET I I	• • •		0722	1215	0093		0	
	36.24	1122	1136		DCT	• •		0723	1216	3903		0	
	3625	1123	9362		SET I 2			0724	1217	0393		2	
	3626	1124		•	-5			0725	1223	0030		Ø	
	3627	1125			CLR			0726	1221	3033		3	
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	3633	1131	5133		S1C +2	· · ·		0732	1225	9494		3434	/-
	3634	1132	1393		LLA	•		0733	1226	3300		0,	
	3635	1133			3338		•	0734	1227	9338		0	
	0636	1134			STA I 3			0735	1230	3641		3641	10
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					•-3		-	0137	1232	2151		2151	12
	3643	1136										2651	/3
	96.01	1137			ALA I			3749	• 1233	2651		0477	/4
	3648	1143			40			3741	1234	3477			
	3443	1141	5143		51C .+2	-		0742	1235	3651		0651	/5
	36 04	1142	1333		LLA	-		0743	1236	4225		4225	16
	9645	1143	0339		0290			0744	1237	6950		6050	/7
	0646		1363		STA I 3			0745	1240	2651		2651	/8
	36 47	1145			ASK 1 2			0746	1241	3651		3651	19
	-		7126		JAP GD1			97 47	1242	3333		0	
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	9652							8751 j	1244	39999		0	
	8653			/				37 52					
	3454			1				0753			/		
	9655	1153	8398	CTAB.	Ø			0754	1245	4477	CTAB1.	4477	
	3656	1151			2			07.55	1246	4. 144		4344	/F .
	0657	1152			0			0756	1247	3330		3333	
					ð			07 57	1259	4477		4477	
	3(6)	. 1153						0760	1251	3044		3344	12
	0EE 1	1154			3								- •
	3662	1155			0			0761	1252	0000		3 7	
	3663	1156	9333		Ø			9762 -	1253	3333		3	
	0664	1157	0333		8			0763	1254	3333		Ø	
	3665	1163			0			9764	1255	4477	DCBUF.	4477	
	0666	1161			3			0765	1256	4344		4044	/1
								-	-				

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	0766	1257	0330		0					1065			1	
	076 7	1269	0930		ø					1066			1	
	3773	1261	3333		0			•		1067				*4
	9771	1262	0390		9					1073	000	4 0000	DPTR	3
	3772	1263	3333		0					1371	202		CURS	õ
	9773	1864	3333		ø					1972	. 000		TPTR.	õ
	0774	1265	3993		ø					1073	000		FCTR.	ø
an an An taon	3775	1266	0333		à					1974	0.00			*43
$1 \le l_{i \le j \le j}$	8776	1267	0000	all and a second	ā .									+ - 0
- 1. s	2777	1273	้หมอง		Ø.					NU ERF	2005			
69 2 I.	1399	1271	0.1.20		a i						.01.0			
19. S.	1371	1278	0000	机自己箱 化磷酸化	a maria	gar Salar	151			PLI	1921			
Ós teo	1932	1873	0335	$\mathcal{B}(\tilde{\mathcal{M}},\tilde{\mathcal{K}},\tilde{\mathcal{K}}) = \int d\mathcal{K}_{0}$	a con c	ar i s	Berthold State			CTAB	1159			
	1333	1274	0.130	$\xi_{j}^{2}=\xi_{j}^{2}\xi_{j}^{2}\xi_{j}^{2}+\xi_{j}^{2}\xi_{j}^{2}+\xi_{j}^{2}\xi_{j}^{2}+\xi_{j}^{2}\xi_{j}^{2}+\xi_{j}^{2}\xi_{j}^{2}+\xi_{j}^{2}\xi_{j}^{2}+\xi$	a Vican	terita da.	and the second second	n an the second seco		CTAPI	1245			
新進の	1934	1275	4.5.3/4	are breen	anses - E	اليهاجر المجاري	E de la com			CURS	1005			
198	1335	1276	0000			an a				LCPUF	1255			
	1036	1277	2176		0176					DCT	1106			
2.2.5		1301	7432		7402		/v							
Tree 2	1337		3803	the second se	1402					DCUR	0751			
12.3	1919	1331	1. 1.1 (1998) 11	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	US SAN	an a				DCU1	3776			
1999 -	1311	1332	0000	and the second second second	0	81.5	e production de la construcción de		•	LDAT	3777			
15 61	1912	1333	3333	le Sér Li	0		an an An Shekara	n at a sea		DLAI	1004			
	1913		1	P. C. S. Post						DIA2	1920			
	1314	1395		· · · · · · · ·	0		•		1.1	DISP	3132			
15 A.	1015	1376	3303		0					DII	0725			
a	1516	1337	2333	A Property of the	9 5	an sha	en en en en en			LPIR	3334			
ang t	1317	1319	0393	1.22.4	2		-			DSORT	0191			
- 5 - 1	1329	1311	990)		0					DSP	0224			
	1321	1312	0030		0					LSPL	0103			
	1988	1313	3030		0					ES1	3441			
t jekt	1923	1314	3233		22		· *			1.52	3445			
- 6	1024	1315	2332		8					D\$3	0451			
ч Ж. д	1325	1316	3333		9			, .		LIPLK	9436			
s. •	1326	1317	3393		0					FCIR	9937			
ġ. t	1027	1323	8330		8					GDCS	1116			•
	1038	1321	1377		1077		A . A			GD1	1126			
	1931	1322	7710		7710		/H			61/S	1147			a.'
	1332	1323	0331		Ø					K9PD1	1031			•
	1933	1324	0933		0					LIATA	9193			i,
	1334	1325	0999		0					LUNTI	3414	-		· .
	1035	1326	3333		0					LUATS	3416			
	1336	1327	9909		3					69BL1	1053			
	1937	1333	0330		0					MAIN	0233			
	1343	1331	8333		9					M9 P D I	1/354			
	1341	1332	0330		8					VDI SP	9695	•		
	1342	1333	0303		¢.					N9PL1	1965			
	1343	1334	9399		Ø		4			P9PD1	1191			
	1344	1335	0339		2					09711	1192			
	1845	1336	0739		9					SEI SP	36-13			
	1346	1337	3339		0					SUSORT	Ø437			
	1047	1349	3338		9					SLLAIA				-
	1353	1341	3.133		ø					TPTR /				
		1342	3333		0							1		•
	1951	1046			0									
	1951	1343	3333		-									
			3339 9339		3									
	1351 1352 1353	1343			3									
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	1351 1352 1353 1354 1355	1343 1344 1345 1346	0030 0039 0043		0						•			
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	1951 1052 1054 1054 1055 1056 1057 1060 1061 1061	1343 1344 1345 1346 1347 1350 1351	0030 0039 0043 0030 0030 0303 0303 0303		0 2 0 0 3 0		·		·				•	
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5.00	Salas and a standard	And the second second	ALL CONTRACTOR	and the second secon							
							0076	0213	0002		PLP
							0977	00.0	0000		PADE
	0000			*59			0139	0214	4500	•	JMS I LDATA
	0031			/DISPLA	Y CALIBRATED DATA WITH FIELD CUHSORS	-	0191	0215	4501		JMS I DSORT
	6035			/ DI SF-C	AL		2102	0216	4500		JAS I LUATA
	09993			1			2103	0217	4501	•	JMS I DSJRT
	2334			1		•	0104	0229	4500		JMS I LDATA
1	8385		•	/16-6-7	5		Ø195		4501		JMS I DSJRT
	8236			1	-		0196	0222	4500		JAS I LUATA
	9337	*171		/M. J. JA	RRETT+		3197				JMS I DSORT
	0313	14.1		1	· · · · · · · · · · · · · · · · · · ·		0110		4592		JMS I DISP
	3911		<u>.</u>	1			0111	0225			JAP +-1
	3312		ça y	/DI SPLA	YS DATA FROM TAPE CONTAINING		2112	0405	.	1	
6 9	3713	21 2 3	1 . ÷	/CALIBR	ATED DATA ON UNIT 2.A DISPLAY OF TV		Ø113			1	
	3914		1. T. (1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	/FIELD	NUMBER IS PROVIDED. CORRESPONDING TO		0114				
	0315			/CURSUR	S WHICH MARK EVERY POINT OCCURING		0115			ZSUBROU	TINE TO LOAD 3 BLOCKS OF DATA
	0016		New York		TV FIED SELECTED.		Ø116			/	
	0017		Sec. Com				0117			•	LMODE
	3723				f an the second s		0120				*400
	0721			/DATA T	BE DISPLAYED IS PLACED IN A		0121				PMODE
	3382	Strates -	(1) 3 11	/1024 P	JINT BUFFERS AND A MOULIG WINDOW	*	0122	3433	0000	SL DATA,	
	0523	7		710 DIS	PLAY THE DATA IS CONTROLLED BY		0123	0401			LINC
	0:124	s.,		/PUT 0.	THE TV FIELD ON WHICH CURSORS ARE		0124 .		••••		LMODE
	0325			TO RE	DISPLAYED IS SELECTED BY PUT 4.		0125	0402	0067		SET I FOTR
	0328	•		A second of		•	0126		7774		-3
	3327	The second second		🕐 e e e 🖓 🖓		i	2127		1002		LDA
	8.130			/ PROGRA	M STARTED BY 1/J PRESET, START 20		0130	3495	0436		DTELK
	. 8031			VIN 8 M			0131		1123		ADA I
- ⁻	3332			1			0132	3437	5000		5000
	- 4433			1			ø133		4416		STC LDAT2
	7:134			LUCATI	UN 436 CUNTAINS START BLOCK FOR		0134		1929		LDA I
· · · ·	0035	the second	1.00		0 PL DISPLAYED.		0135		0001		1
	8.036			/HE-STA	KTING PROGRAM LOADS NEXT 12 BLOCKS		0136	0413	0.931		L UXA
1. N. 1.	0037			/OF DAT			0137	6414		LDATI,	
	9743		· ·	1			0140	3415	0700		EDC
	0741			1		•	0141	0416		L DATE,	0329
	0920	•		1			0142	9417			LDA I
• • •	3343			1 .			0143		1001		1001
	3144				P40DE		0144		1140		ADA
	3345				*20		0145	-	0416		LDAT2
	3346	0020	6141		LINC		0146	0423	0327		KSK I FCTR
	8347				LNODE	•	0143 0147	0484	6415		JMP LLATI+1
	0050	9921	6293		JMP MAIN		0150		1003		61/4
	3351			1			0151	0426	0416		LEAT2
	3052				PADDE		0152		1120		ALA I
	0:53				*103		0153		7776		-1
	3154	3100	8433	LDATA,	SLEATA .		0154		4436		STC DTRLK
	0955	8181	0437	DSORT.	SDSORT		0155	0432	3366		SFT I TPTR
	0056	01.32		DI SP.	SDISP		2156	2433			2377
	6357			1			0157	0434			PDP
	3359			1		•	0160	0.0	0000		PHODE
	0361				LMODE		Ø161 '	0435	5628		JAP I SLEATA
	3362				*233			0405	0000	/	
	0763	0230	1 3 2 3	MAIN.	LDA I		Ø162 Ø163			-	LMODE
	3364	0231	0650		LDF 10		0164			1	
	0365		1.340		STA			Ø436	9293	DTELK,	233
	2066	6233	0441		DS1		Ø165 0166	9430	0200	/	
	3067	3234			STA		0166			1	
	037 0	02 35			DS2		0167			יורקקווא	TINE TO SORT DATA INTO FIFLES OF
·	3371	3206	1 349		STA		0170			770 815	LD NUMPERS, VERTICAL AND HUMIZUNIAL
	3172	92.37			US3		0171			/COORDI	
	3373	9210			STC LDATI		0172			/	
	3174	3211			SEI I DPTR		0173			-	PAOLE
	J 37 5		3777		3777		6174				
	-						-				

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المقيد ملاجزة والمتعينين	Press and a second s														
	0175		9437	0000	SDSORT,	0.21/3./3									
	0176		0440	6141	SUSURI	LINC			9274		0641	1777		DSC I 17	
	3177		0-1-40	0141					0275		0642	Ø236		XSK I 16	
			0 6 6 1	0150	561	LNODE			Ø276		0643	6641		JWb5	
	0200		0441	0650	DS1.	LDF 10			9277		0644	0356		SET 16	
	3231		0442	1026		LDA I TPTR			0300		0645	0004		DPTR	
	3595		0443	8644		LDS 4			0301		0646	0375		SET 1 15	
art i.	0203		3444	1064	2.17	STA I DPTS			0332		0647	2776		2776	
	02:14	en la sur para Sur sur para	0445	0650	DS2,	LDF 13			0333		0650	3644		LDF 4	
ter or	32.35	5546	0446	1 3 2 6		LDA I TPTR			0394		0651	0235	DI 1.	KSK I 15	
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	0296	수 있었다.	0447	0645	1 - A.M.	LDF 5			0305		9652	3456	<i>P</i>	SKP	
	3237	24	0453	1344		STA LPTR									
	0210		0451	0653	D\$3,	LDF 10	The Later of the		0306	19 A. 🛓	0653	6665		JW5 DIS	
۲	9211	1. 19 B. 16	0458	1326		LDA I TPTR	그는 그는 거에 가지 그는 것을 가지 않는다.		0307	- R È-	0654	1036	2	LLA I 16	
	0212		3453	0646	$P_{1,k,n}$	LDF 6	a farmer and a second second second		0310	5 - K.	2655	1569	3.1	PCL I	
	and the first start of			1044	1.1.1		alite terre for a second de		0311	· 121 · ·	0656	7400		7438	
	3213		8454						3312		0657	1443		SAL	
	3214	1. 140 1. 1	0455	3206		XSK TPTR	· · · · · · · · · · · · · · · · · · ·	1.11	0313		0667	0995		CURS	
	9215		0456	6441		WIT 201			9314		3661	6651	,	JMP DI1	
	3216	feli u se	8457	0002		PDP			9315		0662	6673		JWB DCOR	
	0217				*	PMODE	· · · · ·		Ø316		0663	0644		LDF 4	
	0569		8469	5637		JMP I SDSORT	· · · · · · · · · · · ·		0317		0664	6651		JAP DII	
	\$321				1		[10] A.F. A.M. S. M.		0320		0665	6716	DI 2,	JAP DDAT	
24	0355				1				0321		0666	0002		PDP	
	3223	34.2			1 1 1	신제로 영화되었는 그 왜 가 많다.			0322					PHULL	
S	3224	3.9			/SUBRJU	TINE TO DISPLAY	SIE POINTS AS A	·	0323		0667	5600		JMP I SDISP	
	0225				/MUVING	VINDOW OVER 102	4 PUINTS, WITH CURSO	R	0324		0001	5000	· • •		
	7826	\$ ~ ~ y			1	and a second		1					1		
	3227					LMUDE	· _		@325	·		• • • • • •	for a second	'	
	3233	412.4	No. 1			*600									
	5231	1.5			1	PAJDE	an an an Argan an Argan								
	0232		0600	0000	SDI SP.	0000									
	9233		3691	6141	5015FJ	LINC	•					•		•	
			06.01	0141											
	3234	en entre i la				LMOLE	· · · · · ·					•			
	3225		96.35	9311		CLH									
	0236		9693	2100		SAN U	SET UP START								
	5237	and a strategy	06.34	1153		ADA I	/LUCATION OF MOVING	5						•	
	9243		0695	1000		1600	ZKINDOW					•			
	3241		0636	1620		PSE I									
	3845		3637	2333		2009		•							
	2243		0610	4334		STC DPTR									
	3724		3611	3184		SA.4 4	/CURSOR							*	
	324.5		9612	1123		AUA I									
	3246	$p_{i} \in \{1, \dots, n\}$	Ø613	1033		1398				•					
	0247		9614	0342		SCR 2									
	3253		0615	1049		STA									
	3351		0616	3005		CURS					,	1			
	2252		0617	9.361		SET 1 1									
	0253			1.325											••
						DCT									
	3254 006 6		0621	6743		JAP RD1									
	0255		0688	0363		SHT I 3									
	3256			1177		DCRUF+3			·					~	
	3257		3624			JMP GDCS				1					
	0563			0034		SFA									
	0261			1569		PCL I									
	JS6S		Ø627	0233		239 .									
	0263 -		Ø630	6934		LSF									
	9264		0631	0377		SET I 17									
	3265			1173		DCBUF-1									
	0366		3633	0961		SFT I 1									
	3267		3634	0323		0							-		
	327 3		3635	9976		SET I 16									
	0271		Ø636	7757		-50									
	3272		0630 0637												
						LDA I									
	027 3 -		9640	0511		377									
	-														

	•										
						0976	0210	4414		SIC LDAIL	
						3377	3211	3.164		SFT I DPTR	
2333			*23	Y DATA WITH CURSJR - DISC		3133	3212	3777		3777	
3731				I DAIM WITH CONSON DIDE		0131	3213	9332		PLP	
0305			1			0102				PKUDF	
0313				· · · ·		3103	0214	4500		JAS I LLATA	
2034			/18-5-70	Brank in the second		3134	0215	4501		JAS I DSORT	
0005			1	and an		0105	9216	45:00		JAS I LLAIA	
9376							3217	45:31		JMS I DSJRI	
3337		Sec.	/M- J- JA			0196	2 - C - A	4520	ν.	JAS I LLAIA	
0.319		je k		· 我们们,就像我们们的问题。		3107	0223			JAS I LSURI	
9311	2. W & 2.		VEISPLA	YS LATA FRUM TAPE CONTAINING		0114	0221	4531			
3.712			/UNCAL H	BHATED DATA UN UNIT R.A DISPLAY		3111	0888	4508		JAS I LLAIA	
3.313	$\mathcal{M} = \{ d^{(k)}, d^{(k)}, d^{(k)} \}$	2 / - e	JUL CAN	LEA CHANNEL NUMBER, TU FIELD		9112	0223	4541		JAS I DSJHT	
0714		1. 28 M	/ NUMBER	VERTICAL COURDINATE, HORIZUNTAL		0113	9224	4502	DSP	JMS I DISP	
3515	에는 이양관품이 같		CUJRDI	NATE AND AN INDICATION AS TO		0114	0225	5224		145 ·-1	
9316			ZERETHE	A THE FURCH PLATE (FP) WAS SAMPLED		0115			/	·	
9517		that is a second	115 ALS	J PRUVI DED.		0116			1	•	
B 129		-12 m1				0117					
9921	- ビート ゆういうき ニート	\$12 - 51 -	1			B129			SUPHUI	UTIVE TO LOAD 3	ELOCKS OF DATA
1.198		SAAS.	/LATA T	U DE DISPLAYED IS PLACED IN A		0121			/		
9393	No. 1	968 (b) .	11324 P	OINT BUFFER, AND A MOVING WINDOW		0122				LYOPE	
9324			ZTJ 145	PLAY THE DATA IS CONTROLLED BY		0123				*433	
3.125	1	a series	10.17 3.	A CURSUR IS CUNTROLLED BY PUT 4		0124				PAU DE	
1326		ga inte	ITS PIN	VIEL A REALUUT JE DATA AS DESCHIBED	a Dina ang sa	#125	0400	3398	SLDATA		•
1.			ARJUE-		!	9126	0401	6141		LINC	
9433			1			3127				l no de	
			1 A C C C C C			0133	3492	3367		SFT I FCTE	
3.331			18-2754	1/0 PRESET. START 20 TO START		0131	9473	7774		-3	
3 132			/			0132	2014	1030		LIA	
3333						0133	0435	0436		LTPLK	
3 334			1. 36421	ON 2436 CONTAINS INITIAL TAPE PLOCK		0134	. 3436	1123		ALA I	
1335			/606411	P 12 BLOCKS ANE LOADED.		0135	24:07	5783		50.30 .	
3336				p is acous the conserve		0136	0410	4416	1	STC LLAT2	
3737			1	ARTING THE PROGRAM LUALS THE NEXT 12		0137	3411	1023		LIAI	
3343						0149	0412	0391		1	
1041	1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -		VPLOCKS	j•		0141	0413	0331		- AKJ	
3742			/			8142	0414		LDATI.		
3343		1. 1907 - 1917 1				0143	0415	07.93		RLC	
3344			/			0144	3416		LDAT2,	2303	
3)45			1			0145	3417	1320	00m10.7	LIAI	
1706				PAJDE .			0423	1301		1011	
3.31.7				*23		0146					
0359	0959	6141		LINC		3147	0421	1143		AL4	
0351				LAJIE		0150	6422	3416		LDATS	
3358		6203		JAP MAIN		0151	0423	0227		XSK I FCTR	
3153			1			0152	3424	6415		JMP LDATI+1	
3754				PAJDE		0153	0425	1000		L1A	
3,155				*100		0154	0426	3416		LIATS	
3356		3439	LLATA.	SLLATA		0155	0427	1120		ALA I	-
3157			LSDET.	SISJRI		0156	0439	7776		-1	
			LI SP.	SDISP		01 57 _.	0431	4436		STC LTPLK	
0369			LSPL,	LSP		0169	3432	0366		SFI I ТРТК	
0.000		4664	/			0161	9433	2377		2377	
8362						3163	9434	0332		5F5	,
-9.)E3				LAJLE		0163				PAJEE	
3364				*230		0164	0435	5630		JAP I SLDATA	
0365			4AT -3			Ø165			1 .		
4066			MUI 🖓			0166				LMODE	
3367		3653		LLF 13		3167			1		
3:57 :		1943		STA STA		3173	9436	0239	DTPLK.	234	
3.371				DS1		9171	0.00		/		
7,771		1343		STA		3172			1		
377				LS2		3173				UTINE TO SORT D	ATA INTO FIFLES OF
212				STA		0174			-		TICAL AND HUMIZONIAL
3.17	5 0237	7 0451		D\$3		-			7 IV F11	LUL NULOEADFVER	**************************************
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3175			/COORDI	NATES			9274	9640	0061		SFT I I	
0176			/				9275	3641	1122		LCT	
			•	PMJ DE.			0276	8642	7935			
9177			05.0300								JMP RL1	
3233	3437	0979	SDSORT.				9877	Ø6 43	3063		SET I 3	
3231	0043	6141		LINC			03JJ	Ø644	1316		DCBUF+25	
0232				LAJDE		•	ə 391	0645	7132		JMP GLCS	
3233	3441	3653	LS1.	LDF 10			9392	0646	0644		LDF 4	
9594	3448	1026		LLA 1 TPTR			9393	0647	1075		LLA CURS	
				LUF 4			9394	0653	1560			
0285	8443	0644									ECL I	
0296	2444	1364		STA I LPTR			0305	0651	7400	•	7403	
3207	2445	9653	DS2.	LDF 10			0336	0652	0061		SET I 1	
3813	0446	1926		LLA I TPTR			0307	0653	1155		LUT	
0211	3447	3645		LLH 5			0319	0654	7035		JAP BD1	
1212	3453	1844		SIA DPIR			0311	0655	0963		SFT I 3	
0813	2451	9650	DS3.	LLF 10			0312	0656				
	200 C (10		1231						1274		DCPUF+3	
9214	0452	1326		LDA I TPTR			0313	06 57	7132		JAP GECS	
3215	Ø453	9646		LDF 6			9314	0667	J963		SET I 3	
0216	0454	1344		STA DPTR			0315	9661	1274		DCBUF+3	
3217	0455	3236		XSK TPTR			0316	3662	1005		LUA CURS	
Ø223	0456	6441		JMP DS1			3317	0663	9310		RUR 10	
0221							3320					
	3457	3035		PLP				0664	1560		PCL I	
0888				PAJDE			3321	9665	7770		7770	
1983	9468	5637		JAP I SDSORT			1322	9666	1123		ADA I	
3224			1		•		0323	9667	1204		CTAB+20	
3225			1				3324	3673	4672		SIC +2	
3226	an the first		1			· ·	0325	0671	1073		LLA	
			25000311	TTUE TO DIED AN	STO DUINTE AS A	•	2326					
3227					512 PUINTS AS A			0672	0000		19990	
3533			/MUVING	WINDOW OVER 14	24 PUINTS, WITH CURSOR		Ø327	9673	1063		STA I 3	
3231			1.				9339	0674	1333		LLA	
1232				*6.10	• · · · · · · · · · · · · · · · · · · ·		0331	0675	3672		•-3	
1233	0690	3363	SLISP,	3			333 2	Ø676	1120		ADA I	
3274	06:31	6141		LINC			0333	9677	3343		40	
	00.04	C 1 4 1		-	•		0334					
3235				LIGULE				0733	47/02		SIC +2	
3236	3682	0193	NUI SP.	SAM Ø	SET UP START		0335	07 31	1000	•	LLA	
3237	0633	1120		ADA I	/LOCATION OF MOVING		9336	0702	0000		0.100	
0243	0694	1339		1930	/ VI NDUV		0337	0733	1063		STA I 3	
0241	9€35	3341	•	SCR 1			0349	0734	1005		LLA CURS	
3242	06.16	8450		47. F.	•		3341	0735	0261		RJL I 1	
							0342					
0243	06.07	6612		J46 •+3		•		37:16	3472		LZF I	
3244	3613	1623		BSE I			3343	Ø7 37	6725		JMP DI1	
3245	3611	1777		1777		•	3344	3719	3363		SF1 I 3	
0246	3612	1623		BSE I			0345	9711	1354		DCRUF+63	
3247	3613	2003		2333			0346	9712	3062		SET I 2	
	3614	1343		STA			3347	3713	1260		CTAB1-1	
0253						•	0350	0714				
3251	3615	9334		DPTR		•			0061		SFI I I	
3252	3616	9134		SAM 4	CURSOR .		0351	0715	7772		- 5	
0253	3617	1123		ALA I			9352	3716	1022		LDA I 2	
0254	3623	1039		1033	• • • •		2353	0717	1363		51A I 3	
3255	9621	0341		SCR 1			0354	0720	0821		KSK I 1	
							0355	0721	6716			
3256	9655	2064		ADD LPTR							- JHP3	
0257	3623	1620		BSE I			0356	9722	0976		SET I 16	
0263	0624	5993		2300			0357	0723	7796		-71	
3261	Ø6 25	4035		STC CURS			3369	0724	67.87		JM2 +3	
0262	3626	3646		LLF 6			Ø361	0725	3376	DI 1.	SFT I 16	
				LDA CURS			3362	5726	7114		-€3	
3563	9627	1035					9363					
1264	0633	0.361		SET I 1				0787	0324	•	SFA	
3265	9631	1122		DCT		•	0364	3739	1560		BCL I	
3266	3632	7035		JMP BL1		2	0365	0731	0200		203	
3267	0633	0363		SHT I 3	ъ.		93E6	9732	3334		ESF	
	9634	1343		DCBUF+47			9367	9733	0377		SFT I 17	
3273							3373	0734	1270			
3271	3635	7132		JMP GDCS							DCBUF-1	
25.15	JE36	9645		LDF 5			3371	9735	0061		SFT I I	
3273	2637	1305		LUA CURS			9372	0736	0000		(ð	
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-								•	0 472	1024	1120		ADA I	
9373	0737	1323		LLA I					0472	1025	3470		470	
Ø37 A	0743	0377		377					0473	1026	1120		ADA I	
3375	0741	1777		DSC I 17					0474	1327	7577		-203	
0376	0742	3236		XSK I 16					0476	1030	0017		COM	
0377	0743	6741		JMP2					0477	1031	ð 141		DIS 1	
. 8493	07 44 07 45	6751		JMP DCUR JMP DDAT					0500	1932	2237		KSK I 1	7
3431	0745	7005	• • • • • • • • • •	JAP DOUR					9591	1033	7012		JAP DUA	1
94.12	87 46 37.47	6751		PDP					0502	1034	6303	DDA2,	J.1P Ø	
3433	87 47	6995	· · · ·	PMJDE					0593			1 .		
8434 8435	6758	5690		340 T CHA CO	Fig. Kepelinski			-	4 7577 2 7 1					
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9497			59 N 1 1 1 1 1	1	a di serara									
7427	•	e e		LAJDE					<i></i>		:			
9411			a ≱ 10 € 1726	· 例如: 2.3% (2.4%)	5 4 1 ¹ 1	E. A.			n en					
3412	07 51		LCUR.	LDA					• • • •					
2413	0752	3333		8					P. C. B					
6414	8753	5004		STC DCU1	a a la contra en									
9415	87 54			LDF 6		•			•					
3416	Ø7 55	1005		LLA CURS	ار میں از مہرد ایک ایک ایک ا									
3417	3756	9341	5 27 5 89 C	SCR 1	ан сайта. Ал сайта сайта				•		1			
. 3423	0757	4031	an an tha	STC 1		•								
. 3021	3769		ોંડો જ સાહેય છે. સંસ્થાર	SET 1 17	•	1	•							
8455	0761	7773	A. Sec.	-4			į							
\$423	0762	0645		LUF 5										
3424	0763	1005	lag in the	LDA CURS										
8425	0764	1129		ALA I										
3426	0765	7397		-470										
8427	0766 0767	0471		APJ I JMP +3						•				
2437 0#21	0767 4773	6772	•	ADA I	, an in the s	(1,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2,2								
9431	9773 0771	1123 3473		47.3										
3432	0772	1123		ADA I										
9433 9434	3773	7577		-230										
8435	3774	0317		COM	•				•					
3436	0775	1123		ADA I						•		. 1		
3437	0776	0004		4								1		
3447	3777	0141		DIS 1		·						i		
3441	1.139	1123		ALA I										
31.42	1931	3331		1										
3043	1932	Ø237		XSK I 17					•					
3464	10.13	6777		J4P4										
3445	1994	6999	DCU1.	JXP 0						,				
9446			1			•								
3447			/											
3453														
3451														
3452			DDAT	LLA						•	•			
3453		1990	DDAT.	0								•.		
3454		0000 5020		STC DDA2					1					
3455	1097	5334		SE1 1 17										
3456	1919	0077	COUNTR.											•
9457 256 7	1011	2777 Ø646	DDA1.	LDF 6										
3463 7861	1312	1024		LDA I DPTR										
7461 7469	1314	3341		SCR 1										
3462 1463	1914	- 4301		STC 1										
3464	1916	3645		LLF 5										
3465	1917	1334		LDA DPTR										
0466	1329	1120		ALA I										
8468	1321	73:37		-473										
3473	1022	0471		APJ I										
0471	1923	7 926		J4P +3										
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						-				
						0076		3777		3777
6333			*23			Ø Ø 7 7	Ø213	0002		PDP
3331			/ DI SPL	AY DATA WITH FIELD CURSOR - DISF		0103				P.40DE
0338		-	1			0101	0214	4500		JAS I LLATA
			1	· · · · · · · · · · · · · · · · · · ·		0102	9215	4501		JAS I DSORT
2023										
0034	n Ayster (t til s	/18-5-			0103	•	4500		JMS I LDATA
99.45	1. S.	a toya	1			0194	ð217			JMS I DSJRT
9336	Sec. April 1		/M.O.JI	ARRETT.		0105	9559	4500		JMS I LUATA
0337			1. 1.			0196	0221	4501		JMS I DEORT
0313			n dia			0197	0222	4500		JMS I LDATA
(i) A second se second second sec	in the second					0110		4501		
09 i i	1. A.		/ DI SPL	AYS DATA FROM TAPL CONTAINING						JMS I LSORT
. 9316				DINATE DATA UN UNIT 2-READ OUT		0111		4502	DSP,	JMS I DISP
9313	"小小"考虑好多		- 19E- 191	E TW FIELD NUMBER IS PROVIDED.		0112	3552	5224		JMP1
3214	and the second		CURRES	SPUNDING TO CURSORS WITCH MARK		0113	4. S. S. S. S.		1	
3315				POINT OCCURING IN THE TO FIELD		0114		2.	1	
2316						9115		1.00	1	
1 A C 41 FURST	1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -					0116			10000	
3817	S	10.08		· 法注意的 高速 经公司 · · · · · · · · · · · · · · · · · · ·					SUBRU	UTINE TO LOAD 3 BLOCKS OF DATA
3,383	Start	1.00		and the second se		0117			/	
Ø381	1. A.	4 4 M M	/DATA 1	N BE DISPLAYED IS PLACED IN A		0120				LMUDE
0922		20 ° 2 ' 2	/1024 1	DINT BUFFERS AND A ADVING WINDOW		0121				*400
9383	والمراجع والمتحد المتحد	Sec. Sec. 1	ITO DIS	PLAY THE LATA IS CONTRULLED BY		9122		· · ·		PMUDE
0024	Sec. 1	나는 것 아랍 문	1011 9.	CURSUNS ARE CONTHOLLED BY POT 4		0123	0400	3090	SL DATA	
						0184	0401		00 DA 1A)	
- 0,425,				DVILE A REALDUT OF DATA AS DESCRIBED			0401	6141		LINC
2386		•	ABUVE.			Ø125				LMJ DE.
2387			1	ere en de la desta de la desta de la composición de la seconda de la composición de la composición de la compo	. 1	3126	0402	0067		SET I FCTR
\$738			1	an an an Anna an Anna Anna an Anna an		0127	0403	7774		-3
0731			/ PROGRA	M STARTED BY 1/0 PRESET, START 20		0130	0434	1000	•	LDA
0732			VIN 8			0131	0435	3436		DTPLK
1				IO DE.		0132				
0333			/				9496	1125		ADA I
3334	1947 - 194 <u>8</u>		1 Beach	•		Ø133	6497	5009		5000
0735			/LUCATI	UN 436 CUNTAINS START BLK FUR DATA		Ø134	9413	4416		STC LDAT2
0236				DI SPLAYED.		0135	6411	1020		LDA I
3337 .				ANTING PROGRAM LOADS NEXT 12 BLOCKS		0136		0301		1
and the second	1.000									
2049		. ÷.	JUF DAT	A•		0137	0413	0001		A&O
3341			/	and the second		2140			LDAT1,	LDF 10
0142			1			0141		37 39		RDC
8343			1			0142	9416	0200	LDATE .	13 (A 10) (B
3344				PMODE	8 ·	9143	0417			LDA I
3345						0144	3420			1031
				*29						
3746	6353	6141		LINC		3145		1140		AD4
3.547				LAUDE	•	0146		0416		LUATS
3353	3021	6200		JAP MAIN		0147	9423	0227		XSK I FCTR
0351			1			0150	0424	6415		JAP LDATI+1
0352				PMJ DE.		0151	0425			LDA
						0152		3416		
2253		.		*130						LDAT2 •
0354	01 39		LIATA,	SLDATA		0153	0427			ADA I
0055	0101 [.]	3437	DSORT.	SESORT		0154				-1
3356	0192	3630	LISP	SUI SP.		0155	3431	4436		SIC DIPLK
2157	ə1 33			DSP		0156	0432	3366		SET I TPTR
	0100	01201	/	251		0157	0433			
0363						0163				2377
3361			/	· ·			0434	0002		PDP
3468				LMODE		0161				PAO DE
8863				*233		0162	Ø435	5600		JMP I SLDATA
(1)64	6233	1820	MALN.	LDA I		Ø163			1	
0365	0201	9653		LLF 10		0164				LMJDE
						3165			1	
0066	0808	1:343		STA					•	
3367	52 33 .	0441		DS1		3166	0436	9112	DTELK.	112
3:73	0234	1343		STA		0167			/	
3371	02:05	3445		DS2	<i></i>	0173			1	
0372	0206	1040		STA		0171				TINE TO SORT DATA INTO FIELDS OF
						0172			/TO = T	The source of the second of th
0073	0207	0451		DS3						LD NUMBERS, VERTICAL AND HUMIZUNTAL
3374	0210	4414		STC LDATI		0173			VCOURDI	NATES
0075	9211	9064		SET I DPTR		0174			/	
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	0175					PMUDE								
	0176			100				•	0274	0641	0999		Ø	
		94		009	SDSORT.	0000			0275	8642	0976		SET I 16	
	9177	04	40 6	141		LINC			0276	0643	7757		- 20	
	8283					LMJDE								
	3281						•		0277	Ø644	1020		LDA I	
		<u> </u>		650	DS1.	LDF 10	*		0302	0645	0377		377	
	9292	04	42 1	Ø26		LDA I TPTR			0301.	0646	1777		DSC I 17	
	0203	94	03 A	644		LDF 4								
									9392	0647	Ø236		XSK I 16	
6 A.S.	0264	94		964	18 a 1 a 1	STA I DPTR			03030	0653	6646		JAP2	
Sec. 199	0235	34	45 Ø	650	DS2	LDF 10			0394	0651	0056		SET 16	
	9236	84	1 84	326		LDA I TPTR			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			•		
10.00									3335	0652	0334		DPTR	
할수요?	0207	34	- 12 - 12 - 12 - 12 - 12 - 12 - 12 - 12	645		LDF 5 L LANS ALL			0336	9653	0075		SET I 15	
	3519	64	50 1	344	15 N.	STA DPTR			Ø337	0654	2777		2777	
	6211	34		650			- "你们的你们的你们的你们。" ""躲在我们就是你们的你们的你们。"							
(영국의 등 등									0319	0655	3644		LDF 4	
	8618	34		026	- 大型語 (24)	LDA ISTPTR	化乙酮酸 化合合体 化	1	0311	26 56	0235	DI 1.	XSK I 15	
in the second	3213	84	53 Ø	646	J	LUF 614 States and set	All and the second second		0312	0657	0456		SKP	
	0214	04	64 E	044		STA DPTR	i de la companya de l							
Sec. 1						SIG WELL			0313	0660	6672		JWB DIS	
	6215	84		886		ASK TPIN	Provide States and the states of		0314	2661	1036	•	LDA I 16	
	8216	94	6 6	441		149 151	- 長いも 住い しん なんちなから いやかいち かいしい		0315	0662	1560		PCL I	
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an a	0328				1 and the second									
14 a 🖉	4223						en en segue en transmission de transmission de transmission de la companya de la companya de la companya de la		Ø321	0666	6656		JAP LII	
					Course Starting	Barton Barton Barton States - A			0322	Ø667	6675		JAP LCUR	
	0824				🖌 sa sa sa sa sa sa		•		0323	0670	0644		LDF 4	
	0285				/sunadu	TINE TO LISPLAY	STO POTATE AS A	1						
	08.86	de la servici							0324	9671	6656		JAP DII	
			· · · · ·			WINDOW OVER 192	4 POINTS, WITH CURSOR		Ø325	0672	6731	DI 2,	JMP LIAT	
	32.27				1			· · · · ·	0326	0673	0302		PT-P	
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	9231													_
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	9247	261	4 17	343		STA								
	3853	261	5 0	134		DPIR				41 T				
	2251	361		1.34		SAN 4	CURSOR							
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	0252	961	7 11	159		ADA I	•							
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	8254	062				SCR 2	•	<u>.</u> .						•
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APPENDIX A.4

Characteristics of "Scotchlite" Retro-reflective sheeting.

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Optical Properties

"Scotchlite" Brand Reflective Sheetings High Gain # 7610 and # 7611 have the retro-reflectance values listed on the following tables. The values are expressed as a multiple of the brightness of a perfect diffuse white surface. This multiple is shown as the luminance factor. These values were obtained from retro-reflectance measurements of typical samples of #7610 and #7611 Sheetings.

Table I – Luminance Factor vs. Incidence Angle

Angle of Incidence	0 ⁰	10 ⁰	20 ⁰	30 ⁰	45 [°]
Luminance Factor	590	595	620	660	710

(All readings were taken at an 0.5° divergence angle).

Table II - Luminance Factor vs. Divergence Angle

Angle of Divergence	0°	1/4°	1/3°	1/2 ⁰	3/4°	lo	-1-1/2°
Luminance Factor	1610	1280	1090	590	195	115	55

(All readings were taken at a 0° incidence angle).

Table 1 data shows that retro-reflectance of # 7610/# 7611 Sheetings remain high up to very oblique angles of incidence.

Table 11 shows that retro-reflective efficiency of #7610/#7611 Sheetings decrease rapidly as the angle between the incident light ray and the sensor or receiver is increased only slightly.

Since the retro-reflective surface of "Scotchlite" Brand Reflective Sheetings High Gain #7610 and #7611 is actually a continuous bond of exposed glass spheres, the result is a surface which is non-specular and therefore resistant to glare interference from ambient light.

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