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FEASIBILITY OF EVALUATING
THE INTEGRITY OF FTR DUCT
TO END FIXTURE WELDS USING
ACOUSTIC EMISSION MONITORING

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R. L. Trantow

November, 1975

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ABSTRACT

A method of applying real-time acoustic emission (AE) source location to evaluate the integrity of duct-to-end fixture welds was developed and evaluated using the HEDL R8-4 AE monitor coupled with a PDP-8e minicomputer. Operational software was developed to control the system's data acquisition, storage, and display functions.

Performance was evaluated on the basis of comparisons between AE source location data and subsequent destructive examination of six duct-to-transition ring qualification welds. Ten separate discontinuities seen in the metallography performed at 35 locations along these welds, correlated with the averaged acoustic emission activity revealed by the AE source location maps. This relationship is not presently considered to be usable as a system calibration method however, because of the limited range of discontinuity lengths (from 0.0003 to 0.004 in. long) that were correlated.

The presence of six other discontinuities, found in regions showing low levels of emission activity, indicated that significant stress risers can go undetected under the conditions investigated during this study.

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FEASIBILITY OF EVALUATING THE INTEGRITY OF FTR DUCT-TO-END FIXTURE WELDS USING ACOUSTIC EMISSION MONITORING

I. INTRODUCTION

Occasionally, welds are encountered in component configurations which prevent a meaningful volumetric examination of the weld by conventional non-destructive methods. In the particular case of the duct-to-end fixture closure welds, employed in Fast Test Reactor (FTR) fuel ducts, presently available radiographic and ultrasonic techniques are not applicable. This leaves liquid penetrant as the only available method for examining the integrity of these welds. Penetrants, however, are only sensitive to discontinuities open to the surface under examination, and some supporting information on the interior integrity of this weld is desirable.

This report documents an effort to develop and evaluate real-time acoustic emission (AE) methods for evaluating the integrity of welds in fast test reactor core components. This study was conducted during FY-1975 at the Hanford Engineering Development Laboratory (HEDL) under the ERDA/RRD-sponsored 189 FF029/GTJ program.

II. SUMMARY

Techniques for applying real-time acoustic emission (AE) monitoring to evaluate weld integrity in difficult-to-examine structural configurations, such as the FTR duct-to-end fixture closure welds, were developed and evaluated.

The HEDL R8-4 AE monitor was interfaced with a PDP-8e minicomputer for these evaluations to enable AE source location, as well as emission detection. Software programming was developed to allow: (1) the assignment of source location within the PDP-8e, (2) control of all data manipulation functions through a teletype terminal, (3) display of the source location and activity data on a video terminal, and (4) source location data storage on DEC tape for evaluation at any time following the weld monitoring. Calibration of

system parameters was based on detection of real AE signals generated within welds specifically constrained to promote cracking.

Using this system, six duct-to-transition ring qualification welds were monitored, and the resulting DEC tape data records were later reduced to source location and emission activity maps. These maps revealed regions of high acoustic activity, as high as 12 events registered at one location, with an average background noise level of less than one event per location.

Metallography was subsequently performed at selected locations within these high emission regions to identify the sources of acoustic activity. However, due to inaccuracies associated with the acoustic determination of true source location, both source location and identification are usually accomplished by the metallographic technique of progressively polishing through the high emission region. In an effort to avoid the expense of progressive polishing, visual examination of the inside surface of the weld root was used to precisely locate crack initiation sites. Eight locations, exhibiting cracks or tunnels along the fusion line between weld and base metal (transition ring) were thus identified within the acoustically active regions of four weld specimens. These eight locations were added to the 27 locations normally selected for sectioning and metallography in the course of qualifying a welding process.

The metallography of these 35 specimens revealed microstructural discontinuities that resembled cold shuts and hot tears along the fusion line between weld and transition ring base metal. Some of these discontinuities were filled or partially filled with a tenacious material whose major constituents were identified as titanium, manganese, and silicon.

The usefulness of the real-time AE source location system and monitoring techniques evaluated herein is based on the degree to which acoustic activity can be used as an indicator of discontinuity size. The extent of this relationship was determined by plotting micrographically-measured discontinuity lengths as a function of the averaged emission activity at the photomicrograph location. A trend in this relationship, spanning discontinuity lengths from 0.0003 to 0.004 inches, was revealed by 10 of the data points plotted.

However, seven other data points registered levels of emission activity significantly lower than what would be expected based on their discontinuity lengths. Only one data point with higher emission activity than expected was encountered. The remaining 17 data points are associated with photomicrographs that revealed no obvious source of emission activity.

III. CONCLUSIONS

The apparent relationship between discontinuity size and averaged AE activity indicates that the AE source location system and monitoring technique evaluated in this study is, at least to a limited degree, capable of revealing the location and magnitude of discontinuities along the weld fusion line. However, the scatter and limited span of the data supporting this relationship makes its use as a system calibration highly speculative until confirmed and supported by additional data over a wider range of discontinuity lengths.

Not all micrographically-visible discontinuities (cold shuts in particular) were formed by plastic deformation or cracking; hence, they were not revealed in the AE source location data. Because of this, significant stress risers within the weld zone may go undetected when the activation of emission sources is dependent on thermal stresses due to welding alone.

The attempt to reduce the amount of metallography by visually examining the exposed inner weld root surface revealed weld root discontinuities in support of the relationship above in five out of eight cases. However, this specimen screening technique proved to be of only limited usefulness, since visible fusion line discontinuities were not revealed for some of the most acoustically active regions. The greatest likelihood of identifying emission sources not associated with the inner weld root surface still appears to be by the use of progressive polishing techniques.

IV. RECOMMENDATIONS

The presence of an apparent relationship between discontinuity size and the degree of AE activity warrants a second weld monitoring effort to confirm and more accurately define the relationship seen. The progressive polishing technique should be employed during this second evaluation to maximize the probability of identifying all significant AE sources.

Efforts to activate normally silent stress risers by imposing externally-generated stresses, whether by tensile loading or component pressurization, should be considered to ensure that all significant stress risers are revealed.

V. BACKGROUND

The acoustic emission method is based upon detecting the minute elastic waves generated by small but rapid plastic deformations at highly-stressed locations within a material. While a number of deformation mechanisms are known to emit acoustic energy, the gross slip and microcracking associated with a propagating crack tip are particularly active. Early monitoring techniques employing a single sensor simply listened to the emission activity to qualitatively evaluate the integrity of the entire weld. However, when monitoring welds in expensive components, it is equally important that the location of AE sources also be revealed in order that the potential defect might be identified and some corrective action taken, if necessary.

VI. EQUIPMENT

Acoustic emission source location is usually calculated from the difference in arrival time of acoustic signals at AE sensors located at different distances from the emission source. In this study, differential time of flight inputs were provided by three AE sensors mounted on the duct, equally-spaced at alternate corners, and displaced 1-5/8 inch from the centerline of the weld (see Figure 1). These sensors are omnidirectional units, tuned to 500 kHz. Their 0.16 inch diameter PZT elements are sensitive to both longitudinal and shear waves.

The AE sensors are connected to 500 kHz tuned preamplifiers to boost their output by approximately 200 times prior to being fed to the Model R8-4 AE monitor for differential arrival time determinations. A block diagram of the entire system showing the mounting locations of the AE sensors relative to the duct-to-transition ring weld sequence, and the interconnections at the AE monitor, are shown in Figure 2.

Source location data storage and display on DEC tape and CRT terminal, respectively, are provided by a PDP-8e minicomputer also interfaced with the

FIGURE 1. Placement of Sensors During Real-Time AE Monitoring of the Fuel Duct-to-Transition Ring Qualification Welds.

HEDL 7506-156

FIGURE 2. Block Diagram of Acoustic Emission Source Location System.

AE monitor. A photograph showing the instrumentation arrangement used during the weld monitoring tests is included as Figure 3. Software version AE 0275 was developed specifically for this system and causes the PDP-8e to function as a four-field multichannel analyzer. Under control of this program, the PDP-8e receives differential arrival time data generated by any pair of the three corner-mounted sensors, and registers the event at a time-related location within one of the first three fields. Data assignment to the fourth field, display manipulation, data printout, and data record read and write to DEC tape are all interactively controlled from a teletype terminal. Software operating instructions and printout of the AE 0275 program are included in Appendix C.

VII. CALIBRATION PROCEDURES

Determination of AE source location is based on differences in AE signal arrival times at two sensor locations, and are dependent on the acoustic wave velocities within the material. Idealized calculations of propagation time can be performed based on component geometry and published acoustic wave velocity values. However, real propagation times in thin materials may be influenced by changes in the mode of acoustic propagation, and are further complicated by the presence of numerous secondary signals that are generated by mode conversions between longitudinal and shear components. Generally, AE systems are velocity-calibrated through the process of either injecting simulated AE signals or causing real emissions in a test piece at known locations. The system's velocity parameters are then adjusted so that the indicated source location coincides with the point of injection. Both techniques were tried.

The use of artificial AE signals for amplitude, as well as velocity, calibration is highly desirable since they may be readily injected at any accessible location on the actual component. This technique was attempted using signals generated by a spark discharge within a tube which was aimed at the duct surface. We were unable to obtain reliable source location indications, however. Triggering errors introduced by the discharge transient, difficulties in restricting the air-coupled shock wave to the desired point

6a. HS-31, 3A

6b. HS-32, 1D2

6c. HS-33, 1D2

6d. HS-35, 1C

FIGURE 6. Photomicrographs Illustrating the General Form of Discontinuities Occurring Along the Weld Fusion Line of the Duct-to-Transition Ring Weld. (HS-XX = Weld Number and "1D2" = Cross Section Identification).

of impingement, and the injection of primarily longitudinal waves are all possible sources of the location errors encountered with this signal injection technique.

Real AE signals, generated by contaminating the tack weld beneath one of the sensors with tungsten to cause weld cracking, were used to calibrate the system for AE wave velocity. Repeated remelting of the contaminated tack weld under differing system velocity settings was employed to obtain the velocity calibration setting of 5.88 (R8-4 dial setting) used in these closure weld evaluations. This setting causes the system to divide the distance between each pair of sensors into 55 possible source location assignments.

Source location assignments in this system are made on the basis of dividing the difference in arrival times into equal time increments. Because of the 1-5/8 inch displacement of sensors from the weld axis, the physical source locations corresponding to the time assignments are not equally spaced and correction of the uniform data spacing to produce true source location maps was required. Details of the correction used may be found in Appendix A.

As with the velocity calibration, the initial threshold level at which the R8-4 monitors source location circuitry would respond was also based on observations of real emission signals. These particular emission signals were generated and monitored during the welding of several 300 series stainless steel weld coupons. These coupons were designed with inherent stress risers and were constrained in a manner that maximized weld cooling stresses to promote cracking. Peak acoustic emission signal levels ranging between 430 and 1500 μ volts at the sensor were observed, and the threshold level was conservatively established at 360 μ volts peak at the sensor. However, subsequent monitoring of prequalification end fixture closure welds indicated much lower levels of emission activity. To ensure capture and location of at least some emission sources in what could be an inherently quiet weld structure, the threshold level was reduced to 145 μ volts peak at the sensor.

With system sensitivities set as described above, ground loop and airborne electrical interference from the welding equipment was encountered. This was especially true during arc initiation, where high-frequency signals

from the welding system were large enough to disrupt the PDP-8e's programming. By placing the PDP-8e in "hold" during this period, the programming was protected. Once the arc was established, programming was restarted and normal real-time monitoring was possible. To ensure capture of weld cooldown events, the monitoring was continued for approximately one minute following the extinguishing of the arc.

VIII. SOURCE LOCATION DATA ANALYSIS

Each duct-to-transition ring closure weld is comprised of six tack welds located in the center of each duct flat, and six automatic back step welds which are initiated at a tack weld and terminated at an adjacent tack weld. A source location data record of all detected emission activity for each of these 12 weld steps was recorded as a separate record on DEC tape for detailed analysis at a later date.

Acoustic emission source location and activity maps were prepared from DEC tape records for each of the six duct-to-transition ring qualification welds. These maps are composed of the sum of all AE events recorded during the monitoring of the 12 discrete welds that make up each duct-to-transition ring qualification weld. The source location map for qualification weld HS-32 is shown in Figure 4 as an example, with the reduced versions of all six source location maps presented in Appendix B.

Four of the six source location maps exhibited regions of high AE activity, with up to 12 events recorded at one location. This is a significant level of activity, since the background emission activity appears to lie between zero and one event per location for all welds monitored. One of these high-emission regions was selected for each of the four most active qualification welds for metallographic examination to determine the source of AE activity.

In this particular AE source location application, simply sectioning the weld at the indicated location was not expected to consistently reveal the source of emission activity. Anticipated inaccuracies in determining the precise location of AE sources expand the length of weld in which the indicated source might logically be found to almost 1/2 inch. Since we wanted

- Legend
- Dots represent single emissions assigned to a channel during and one of the 12 separate tack and back step welds represented in this weld series.
 - Lines represent multiple emissions assigned to a channel during any given weld. The length of the line in tenths of an inch represents the number of emissions counted at that location.
- Data plotted on the outside of the weld outline were obtained during the back step weld series, while data plotted on the inside were obtained during the tack weld series.
- Identification codes such as 1A, 2D2, etc., are provided at the locations of weld cross-section specimens removed for metallography.

FIGURE 4. Typical Acoustic Emission Source Location Record.

to investigate two locations in each of the four high-emission regions, the length of weld metal requiring metallographic examination could total four inches. Even if we were to progressively polish through the weld cross section in rather coarse 10 mil intervals, upwards of 400 specimen preparations could be required.

Because of the time and expense involved in the traditional progressive polishing approach, we attempted to minimize the amount of metallography by predetermining probable AE source locations within the regions of high emission activity. This was done by visually inspecting the weld root on the inside surface of the weld under the assumption that, if cracking did occur, there was a high probability of it being initiated in the weld metal or at the fusion line between the weld and transition ring parent metal. This inside weld root region was exposed by machining away the transition ring base metal down to the weld relief channel around the entire circumference of the ring. A graphic representation of this weld preparation technique is shown in Figure 5.

Visual examination of the root areas at 10X revealed a large number of "scale-like" islands and bands that seemed to be floating on the solidified weld metal. A somewhat lower population of narrow seams along the fusion line were also revealed. Upon examination at 70X, eight locations were identified along the fusion line that contained what appeared to be cracks or tunnels and, therefore, potential emission sources. These eight locations were added to the 16 other locations selected for sectioning and metallography in the normal course of weld qualification. The location of each of these 24 specimens was identified on the appropriate acoustic emission source location map to increase the data base for correlating acoustic emission activity with weld structures seen in subsequent metallography of the weld cross sections.

IX. EVALUATION OF RESULTS

High-magnification (500X) photomicrographs of weld cross sections in the region of the weld root fusion line revealed structures resembling cold shuts and hot tears. In some instances, these discontinuities were either filled

FIGURE 5. Fuel Duct-to-Transition Ring Sample Preparation Prior to Examination of the Inside Surface of the Weld Root for Crack Initiation Sites.

or partially-filled with a tenacious material which occasionally exhibited what appeared to be cracking. Electron microprobe analysis subsequently identified the main constituents of this material as titanium, manganese, and silicon, which are most probably combined with oxygen to form a silicate.

Four photomicrographs of the fusion line cross sections are shown in Figures 6(a), (b), (c) and (d) as characteristic examples of the structures seen in photomicrographs of the other 17 weld sections. Figure 6(a) shows a 0.001 inch long opening along the interface between transition ring parent metal and weld metal. Its blunted root suggests plastic deformation at high temperatures (hot tearing), or possibly a cold shut that was opened by hot tearing. Three acoustic emission events were recorded directly adjacent to this specimen location.

Figure 6(b) shows a region of parent metal that appears to have been extruded by shearing along a 0.005 inch line by shrinkage forces generated during weld cooling. Only three acoustic emission events were recorded directly adjacent to this specimen location; however, an adjacent region registered six events. Figure 6(c) shows a cold shut filled with the silicate material, along with an entrained circular region of the same material buried deeper in the fusion line. What appears to be a 0.0014 inch long crack may be seen in the larger volume of silicate material. Two acoustic emission events were recorded at this location with four events recorded at both adjacent locations. Figure 6(d) shows an apparent cold shut partially filled with foreign material at its tip. While this was the longest discontinuity recorded in the photomicrographs (0.009 inches long), there was only one acoustic emission event recorded in this region.

In an effort to determine if the level of emission activity could be correlated with actual structural conditions, micrographically-measured discontinuity length was plotted as a function of averaged emission activity at the cross section locations. This averaged emission activity consisted of the sum of events, registered at, and on either side of, the cross section location, divided by three. Averaged location activity data were used to minimize the effect of abrupt changes in emission activity between

6a. HS-31, 3A

6b. HS-32, 1D2

6c. HS-33, 1D2

6d. HS-35, 1C

FIGURE 6. Photomicrographs Illustrating the General Form of Discontinuities Occurring Along the Weld Fusion Line of the Duct-to-Transition Ring Weld. (HS-XX = Weld Number and "1D2" = Cross Section Identification).

adjacent locations which are thought to be due to inaccuracies in the AE system's assignment of event location.

The data plot is shown in Figure 7, based on the tabulated data presented in Appendix B. While considerable data scatter is evident, there does appear to be a trend in the relationship between averaged emission activity and discontinuity length. This trend is indicated by the line shown. Because some of the discontinuities used in establishing this line were very small and associated with average emission activities lying in the fractional event region, this indicated trend should be regarded as speculative until supported by additional data. However, the trend line does provide a point of reference for discussing the acoustically quiet discontinuities and unidentified emission sources.

Compared with the trend line relationship, weld cross sections 35_{1C}, 34_{4D}, 35_{5B1}, 32_{2G}, and 35_{6B} exhibited levels of emission activity significantly lower than anticipated for the size of discontinuities actually revealed. This low level of AE activity may be partially explained by the fact that sections 35_{1C}, 34_{4D}, and 35_{5B1} appeared to be cold shuts formed during the flow and solidification of the weld puddle. Since acoustic emissions are primarily emitted from overstressed regions undergoing fracture or rapid plastic deformations on the microscopic level, cold shuts are not expected to be particularly active emission sources. The two remaining sections, 32_{2G} and 35_{6B}, revealed structures similar to their much more active counterparts seen in sections along the trend line. Their lack of activity is not presently understood.

At the other extreme, cross sections 32_{1D1}, 33_{3D1}, 31_{1G}, 35_{1B}, and 35_{4B} exhibited levels of emission activity higher than appropriate for the size of discontinuities seen in their respective photomicrographs. A number of less obvious sources of acoustic emission are possible, such as strain-induced twinning, martensitic transformations, macro-slip, and oxide cracking to list a few. However, with the exception of oxide cracking, the acoustic activity of these mechanisms is dependent on the metallurgical nature of the alloy involved. As such, activation of any one of these mechanisms is more likely to be distributed uniformly along the weld bead, and will be detected

FIGURE 7. Plot of Discontinuity Length Versus Averaged Acoustic Activity for the 35 Metallographically Examined Weld Specimens.

as background noise. The background noise level recorded during these qualification welds was very low, i.e., between zero and one event per location. The conclusion is that, since each location that was selected for sectioning is represented by one cross section photomicrograph, there is a good probability that the true sources of emission activity were simply missed.

Four of the cross sections contained silicate structures exhibiting what appeared to be cracks. Because of the brittle nature of ceramic materials, high levels of emission activity would be expected from these structures. These data were replotted, substituting the brittle structure crack length for the previously-plotted discontinuity length (see the Legend of Figure 7 for identification of the replotted data). The majority of replotted brittle cracking data parallels the trend line; however, there is presently too little data to verify this second relationship.

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- J. C. Spanner for much-appreciated editorial assistance.

APPENDIX A ACOUSTIC SOURCE LOCATION CORRECTION

Source location assignments of acoustic events are stored in the PDP-8e minicomputer and displayed on the video terminal in equal increments of the differences in the acoustic signal arrival times at different AE sensors. However, because of the lateral displacement of the sensors from the weld bead, the difference in signal arrival time is not a linear function of true acoustic source location. The AE source location maps presented in this report have been corrected to display true position of source location assignments based on the relationship shown in Equation 1.

$$d = \frac{A}{2} \sqrt{\frac{4E^2}{D^2 - A^2} + 1} \quad (1)$$

where d , A , D , and E are defined by the various dimensions on the sketch to the right. This sketch represents the spatial relationships present during the AE monitoring reported.

FIGURE A-1. Spatial Relationship Between AE Sensors and the Duct-to-Transition Ring Weld.

When the AE source is directly under one of the sensors, i.e.,

$$d = \frac{D}{2}, \quad (2)$$

"A" will be at its longest extension, $A_{\max}$. In this limiting case,

$$A_{\max} = \sqrt{D^2 + E^2} - E. \quad (3)$$

To be useful, the length of "A" must be specified in terms of the source location designations, used as data assignment addresses within the first field of a four-field multi-channel analyzer created within the PDP-8e. This is accomplished by modifying Equation 3 to include both the field center designation (512) and the number of increments that $A_{\max}$ will be divided into (27). " A_L ", the length of "A" for any specific data storage location, "L", is shown in Equation 4.

$$A_L = (512 - L) \frac{\sqrt{D^2 + E^2} - E}{27} \quad (4)$$

Substituting A_L for A in Equation 1 gives:

$$d = (512 - L) \frac{\sqrt{D^2 + E^2} - E}{54} \sqrt{\frac{4E^2}{D^2 - \left[(512 - L) \frac{\sqrt{D^2 + E^2} - E}{27} \right]^2} + 1} \quad (5)$$

Based on the relationship shown in Equation 5, the true source locations associated with each digital location were calculated and plotted, as shown in Figure A-2, to correct the AE source location maps presented in Appendix B. A tabulation of the data plotted in Figure A-2 is included in Table A-1.

FIGURE A-2. Plotted Relationship Between Digital Source Location and Actual Source Location for the Duct-to-Transition Ring Closure Welds.

TABLE A-1

TABULATED RELATIONSHIP BETWEEN THE DIGITAL SOURCE LOCATION (CHANNEL NUMBERS) AND THE CALCULATED SOURCE LOCATION IN INCHES FROM THE CENTERLINE BETWEEN TWO ADJACENT AE SENSORS

<u>Channel No.</u>	<u>Location</u>	<u>Channel No.</u>	<u>Location</u>	<u>Channel No.</u>	<u>Location</u>
512	0.000	503	0.7401	494	1.5317
511	0.0815	502	0.8243	493	1.6271
510	0.1631	501	0.9090	492	1.7250
509	0.2447	500	0.9945	491	1.8259
508	0.3265	499	1.0809	490	1.9303
507	0.4086	498	1.1683	489	2.0389
506	0.4909	497	1.2569	488	2.1527
505	0.5735	496	1.3469	487	2.2728
504	0.6566	495	1.4383	486	2.4008
				485	2.5390

APPENDIX B

RECORD OF ACOUSTIC AND METALLOGRAPHIC WELD EVALUATION

This appendix contains the AE source location maps generated from the monitoring records of the six fuel duct-to-transition ring qualification welds, along with the photomicrographs of weld cross sections taken at the locations identified on these maps. These records have been grouped according to qualification weld number with the basic source location map heading each group. The metallographic record of weld cross section specimens, selected on the basis of visible weld fusion line discontinuities, directly follows the basic source location map. The record of weld fusion line discontinuities, revealed in the metallography of those cross sections selected in the normal course of qualifying this particular weld, terminates the weld evaluation group for the specific weld number. A tabulated comparison between measured discontinuity length and averaged AE activity is included at the end of this appendix as a documentation of the data presented in Figure 7 of the text.

- LEGEND:
- Dots represent single emissions assigned to a channel during any one of the 12 separate tack and back step welds represented in this weld series.
 - Lines represent multiple emissions assigned to a channel during any given weld. The length of the line in tenths of an inch represents the number of emissions counted at that location.

Data plotted on the outside of the weld outline were obtained during the back step weld series, while data plotted on the inside were obtained during the tack weld series.

Identification codes, such as 1A, 2D2, etc., are provided at the locations of weld cross-section specimens removed for metallography.

FIGURE B-1. Acoustic Emission Source Location Record - Weld HS-31.

AE Source Location Map with Expanded Section

Photomacrograph of the Weld Fusion Line on the Inside Surface of the Weld

Photomacrograph X-Section of the Weld at the Visually Designated Location Shown by the "*"

LEGEND:

- * - Visually Selected Weld Discontinuity
- A - Averaged AE Response Based on the Average of Counts Stored in Each Three Successive Source Locations

Photomicrograph of the Contact Between the Weld and Transition Ring Parent Metal at the Root of the Weld

FIGURE B-2.
Relation Between Weld Discontinuities at Visually Selected Location 3A and AE Source Location Data for Transition Ring Weld HS-31.

AE Source Location Map with Expanded Section

Photomicrograph of the Weld Fusion Line on the Inside Surface of the Weld

Photomicrograph X-Section of the Weld at the Visually Designated Location Shown by the "*"

LEGEND:

- * - Visually Selected Weld Discontinuity
- A - Averaged AE Response Based on the Average of Counts Stored in Each Three Successive Source Locations

Photomicrograph of the Contact Between the Weld and Transition Ring Parent Metal at the Root of the Weld

FIGURE B-3.
Relation Between Weld Discontinuities at Visually Selected Location 5D2 and AE Source Location Data for Transition Ring Weld HS-31.

1A

1B

1D1

AE Source Location Map with Weld Cross Section Specimen Locations Identified

Photomicrographs of the Contact Between the Weld and Transition Ring Parent Metal at the Locations Identified

FIGURE B-4.
Relation Between Weld Discontinuities at Locations 1A, 1B, and 1D1 and AE Source Location Data for Transition Ring Weld HS-31.

- LEGEND:
- Dots represent single emissions assigned to a channel during any one of the 12 separate tack and back step welds represented in this weld series.
 - Lines represent multiple emissions assigned to a channel during any given weld. The length of the line in tenths of an inch represents the number of emissions counted at that location.

Data plotted on the outside of the weld outline were obtained during the back step weld series, while data plotted on the inside were obtained during the tack weld series.

Identification codes, such as 1A, 2D2, etc., are provided at the locations of weld cross section specimens removed for metallography.

FIGURE B-5. Acoustic Emission Source Location Record - Weld HS-32.

AE Source Location Map with Expanded Section

Photomacrograph of the Weld Fusion Line on the Inside Surface of the Weld

Photomacrograph X-Section of the Weld at the Visually Designated Location Shown by the "*"

LEGEND:

- * - Visually Selected Weld Discontinuity
- A - Averaged AE Response Based on the Average of Counts Stored in Each Three Successive Source Locations

Photomicrograph of the Contact Between the Weld and Transition Ring Parent Metal at the Root of the Weld

FIGURE B-6.
Relation Between Weld Discontinuities at Visually Selected Location 1D1 and AE Source Location Data for Transition Ring Weld HS-32.

AE Source Location Map with Expanded Section

Photomicrograph of the Weld Fusion Line on the Inside Surface of the Weld

Photomicrograph X-Section of the Weld at the Visually Designated Location Shown by the "*"

LEGEND:

- * - Visually Selected Weld Discontinuity
- A - Averaged AE Response Based on the Average of Counts Stored in Each Three Successive Source Locations

Photomicrograph of the Contact Between the Weld and Transition Ring Parent Metal at the Root of the Weld

FIGURE B-7.
Relation Between Weld Discontinuities at Visually Selected Location 1D2 and AE Source Location Data for Transition Ring Weld HS-32.

2G

2D

AE Source Location Map with Weld Cross Section Specimen Locations Identified

Photomicrographs of the Contact Between the Weld and Transition Ring Parent Metal at the Locations Identified

FIGURE B-8.
Relation Between Weld Discontinuities at Locations 2G and 2D and AE Source Location Data for Transition Ring Weld HS-32.

- LEGEND:
- Dots represent single emissions assigned to a channel during any one of the 12 separate tack and back step welds represented in this weld series.
 - Lines represent multiple emissions assigned to a channel during any given weld. The length of the line in tenths of an inch represents the number of emissions counted at that location.

Data plotted on the outside of the weld outline were obtained during the back step weld series, while data plotted on the inside were obtained during the tack weld series.

Identification codes, such as 1A, 2D2, etc., are provided at the locations of weld cross section specimens removed for metallography.

FIGURE B-9. Acoustic Emission Source Location Record - Weld HS-33.

AE Source Location Map with Expanded Section

Photomicrograph of the Weld Fusion Line on the Inside Surface of the Weld

Photomicrograph X-Section of the Weld at the Visually Designated Location Shown by the "*"

LEGEND:

- * - Visually Selected Weld Discontinuity
- A - Averaged AE Response Based on the Average of Counts Stored in Each Three Successive Source Locations

Photomicrograph of the Contact Between the Weld and Transition Ring Parent Metal at the Root of the Weld

FIGURE B-10.
Relation Between Weld Discontinuities at Visually Selected Location 1D1 and AE Source Location Data for Transition Ring Weld HS-33.

AE Source Location Map with Expanded Section

Photomacrograph of the Weld Fusion Line on the Inside Surface of the Weld

Photomacrograph X-Section of the Weld at the Visually Designated Location Shown by the "*"

LEGEND:

- * - Visually Selected Weld Discontinuity
- A - Averaged AE Response Based on the Average of Counts Stored in Each Three Successive Source Locations

Photomicrograph of the Contact Between the Weld and Transition Ring Parent Metal at the Root of the Weld

FIGURE B-11.
Relation Between Weld Discontinuities at Visually Selected Location 1D2 and AE Source Location Data for Transition Ring Weld HS-33.

3D1

3A

AE Source Location Map with Weld Cross Section Specimen Locations Identified

Photomicrographs of the Contact Between the Weld and Transition Ring Parent Metal at the Locations Identified

FIGURE B-12.
Relation Between Weld Discontinuities at Locations 3D1 and 3A and AE Source Location Data for Transition Ring Weld HS-33.

- LEGEND:
- Dots represent single emissions assigned to a channel during any one of the 12 separate tack and back step welds represented in this weld series.
 - Lines represent multiple emissions assigned to a channel during any given weld. The length of the line in tenths of an inch represents the number of emissions counted at that location.

Data plotted on the outside of the weld outline were obtained during the back step weld series, while data plotted on the inside were obtained during the tack weld series.

Identification codes, such as 1A, 2D2, etc., are provided at the locations of weld cross section specimens removed for metallography.

FIGURE B-13. Acoustic Emission Source Location Record - Weld HS-34.

4G

4D

AE Source Location Map with Weld Cross Section Specimen Locations Identified

Photomicrographs of the Contact Between the Weld and Transition Ring Parent Metal at the Locations Identified

FIGURE B-14.
Relation Between Weld Discontinuities at Locations 4G and 4D and AE Source Location Data for Transition Ring Weld HS-34.

- LEGEND:
- Dots represent single emissions assigned to a channel during any one of the 12 separate tack and back step welds represented in this weld series.
 - Lines represent multiple emissions assigned to a channel during any given weld. The length of the line in tenths of an inch represents the number of emissions counted at that location.

Data plotted on the outside of the weld outline were obtained during the back step weld series, while data plotted on the inside were obtained during the tack weld series.

Identification codes, such as 1A, 2D2, etc., are provided at the locations of weld cross section specimens removed for metallography.

FIGURE B-15. Acoustic Emission Source Location Record - Weld HS-35.

AE Source Location Map with Expanded Section

Photomacrograph of the Weld Fusion Line on the Inside Surface of the Weld

Photomacrograph X-Section of the Weld at the Visually Designated Location Shown by the "*"

LEGEND:

- * - Visually Selected Weld Discontinuity
- A - Averaged AE Response Based on the Average of Counts Stored in Each Three Successive Source Locations

Photomicrograph of the Contact Between the Weld and Transition Ring Parent Metal at the Root of the Weld

FIGURE B-16.
Relation Between Weld Discontinuities at Visually Selected Location 1C and AE Source Location Data for Transition Ring Weld HS-35.

AE Source Location Map with Expanded Section

Photomicrograph of the Weld Fusion Line on the Inside Surface of the Weld

Photomicrograph X-Section of the Weld at the Visually Designated Location Shown by the "*"

LEGEND:

- * - Visually Selected Weld Discontinuity
- A - Averaged AE Response Based on the Average of Counts Stored in Each Three Successive Source Locations

Photomicrograph of the Contact Between the Weld and Transition Ring Parent Metal at the Root of the Weld

FIGURE B-17.
Relation Between Weld Discontinuities at Visually Selected Location 5E2 and AE Source Location Data for Transition Ring Weld HS-35.

5B1

6B

4B

AE Source Location Map with Weld Cross Section Specimen Locations Identified

Photomicrographs of the Contact Between the Weld and Transition Ring Parent Metal at the Locations Identified

FIGURE B-18.
Relation Between Weld Discontinuities at Locations 5B1, 6B and 4B and AE Source Location Data for Transition Ring Weld HS-35.

- LEGEND:
- Dots represent single emissions assigned to a channel during any one of the 12 separate tack and back step welds represented in this weld series.
 - Lines represent multiple emissions assigned to a channel during any given weld. The length of the line in tenths of an inch represents the number of emissions counted at that location.

Data plotted on the outside of the weld outline were obtained during the back step weld series, while data plotted on the inside were obtained during the tack weld series.

Identification codes, such as 1A, 2D2, etc., are provided at the locations of weld cross section specimens removed for metallography.

FIGURE B-19. Acoustic Emission Source Location Record - Weld HS-36.

6D

AE Source Location Map with Weld
Cross Section Specimen Locations
Identified

Photomicrographs of the Contact
Between the Weld and Transition
Ring Parent Metal at the Locations
Identified

FIGURE B-20.
Relation Between Weld Discontinuities
at Location 6D and AE Source
Location Data for Transition
Ring Weld HS-36.

TABLE B-1
MEASURED DISCONTINUITY LENGTH AND AVERAGED AE ACTIVITY
AT THE PHOTOMICROGRAPH LOCATIONS

<u>Specimen Designation</u>	<u>Discontinuity Length in Mils</u>	<u>Comments</u>	<u>Averaged AE Activity Over 3 Locations (Events)</u>
31-3A	0.8		1.7
5D2	2.3	Possible microcracking	2.7
1A	0.3		0.7
1B	0.7 (1.2) ¹	1. Length of surface scale	1.0
1D1	1.4	Total of 3 possible shear line cracks	3.3
1G		No visible cracks	1.7
32-1D1	0.4	Possible microcrack	6.0
1D2	4.2 (5.5) ²	Shear line, (2) 1.3 mils surface cracks counted	4.0
2G	1.6		0.3
2D	0.8		2.0
2A		Not shown on Fig. 7	1.7
2C			1.3
33-1D1	3.4 (1.6) ³	Metal/silicate separation	3.7
1D2	2.7 (1.4) ⁴	3. Crack in silicate only	3.3
3D1	0.1	4. Crack in silicate	2.0
3A	4.2 (0.6) ⁵	5. Crack in silicate	1.7
3E			0.3
3G			2.3
34-4G	0.4		0.7
4D	3.6	Filled with silicate, two inclusions not counted	0.3
4A			1.0
4F			0.3
35-1C	9.4 (1.1) ⁶	Partially filled with silicate, crack length in silicate (6)	0.7
5E2	3.7	Filled with silicate	1.7
5B1	2.1	Filled with silicate	0.0
6B	2.3	Filled with silicate	0.0
4B	0.1		1.7
1B			1.3
2B			0.3
5A			2.7
5D			2.3
5G2			0.3
36-6D	0.1		0.3
6A			0.3
6C			0.3
6G			0.7

APPENDIX C

ACOUSTIC EMISSION SOURCE LOCATION PROGRAM AE0275

AE0275 is a single precision source location display and data logging program for use on a PDP-8e minicomputer interfaced with the A. E. Monitor Model R8-4. This program is based on an earlier program developed by DEC Corporation, called SING8K, which is a precision and a half single parameter data acquisition program used to analyze 4096 channel pulse height spectra. AE0275 is stored in the first 4K section of PDP-8e core, with the 4096 channels of data stored in the second 4K section of core. A copy of AE0275 is provided immediately following this description of program operation.

DESCRIPTION

This program acquires source location data from the A. E. Monitor and receives and executes commands from the keyboard. These commands start and stop data acquisition, display the data with vertical markers for channel identification, expand regions of interest on the screen, integrate (sum) the data between markers, combine selected regions within the first three 1024 channel wide data fields into one continuous display stored in the fourth field, type and punch out data, and output data to DEC tape. Program starting address is 200.

COMMANDS

AE0275 is designed to respond to sixteen legal commands. All commands are executed following the receipt of a carriage return (↵). All commands may be erased before execution by striking the rubout key. A rubout causes the program to ignore everything typed on that line, to type a carriage return and a line feed, and to await another command. All illegal commands are ignored, and the program awaits another command.

The legal commands may be divided into five categories: data acquisition commands, data manipulation commands, display commands, data output commands, and the clock command.

Data Acquisition Commands

X, Enables data acquisition. The clock is reset to the latest value if it had timed out on the previous data acquisition run. If not the clock continued from where it had stopped.

N, Disables data acquisition.

Data Manipulation Commands

Z, Zeros the data area. Data acquisition is disabled.

I, Integrates (sum) the data between vertical markers including the marker channels and prints the result in decimal format. Data acquisition is disabled.

S, This command is used to set a range about the center point (channel 512) of fields 0, 1, and 2 within which data will be gathered into the fourth field. The command has four different forms. Data gathering does not begin until one of the forms is used.

(1) S, This would cause the program to zero the fourth field and enable data gathering into it. The ranges from a previous command would not be disturbed.

(2) S_xxxx, Fields 0, 1 and 2 would be given a range of xxxx.

(3) S_xxxx_yyyy, Fields 0 and 2 would have the range of xxxx while field 1 would have the range of yyyy.

(4) S_xxxx_yyyy_zzzz, All three fields would have different ranges; 0 of xxxx, 1 of yyyy, and 2 of zzzz.

Example:

S 0064 0128 0192,

This would set a range of +64 for field 0, 128 for field 1, and 192 for field 2.

The following constants would be set by RANGE:

ADX = 6050 ₈	ADZ = 6200 ₈	ADY = 6450 ₈
RX = 0050 ₈	RZ = 0100 ₈	RY = 0150 ₈

Display Commands

- D Displays every fourth channel's stored data. The beginning of every field is indicated by a vertical marker. The vertical scale is controlled by the contents of the last three bits of the switch register as follows:

Switch Register (9,10,11)	Counts Full Scale
000	63
001	127
010	255
011	511
100	1023
101	2047
110	4095
111	63

- (1) Dd_xxxx_yyyy, Displays a field of the data region (d=0, 1, 2, or 3) with markers in channels xxxx (low) and yyyy (high). The command may be truncated in which case the upper marker or both markers would be at the ends of the field.

Example:

- D1 0341 0770, Displays the second field (field 0 is the first) with markers in channels 0341 and 0770.
- D0 0340, Displays the first field with markers in channels 0340 and 1023.
- D3, Displays the fourth field with markers in channels 0000 and 1023.
- E, Expands the region of the display between the markers and prints the expansion factor.
- Ld, Increases the lower marker by the single decimal digit d, prints the new marker location, expands the display and prints the new expansion factor.
- Ud, Decreases the upper marker by the single decimal digit d, prints the new marker location, expands the display and prints the new expansion factor.

Data Output Commands

- W) Types out the stored data in each of the channels between the markers. The left column consists of every fifth channel number, the five following columns list the channel contents. Data acquisition is disabled.
- P) Punches out in binary format the contents of the channels between the markers. Data acquisition is disabled.
- Oxx) Writes data area onto DEC tape. The output uses 60 (octal) blocks on the DEC tape; the number xx specifies which set of 60 (octal) blocks is to be used. Transport number 1 is used. Data acquisition is disabled.

Example:

004) Outputs the data area onto the fourth set of 60 (octal) blocks on the DEC tape on Unit 1.

- Rxx) Reads data area in from DEC tape. Transport number 1 is used. Data acquisition is disabled.

Example:

R01) Reads in the data in the first set of 60 (octal) blocks on the DEC tape on Unit 1.

Clock Command

- C_xxxxxxx) Sets the double precision clock registers to the 2's complement of the number typed in. The largest acceptable number is 16,777,215.

Example:

C_5) Sets the clock to receive 5 pulses.

C_500) Sets the clock to receive 500 pulses.

NOTE: In the AE0275 adaptation of SING8K, the C command may be either altered or inoperative.

PROGRAM RESPONSE TO VARIOUS OPERATING CONDITIONS

The program will acquire data until one of three conditions occur:

- (1) Channel overflow,
- (2) Clock overflow,
- (3) The receipt of a keyboard command which terminates data acquisition.

The first two conditions type out a message. If a channel overflows, the message xxxx FULL (where xxxx is the channel number) is typed. If the clock overflows, the message CLOCK FULL is typed. The clock sets the clock flag. After an interrupt the first flag tested is the clock flag. One IOT_ACF_ resets whichever flag is being serviced.

AE0275 PROGRAM LISTING

```

1      / ACTSN3 SRC
2      /8K SINGLE PRECISION PARAMETER PROGRAM
3      /ONE DIMENSIONAL DISPLAY
4
5      FIELD 0
6      ACF=6324          /CLEAR ADC FLAG
7      ARR=6326          /READ AND RESET
8      ASF=6321          /SKIP IF NOT ADC FLAG
9      SNC=6331          /SKIP ON NOT CLOCK
10     DXL=6053
11     DYS=6054
12     DIXY=6055          /INTENSIFY
13     DICD=6051          /CLEAR DISPLAY FLAG
14     DISD=6052          /SKIP ON DISPLAY FLAG DONE
15     STAP=6332          /ENABLE INTERFACE
16     ATC=6144          /CLEAR CLOCK FLAG
17     SXB=6341          /SKIP ON BIT 13
18     AXF=6143          /SKIP IF X COUNTER FLAG READY
19     AYF=6144          /SKIP IF Y COUNTER FLAG READY
20     AZF=6145          /SKIP IF Z COUNTER FLAG READY
21     AXR=6140          /READ X COUNTER
22     AYR=6141          /READ Y COUNTER
23     AZR=6142          /READ Z COUNTER
24     ARST=6146          /RESET ACOUSTIC EMISSION SYSTEM
25     CDF0=6201          /SET DATA FIELD TO 0
26     CDF1=6211          /SET DATA FIELD TO 1
27     CIF0=6202          /SET INSTRUCTION FIELD TO 0
28     CIF1=6212          /SET INSTRUCTION FIELD TO 1
29     CDI0=6203          /SET INSTRUCTIO AND DATA FIELD TO 0
30     CDI1=6213          /SET INSTRUCTIO AND DATA FIELD TO 1
31     *0                /*1 FOR PDP-5 CONFIGURATIONS
32     00000 0400        SWEEP1 /LOADER INITIALIZES
33     00001 4553        JMS I SACL /SAVE AC AND LINK
34     00002 5403        INTER, JMP I ADACST /ADDRESS OF ACSTIC HANDLER FOR ACOUSTIC INTERFACE
35     00003 2600        ADACST, ACSTIC
36     00004 0000        ODT, 0 /LOCATION 0004 RESERVED FOR ODT LINKAGE
37     00005 5043        INTRTY, JMP TTINTR /NOT ACOUSTIC INTERFACE CHECK TTY
38     *15
39     00015 0000        INDEX1, 0 /INDEX REGISTERS
40     00016 0000        INDEX2, 0
41     00017 0000        INDEX3, 0
42     00020 0571        SETCLK, SETITT
43     00021 4554        CONTIN, JMS I RACL /RESTORE AC AND LINK
44     00022 6244        6244 /RESTORE MEMORY FIELD
45     00023 6001        ION
46     00024 5400        JMP I INTER-2 /JMP TO SWEEP ROUTINE
47     00025 6042        OTHER, TCF /IGNORE TELEPRINTER IF
48     00026 6031        KSF /IN INPUT MODE
49     00027 7410        SKP
50     00030 5545        JMP I RETURN+1 /KEYBOARD
51     00031 5021        JMP CONTIN /EXTRANEIOUS
52     00032 0000        READ, 0 /GET A CHAR FROM
53     00033 7200        CLA /THE BUFFER
54     00034 1414        TAD I 14
55     00035 3100        DCA HOLD1
56     00036 5432        JMP I READ
57
58     00037 0000        PUNCIR, 0
59     00040 6026        PLS
60     00041 7200        CLA
61     00042 5021        JMP CONTIN
62     00043 6041        TTINTR, TSF
63     00044 5047        JMP TINTR
64     00045 6342        TCF
65     00046 5547        JMP I PRNTIR
66     00047 6021        TINTR, PSF
67     00050 5026        JMP OTHER+1
68     00051 6022        PCF
69     00052 5437        JMP I PUNCIR
70     00053 7770        MIN10, 7770 /CONSTANTS
71     00054 7760        MIN20, 7760
72     00055 0275        EQUAL, 275
73     00056 0212        LNFEED, 0212

```

74	00057	0215	CRRRTN,	0215
75	00058	7400	M4THOU,	7400
76	00061	7000	M1THOU,	7000
77			OFFSET=M1THOU	
78	00062	5000	M2THOU,	5000
79	00063	1000	P1THOU,	1000
80	00064	2000	P2THOU,	2000
81	00065	3000	P3THOU,	3000
82	00066	7774	MINUS4,	7774
83	00067	7401	MIRBOUT,	7401
84	00070	0004	PLUS4,	0004
85	00071	0017	MASK15,	0017
86	00072	0077	MASK63,	0077
87	00073	0300	MASKX,	0
88	00074	0000	MINHI,	0
89	00075	0000	MINLO,	0
90	00076	0000	LOMARK,	0
91	00077	0000	HIMARK,	0
92	00100	0000	HOLD1,	0
93	00101	0100	HOLD2,	0
94	00102	0000	HOLD3,	0
95	00103	0000	HIGH,	0
96	00104	0000	LOW,	0
97	00105	0000	COUNT1,	0
98	00106	0000	COUNT2,	0
99	00107	0000	COUNT3,	0
100	00110	0000	COUNT5,	0
101	00111	0000	COUNT6,	0
102	00112	0000	COUNT7,	0
103	00113	0000	COUNT8,	0
104	00114	0000	SETTNG,	0
105				
106	00115	0000	CONST6,	0
107	00116	0000	CONST7,	0
108	00117	0000	CONST8,	0
109	00120	0000	INLEAV,	0
110	00121	0000	PRODC7,	0
111	00122	0000	YCONST,	0
112	00123	0000	YORG,	0
113	00124	0000	XCONST,	0
114	00125	0000	XAXIS,	0
115	00126	0000	DSPLCE,	0
116	00127	0000	SAVERAC,	0
117	00130	0000	SAVLNK,	0
118	00131	0000	CLOCK1,	0
119	00132	0000	CLOCK2,	0
120	00133	1107	CLKFUL,	CLKFULL
121	00134	0667	ADRSC6,	TABLE3+7
122	00135	0657	ADRSC7,	TABLE3-1
123	00136	0200	ERROR,	BEGIN
124	00137	1200	EXPPT,	EXPAND
125	00140	0236	FULL,	OVRFLO
126	00141	1716	RESUME,	REL
127	00142	0600	OUTFUT,	PNTDEC
128	00143	1152	ORGPT,	ORIGIN
129	00144	0021	RETURN,	CONTIN
130	00145	1446		DECODE
131	00146	0000	LWORD,	0
132	00147	0000	PRNTIR,	0
133	00150	6046		/PRINT USING INTERRUPT
134	00151	7200		TLS
135	00152	5021		CLA
136	00153	1344	SACL,	JMP CONTIN
137	00154	1351	RACL,	SAVACL
138	00155	2000	TE1,	RESACL
139	00156	0000	SWIT,	SLM
140	00157	4000	M4THOU,	0
141	00160	7776	M2,	4000
142	00161	0000	TEM1,	-2
143	00162	0100	P100,	0
144	00163	2777	P2777,	0100
145	00164	2702	FULDIS,	2777
146	00165	0543	BNPCH,	DISFL
147	00166	0001	ENBWRD,	BNPCH
				0001

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148 00167 7520 M260, -260
149 00170 7563 M215, -215
150 00171 7540 M240, -240
151 00172 0300 MCOM, 0
152 00173 7700 M7700, 7700
153 00174 1435 BEGLNK, BEGCOM
154 00175 1457 ERRLNK, DECODE+11
155
156 *200
157 00200 6032 BEGIN, KCC /CLEAR FLAGS
158 00201 6042 TCF
159 00202 6077 6077 /SET MAX BRIGHTNESS ON OSCILLOSCOPE
160 00203 1057 TAD CARRTN /PRINT CR,LF
161 00204 4147 JMS PRNTIR
162 00205 1056 TAD LNFEED
163 00206 4147 JMS PRNTIR
164 00207 5574 CMMAND, JMP I BEGLNK /JMP BEGCOM
165 00210 7200 CLA
166 00211 1233 TAD ADRSC3 /DECODE IT
167 00212 3017 DCA INDEX3
168 00213 7240 CLA CMA
169 00214 1235 TAD TABLN
170 00215 3146 DCA LWORD
171 00216 1234 TAD ADRSC1
172 00217 3101 DCA HOLD2
173 00220 1100 TAD HOLD1
174 00221 1417 TAD I INDEX3
175 00222 7450 SNA
176 00223 5230 JMP .+5 /MATCH
177 00224 2101 ISZ HOLD2 /NO MATCH
178 00225 2146 ISZ LWORD
179 00226 5221 JMP .-5
180 00227 5575 JMP I ERRLNK /ERROR - RESTART
181 00230 1501 TAD I HOLD2
182 00231 3101 DCA HOLD2
183 00232 5501 JMP I HOLD2 /GO TO PROPER ROUTINE
184 00233 7377 ADRSC3, TABLE2-1 /ADS OF COMMAND DECODING TABLE
185
186 00234 7420 ADRSC1, TABLE1 /ADS OF ADDRESS TABLE
187 00235 7761 TABLN, 7761
188 00236 6332 OVRFLD, STAA /CHANNEL OVERFLOWED, PRINT CHANNEL NUMBER
189 00237 1102 TAD HOLD3
190 00240 3104 DCA LOW
191 00241 3103 DCA HIGH
192 00242 1066 TAD MINUS4
193 00243 3115 DCA CONST6
194 00244 1134 TAD ADRSC6
195 00245 3116 DCA CONST7
196 00246 4542 JMS I OUTPUT
197 00247 5650 JMP I .+1
198 00250 1104 PRFULL
199 00251 4543 CLDATA, JMS I ORGPT /JMS ORIGIN
200 00252 3015 DCA INDEX1 /SET CONSTANTS TO ZERO OUT ALL
201 00253 3161 DCA TEM1 /OF FIELD1
202 00254 6332 CLD0, STAA /ENTRY FROM ROUTINE ZERO4
203 00255 6211 CLD1, CDF1
204 00256 3415 DCA I INDEX1
205 00257 6201 CDF0
206 00260 2161 ISZ TEM1
207 00261 5255 JMP CLD1
208 00262 5544 JMP I RETURN
209 00263 6001 GO, ION
210
211 *400
212 00400 6001 SWEEP1, ION
213 00401 7604 CLA OSR /READ SWITCHES
214 00402 3156 DCA SWIT
215 00403 3107 DCA COUNT3 /INTERLEAVE AT X=0,4,...
216 00404 1117 TAD CONST8 /CHANGED BY EXPAND
217 00405 3105 DCA COUNT1
218 00406 1120 SWEEP2, TAD INLEAV
219 00407 3106 DCA COUNT2
220 00410 1123 TAD YORG
221 00411 1107 TAD COUNT3
222 00412 3121 DCA PRODUCT /XAXIS IN MEMORY

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222	00413	1107	TAD	COUNT3	
223	00414	3125	DCA	XAXIS	/XAXIS ON SCOPE
224	00415	1125	TAD	XAXIS	/LOAD X
225	00416	1061	TAD	OFFSET	/ADJUST DISPLAY REFERENCE TO LEFT BOTTOM CORNER OF SCREEN.
226					
227	00417	6053	DXL		
228	00420	7200	CLA		
229	00421	1125	TAD	XAXIS	
230	00422	1126	TAD	DSPLCE	/DURING EXPAND, MARKERS
231	00423	0073	AND	MASKX	/SHIFT
232	00424	7650	SNA	CLA	
233	00425	5261	JMP	SCALE	/PUT UP SCALE MARKERS
234	00426	1125	TAD	XAXIS	
235	00427	1075	TAD	MINLO	/VERTICAL MARKER?
236	00430	7450	SNA		
237	00431	5270	JMP	MARK-3	/YES
238	00432	1074	TAD	MINHI	
239	00433	7650	SNA	CLA	
240	00434	5270	JMP	MARK-3	/YES
241	00435	1260	TAD	SKIP	/NO
242	00436	3244	DCA	SWIT4	
243	00437	7000	SWIT3,	NOP	/BASELINE REMOVED FOR DISPLAY TIMING (VR12)
244	00440	1125	TAD	XAXIS	
245	00441	1124	TAD	XCONST	
246	00442	3125	DCA	XAXIS	/UPDATE X ON SCOPE
247	00443	4555	JMS	I TE1	/JMS TO SLM (OUTPUT ROUTINE FOR SCOPE)
248	00444	7410	SWIT4,	SKP	/MARK?
249	00445	5273	JMP	MARK	/YES
250	00446	7200	CLA	/NO	
251	00447	1121	TAD	PRODC	/UPDATE XAXIS IN CORE
252	00450	1122	TAD	YCONST	
253	00451	3121	DCA	PRODC	
254	00452	2106	ISZ	COUNT2	/FIRST INTERLEAVE DONE?
255	00453	5215	JMP	SWEEP3	/NO
256	00454	2107	ISZ	COUNT3	/YES-UPDATE POINTER
257	00455	2105	ISZ	COUNT1	/ALL DONE?
258	00456	5206	JMP	SWEEP2	/NO
259	00457	5200	JMP	SWEEP1	/YES:START OVER
260	00460	7410	SKIP,	7410	
261	00461	7101	SCALE,	CLL IAC	/PUT UP SCALE MARKERS
262	00462	7006	RTL		
263	00463	4742	JMS	I DPOIN	
264	00464	7006	RTL		
265	00465	4742	JMS	I DPOIN	
266	00466	7200	CLA		
267	00467	5226	JMP	SWEEP4	
268	00470	1061	TAD	M1THOU	
269	00471	3244	DCA	SWIT4	
270	00472	5237	JMP	SWIT3	
271	00473	7200	MARK,	CLA	/DRAW VERTICAL LINE
272	00474	1054	TAD	P2THOU	
273	00475	7100	CLL		
274	00476	1054	TAD	MIN20	
275	00477	7420	SNL		
276	00500	5246	JMP	SWIT4+2	
277	00501	4742	JMS	I DPOIN	
278	00502	5275	JMP	-5	
279	00503	4032	LOWER,	JMS READ	/INCREMENT LOWER MARKER
280	00504	1100	TAD	HOLD1	
281	00505	0071	AND	MASK15	
282	00506	1076	TAD	LOMARK	
283	00507	3076	DCA	LOMARK	
284	00510	1076	TAD	LOMARK	
285	00511	5321	JMP	PMARK	
286	00512	4032	UPPER,	JMS READ	/DECREMENT UPPER MARKER
287	00513	1100	TAD	HOLD1	
288	00514	0071	AND	MASK15	
289	00515	7041	CMA	IAC	
290	00516	1077	TAD	HIMARK	
291	00517	3077	DCA	HIMARK	
292	00520	1077	TAD	HIMARK	
293	00521	3104	PMARK,	DCA LOW	/PRINT OUT NEW VALUE
294	00522	3103	DCA	HIGH	
295	00523	1066	TAD	MINUS4	

296	00524	3115	DCA	CONST6	
297	00525	1114	TAD	ADRSC6	
299	00526	3116	DCA	CONST7	
299	00527	1055	TAD	EQUAL	
300	00530	4147	JMS	PRNTIR	
301	00531	4542	JMS	I OUTPUT	
302	00532	1057	TAD	CARRTN	
303	00533	4147	JMS	PRNTIR	
304	00534	1056	TAD	LNFEED	
305	00535	4147	JMS	PRNTIR	
306	00536	1341	TAD	PE	
307	00537	4147	JMS	PRNTIR	
308	00540	5537	JMP	I EXPPT	
309	00541	0305	PE,	0305	
310	00542	1745	DPOIN,	DPOINT	
311	00543	0000	BINPCH,	0	
312	00544	3113	DCA	COUNT8	
313	00545	1113	TAD	COUNT8	
314	00546	7012	RTR		
315	00547	7012	RTR		
316	00550	7012	RTR		
317	00551	0361	AND	MASK7	
318	00552	4362	JMS	CHECK	
319	00553	4037	JMS	PUNCIR	/PUNCH BITS 11-6
320	00554	1113	TAD	COUNT8	
321	00555	0072	AND	MASK63	
322	00556	4362	JMS	CHECK	
323	00557	4037	JMS	PUNCIR	/PUNCH BITS 5-0
324	00560	5743	JMP	I BINPCH	
325	00561	0177	MASK7,	0177	
326	00562	0000	CHECK,	0	
327	00563	3112	DCA	COUNT7	
328	00564	1112	TAD	COUNT7	
329	00565	1104	TAD	LOW /LOW=CHECK SUM	
330	00566	3104	DCA	LOW	
331	00567	1112	TAD	COUNT7	
332	00570	5762	JMP	I CHECK	
333	00571	6344	SETITT,	ATC	
334	00572	2131	ISZ	CLOCK1	
335	00573	5021	JMP	CONTIN	
336	00574	2132	ISZ	CLOCK2	
337	00575	5021	JMP	CONTIN	
338	00576	5533	JMP	I CLKFUL	
339			*600		
340	00600	0000	PNTDEC,	0	/PRINT DECIMAL
341	00601	1115	TAD	CONST6	
342	00602	3113	DCA	COUNT8	
343	00603	1116	TAD	CONST7	
344	00604	3016	DCA	INDEX2	
345	00605	1416	TDEC,	TAD I INDEX2	
346	00606	3254	DCA	H SUB	
347	00607	1416	TAD	I INDEX2	
348	00610	7255	DCA	L SUB	
349	00611	3257	DCA	CHRCTR	
350	00612	4233	JMS	ADD	
351	00613	1257	TAD	CHRCTR	
352	00614	1231	TAD	ZERO	
353	00615	4147	JMS	PRNTIR	
354	00616	2113	ISZ	COUNT8	
355	00617	5205	JMP	TDEC	
356	00620	5600	JMP	I PNTDEC	
357	00621	0000	DEC,	0	/PRINT COUNT8 SPACES
358	00622	3113	DCA	COUNT8	
359	00623	2113	DECL,	ISZ COUNT8	
360	00624	7410	SKP		
361	00625	5621	JMP	I DEC	
362	00626	1232	TAD	SPACE	
363	00627	4147	JMS	PRNTIR	
364	00630	5223	JMP	DECL	
365	00631	0260	ZERO,	0260	
366	00632	0240	SPACE,	0240	
367			/ONE DIMENSIONAL DISPLAY		
368			/PART II		
369	00633	0000	ADD,	0	/DOUBLE PRECISION ADD

370	00634	7100	CLL	
371	00635	1104	TAD LOW	
372	00636	1255	TAD LSUB	
373	00637	3256	DCA TEMPL	
374	00640	7004	RAL	
375	00641	1103	TAD HIGH	
376	00642	1254	TAD HSUB	
377	00643	7420	SNL	
378	00644	5252	JMP .+6	
379	00645	3103	DCA HIGH	
380	00646	1256	TAD TEMPL	
381	00647	3104	DCA LOW	
382	00650	2257	ISZ CHRCTR	
383	00651	5234	JMP ADD+1	
384	00652	7200	CLA	
385	00653	5633	JMP I ADD	
386	00654	0000	HSUB.	0
387	00655	0000	LSUB.	0
388	00656	0000	TEMPL.	0
389	00657	0000	CHRCTR.	0
390	00660	3166	TABLE3.	3166
391	00661	4600		/CONVERSION TABLE
392	00662	7413		/31664600(OCT)=-10000000(DEC)
393	00663	6700		/74136700(OCT)=-1000000(DEC)
394	00664	7747		/77474540(OCT)=-100000(DEC)
395	00665	4540		/77754360(OCT)=-10000(DEC)
396	00666	7775		/77777630(OCT)=-1000(DEC)
397	00667	4360		/77777766(OCT)=-10(DEC)
398	00670	7777		/77777777(OCT)=-1(DEC)
399	00671	6030		
400	00672	7777		
401	00673	7634		
402	00674	7777		
403	00675	7766		
404	00676	7777		
405	00677	7777		
406	00700	7200	INTEG.	CLA
407	00701	6332		STAR
408	00702	7040		CMA
409	00703	1114		TAD SETING
410	00704	1076		TAD LOMARK
411	00705	3016		DCA INDEX2
412	00706	3103		DCA HIGH
413	00707	3104		DCA LOW
414	00710	1055		TAD EQUAL
415	00711	4147		JMS PRNTIR
416	00712	1077		TAD HIMARK
417	00713	7040		CMA
418	00714	1076		TAD LOMARK
419	00715	3113		DCA COUNT8
420	00716	7100	INTEG1.	CLL
421	00717	1104		TAD LOW
422	00720	6211		6211
423	00721	1416		TAD I INDEX2
424	00722	6201		6201
425	00723	7420		SZL
426	00724	2103		ISZ HIGH
427	00725	7000		NOP
428	00726	3104		DCA LOW
429	00727	2113		ISZ COUNT8
430	00730	5316		JMP INTEG1
431	00731	1053		TAD MIN10
432	00732	3115		DCA CONST6
433	00733	1135		TAD ADDRSC7
434	00734	3116		DCA CONST7
435	00735	4200		JMS PNTDEC
436	00736	5541		JMP I RESUME
437				
438	01000	4032	*1000	
439	01001	1100	DSPLAY.	JMS READ
440	01002	1260		TAD HOLD1
441	01003	7710		TAD MINUM
442	01004	5564		SPA CLA
443	01005	1257		JMP I FULDIS
				TAD ADDRSC2

444	01006	3105	DCA	COUNT2
445	01007	3506	DCA	I COUNT2
446	01010	2106	ISZ	COUNT2
447	01011	1062	TAD	M2THOU
448	01012	7040	CMA	
449	01013	3506	DCA	I COUNT2
450	01014	1257	TAD	ADRSC2
451	01015	3106	DCA	COUNT2
452	01016	4543	JMS	I ORGPT
453	01017	4032	DPL2,	JMS READ
454	01020	1100		TAD HOLD1
455	01021	1170		TAD M215
456	01022	7650		SNA CLA
457	01023	5230		JMP DPL1
458	01024	4262		JMS INPUT4
459	01025	3506	DCA	I COUNT2
460	01026	2106	ISZ	COUNT2
461	01027	5217		JMP DPL2
462	01030	1056	DPL1,	TAD LNFEED
463	01031	4147		JMS PRNTIR
464	01032	1070		TAD PLUS4
465	01033	3124	DCA	XCONST
466	01034	1114		TAD SETTING
467	01035	3123	DCA	YORG
468	01036	1070		TAD PLUS4
469	01037	3122	DCA	YCONST
470	01040	1076		TAD LOMARK
471	01041	7041	CMA	IAC
472	01042	3075	DCA	MINLO
473	01043	1077		TAD HIMARK
474	01044	7041	CMA	IAC
475	01045	1076		TAD LOMARK
476	01046	3074	DCA	MINHI
477	01047	1060		TAD M4HUN
478	01050	3120	DCA	INLEAV
479	01051	1066		TAD MINUS4
480	01052	3117	DCA	CONST0
481	01053	1072		TAD MASK63
482	01054	3073	DCA	MASKX
483	01055	3126	DCA	DSPLCE
484	01056	5661		JMP I DSPLPT
485	01057	0076	ADRSC2,	LOMARK
486	01060	7521	MINUM,	-257
487	01061	0400	DSPLPT,	SWEEP1
488	01062	0000	INPUT4,	0 /INPUT 4 DECIMAL
489	01063	1066		TAD MINUS4 /CHARACTERS
490	01064	3373		DCA OR1
491	01065	3121		DCA PRODC
492	01066	4032	IN41,	JMS READ
493	01067	1100		TAD HOLD1
494	01070	0071		AND MASK15
495	01071	1121		TAD PRODC
496	01072	2373		ISZ OR1
497	01073	7410		SKP
498	01074	5662		JMP I INPUT4
499	01075	7104		CLL RAL
500	01076	3121		DCA PRODC
501	01077	1121		TAD PRODC
502	01100	7006		RTL
503	01101	1121		TAD PRODC
504	01102	3121		DCA PRODC
505	01103	5266		JMP IN41
506	01104	1336	PRFULL,	TAD ADRSC4
507	01105	3016		DCA INDEX2
508	01106	5313		JMP FLL
509	01107	7200	CKFULL,	CLA
510	01110	6332		STAA
511	01111	1337		TAD ADRSC5
512	01112	3016		DCA INDEX2
513	01113	1416	FLL,	TAD I INDEX2
514	01114	7450		SNA
515	01115	5320		JMP .+3
516	01116	4147		JMS PRNTIR
517	01117	5313		JMP .-4

518	01120	5541	JMP I RESUME	
519	01121	0303	TABLE6.	0303 /C
520	01122	0314		0314 /L
521	01123	0317		0317 /O
522	01124	0303		0303 /C
523	01125	0313		0313 /K
524	01126	0240		0240 /SPACE
525	01127	0306		0306 /F
526	01130	0325		0325 /U
527	01131	0314		0314 /L
528	01132	0314		0314 /L
529	01133	0215		0215 /CR
530	01134	0212		0212 /LF
531	01135	0000		0000
532	01136	1125	ADRSC4.	TABLE6+4
533	01137	1120	ADRSC5.	TABLE6-1
534	01140	0000	LEADIN.	0 /LEADER-TRAILER
535	01141	1351		TAD COD200
536	01142	7041		CMA IAC
537	01143	3111		DCA COUNT6
538	01144	1351		TAD COD200
539	01145	4037		JMS PUNCIR
540	01146	2111		ISZ COUNT6
541	01147	5344		JMP -3
542	01150	5740		JMP I LEADIN
543	01151	0200	COD200.	0200
544	01152	0000	ORIGIN.	0
545	01153	1100	ORG1.	TAD HOLD1
546	01154	4766		JMS I NUM
547	01155	5360		JMP ORG2
548	01156	4032		JMS READ
549	01157	5153		JMP ORG1
550	01160	0365	ORG2.	AND MK3
551	01161	7112		CLL RTR
552	01162	7010		RAR
553	01163	3114		DCA SETTING
554	01164	5752		JMP I ORIGIN
555	01165	0003	MK3.	0003
556	01166	2351	NUM.	NUMB
557	01167	4032	DSABLE.	JMS READ
558	01170	7200		CLA
559	01171	6332		STAA
560	01172	5544		JMP I RETURN
561	01173	0000	OR1.	0
562			/TAPE2	
563			*1200	
564	01200	1072	EXPAND.	TAD MASK63
565	01201	3073		DCA MASKX
566	01202	1062		TAD M2THOU
567	01203	3120		DCA INLEAV
568	01204	7201		CLA IAC
569	01205	3124		DCA XCONST
570	01206	1076	EXP2.	TAD LOMARK
571	01207	7041		CMA IAC
572	01210	1077		TAD HIMARK
573	01211	7500		SMA
574	01212	5223		JMP EXP1
575	01213	7200		CLA
576	01214	1076		TAD LOMARK
577	01215	3100		DCA HOLD1
578	01216	1077		TAD HIMARK
579	01217	3076		DCA LOMARK
580	01220	1100		TAD HOLD1
581	01221	3077		DCA HIMARK
582	01222	5206		JMP EXP2
583	01223	3074	EXP1.	DCA MINHI
584	01224	1073		TAD MASKX
585	01225	7040		CMA
586	01226	3126		DCA DSPLCE
587	01227	1376		TAD LOMARK
588	01230	7450		SNA
589	01231	5236		JMP EXP3
590	01232	1126	EXP4.	TAD DSPLCE
591	01233	7500		SMA

/NUMB RETURNS HERE IF CHAR IS 0-9.
/OTHERWISE IT RETURNS HERE - COULD CAUSE ENDLESS LOOP

/EXPANSION ROUTINE
/SET UP PARAMTERS
/FOR SWEEP

592	01234	5232		JMP EXP4
593	01235	7041		CMA IAC
594	01236	3126	EXP3,	DCA DSPLCE
595	01237	1074		TAD MINH1
596	01240	7001		IAC
597	01241	7110		CLL RAR
598	01242	7430		SZL
599	01243	7001		IAC
600	01244	7104		CLL RAL
601	01245	3100		DCA HOLD1
602	01246	1100		TAD HOLD1
603	01247	3122		DCA YCONST
604	01250	1122	SHIFT,	TAD YCONST
605	01251	7104		CLL RAL
606	01252	3343		DCA TEMP
607	01253	1343		TAD TEMP
608	01254	1062		TAD M2THOU
609	01255	7700		SMA CLA
610	01256	5303		JMP STOP
611	01257	1343		TAD TEMP
612	01260	3122		DCA YCONST
613	01261	1124		TAD XCONST
614	01262	7104		CLL RAL
615	01263	3124		DCA XCONST
616	01264	1073		TAD MASKX
617	01265	7120		CLL CML
618	01266	7004		RAL
619	01267	3073		DCA MASKX
620	01270	1120		TAD INLEAV
621	01271	7120		CLL CML
622	01272	7010		RAR
623	01273	3120		DCA INLEAV
624	01274	1074		TAD MINH1
625	01275	7104		CLL RAL
626	01276	3074		DCA MINH1
627	01277	1126		TAD DSPLCE
628	01300	7104		CLL RAL
629	01301	3126		DCA DSPLCE
630	01302	5250		JMP SHIFT
631	01303	7040	STOP,	CMA
632	01304	3117		DCA CONST8
633	01305	1120		TAD INLEAV
634	01306	1100		TAD HOLD1
635	01307	7120		CLL CML
636	01310	7010		RAR
637	01311	1076		TAD LOMARK
638	01312	1114		TAD SETTING
639	01313	3123		DCA YORG
640	01314	1062		TAD M2THOU
641	01315	1122		TAD YCONST
642	01316	7120		CLL CML
643	01317	7010		RAR
644	01320	3075		DCA MINLO
645	01321	1074		TAD MINH1
646	01322	7041		CMA IAC
647	01323	3074		DCA MINH1
648	01324	1126		TAD DSPLCE
649	01325	7041		CMA IAC
650	01326	1075		TAD MINLO
651	01327	3126		DCA DSPLCE
652	01330	7001		IAC
653	01331	3122		DCA YCONST
654	01332	1066		TAD MINUS4
655	01333	3115		DCA CONST6
656	01334	1134		TAD ADRS06
657	01335	3116		DCA CONST7
658	01336	1124		TAD XCONST
659	01337	3104		DCA LOW
660	01340	3103		DCA HIGH
661	01341	4542		JMS I OUTPUT
662	01342	5541		JMP I RESUME
663	01343	0000	TEMP,	0
664	01344	0000	SAVACL,	0
665	01345	3127		DCA SAVEAC

666	01146	7010	RAR		
667	01347	3130	DCA SAVLNK		
668	01150	5744	JMP I SAVACL		
669	01351	0000	RESACL, 0		
670	01352	7300	CLA CLL		
671	01353	1130	TAD SAVLNK		
672	01354	7004	RAL		
673	01355	1127	TAD SAVEAC		
674	01356	5751	JMP I RESACL		
675					
676	01400	7200	*1400 PUNCH, CLA		
677	01401	6332	STAR		
678	01402	4633	JMS I LEADER		
679	01403	7240	CLA CMA		
680	01404	1076	TAD LOMARK		
681	01405	1114	TAD SETTING		
682	01406	3016	DCA INDEX2		
683	01407	1077	TAD HIMARK		
684	01410	7040	CMA		
685	01411	1076	TAD LOMARK		
686	01412	3111	DCA COUNT6		
687	01413	3104	DCA LOW		
688	01414	1016	TAD INDEX2		
689	01415	7120	CLL CML		
690	01416	4565	JMS I BNPCH	/PUNCH BEGINNING ADDRESS	
691	01417	6211	PUN1, 6211		
692	01420	1416	TAD I INDEX2		
693	01421	6201	6201		
694	01422	7100	CLL		
695	01423	4565	JMS I BNPCH	/PUNCH CHANNEL COUNT	
696	01424	2111	ISZ COUNT6		
697	01425	5217	JMP PUN1		
698	01426	7100	CLL		
699	01427	1104	TAD LOW		
700	01430	4565	JMS I BNPCH	/PUNCH CHECK SUM	
701	01431	4633	JMS I LEADER		
702	01432	5341	JMP I RESUME		
703	01433	1140	LEADER, LEADIN		
704	01434	5336	MEANSO, JMP I ERROR	/EXPANDABLE COMMAND	
705	01435	1322	BEGCOM, TAD LIT1	/GET F.RST COMMAND	
706	01436	1030	DCA 0		
707	01437	3127	DCA SAVEAC		
708	01440	1130	DCA SAVLNK		
709	01441	5243	JMP STTCOM		
710	01442	5242	JMP		
711	01443	4276	STTCOM, JMS FIXBUF	/START OF COMMAND	
712	01444	1323	TAD LIT2		
713	01445	3145	DCA RETURN+1		
714	01446	4305	DECODE, JMS READ2	/PROCESS CHAR	
715	01447	1100	TAD HOLD1		
716	01450	3414	DCA I 14	/INTQ BUFFER	
717	01451	1100	TAD HOLD1		
718	01452	1324	TAD LIT3		
719	01453	7650	SNA CLA	/CARRIAGE RETURN?	
720	01454	5267	JMP ENDCOM	/YES	
721	01455	2332	ISZ BUFCNT		
722	01456	5021	JMP CONTIN		
723	01457	4276	JMS FIXBUF		
724	01460	1325	TAD LIT4	/BUFFER IS FULL SO	
725	01461	4147	JMS PRNTIR	/IT IS ILLEGAL	
726	01462	1057	DECODE, TAD CARRTN		
727	01463	4147	JMS PRNTIR		
728	01464	1056	TAD LNFEED		
729	01465	4147	JMS PRNTIR		
730	01466	5544	JMP I RETURN		
731	01467	4276	ENDCOM, JMS FIXBUF		
732	01470	4032	JMS READ		
733	01471	1326	TAD LIT5		
734	01472	3145	DCA RETURN+1		
735	01473	1056	TAD LNFEED		
736	01474	4147	JMS PRNTIR		
737	01475	5730	JMP I LIT7	/EXECUTE COMMAND	
738	01476	0000	FIXBUF, 0	/FIX BUFFER PARAMS	
739	01477	7200	CLA		

740	01500	1327		TAD LIT6	
741	01501	3014		DCA 14	
742	01502	1331		TAD MBFCNT	
743	01503	3332		DCA BUFCNT	
744	01504	5676		JMP I FIXBUF	
745	01505	0000	READ2,	0	/KEYBOARD INPUT
746	01506	6031		KSF	
747	01507	5306		JMP .-1	
748	01510	6036		KRB	
749	01511	3100		DCA HOLD1	
750	01512	1100		TAD HOLD1	
751	01513	4147		JMS PRNTIR	
752	01514	1100		TAD HOLD1	
753	01515	1067		TAD MRBOUT	
754	01516	7640		SZA CLA	
755	01517	5705		JMP I READ2	
756	01520	4276		JMS FIXBUF	
757	01521	5262		JMP DECOD2	
758	01522	1442	LIT1,	STTCOM-1	
759	01523	1446	LIT2,	DECODE	
760	01524	7563	LIT3,	7563	
761	01525	0277	LIT4,	0277	
762	01526	1443	LIT5,	STTCOM	
763	01527	1610	LIT6,	BUFAD-1	
764	01530	0210	LIT7,	CMMDAND+1	
765	01531	7756	MBFCNT,	7756	/17 CHARACTERS ALLOWED
766	01532	0000	BUFCNT,	0	
767			*1600		
768	01600	6326	ADATA,	ARR	/ADC HANDLER NOT USED FOR ACOUSTIC SYSTEM
769	01601	3102		DCA HOLD3	
770	01602	6211		6211	
771	01603	2502		ISZ I HOLD3	
772	01604	5207		JMP ADT	
773	01605	6201		6201	
774	01606	5540		JMP I FULL	
775	01607	6201	ADT,	6201	
776	01610	5021		JMP CONTIN	
777	01611	0000	BUFAD,	0	
778	01612	0000		0	
779	01613	0000		0	
780	01614	0000		0	
781	01615	0000		0	
782	01616	0000		0	
783	01617	0000		0	
784	01620	0000		0	
785	01621	0000		0	
786	01622	0000		0	
787	01623	0000		0	
788	01624	0000		0	
789	01625	0000		0	
790	01626	0000		0	
791	01627	0000		0	
792	01630	0000		0	
793	01631	0000		0	
794	01632	7200	WRITE,	CLA	
795	01633	6332		STAA	
796	01634	1076		TAD LOMARK	
797	01635	1114		TAD SETNG	
798	01636	3110		DCA COUNT5	/COUNT5-BEGINNING ADS OF DATA
799	01637	1056		TAD LNFEED	
800	01640	4147		JMS PRNTIR	
801	01641	1077		TAD HIMARK	
802	01642	1114		TAD SETNG	
803	01643	7041		CIA	
804	01644	3111		DCA COUNT6	/COUNT6=NUMBER OF CHANNELS TO PRINTED
805	01645	3103		DCA HIGH	
806	01646	1313	GO1,	TAD M5	
807	01647	3112		DCA COUNT7	
808	01650	1134		TAD ADRSC6	
809	01651	3116		DCA CONST7	
810	01652	1066		TAD MINUS4	
811	01653	3115		DCA CONST6	/SET CONST6 "0 SINGLE PRECISION

812	01654	1114	TAD SETTING	/SUBTRACT THE BEGINNING ADDRESS OF THE
813	01655	7041	CIA	/QUADRANT FROM THE ADDRESS OF THE CELLS
814	01656	1110	TAD COUNTS	/BEING PRINTED
815	01657	3104	DCA LOW	
816	01660	4542	JMS I OUTPUT	/PRINT CHANNEL NUMBER
817	01661	1066	TAD MINUS4	
818	01662	4715	JMS I DECC	
819	01663	6211	GO2,	
820	01664	1510	TAD I COUNTS	
821	01665	6201	S201	
822	01666	3104	DCA LOW	
823	01667	3103	DCA HIGH	
824	01670	1134	TAD ADRES06	
825	01671	3116	DCA CONST7	
826	01672	1066	TAD MINUS4	
827	01673	3115	DCA CONST6	
828	01674	4542	JMS I OUTPUT	/PRINT CHANNEL COUNTS
829	01675	1066	TAD MINUS4	
830	01676	4715	JMS I DECC	
831	01677	1111	TAD COUNT6	
832	01700	1110	TAD COUNT5	
833	01701	7650	SNA CLA	
834	01702	5316	JMP RE1	
835	01703	2110	ISZ COUNT5	
836	01704	2112	ISZ COUNT7	
837	01705	5263	JMP GO2	
838	01706	1057	TAD CARRTN	
839	01707	4147	JMS PRNTIR	
840	01710	1056	TAD LNFEED	
841	01711	4147	JMS PRNTIR	
842	01712	5246	JMP GO1	
843	01713	7773	MS,	
844	01714	0000	TEM,	
845	01715	0621	DECC,	
846	01716	1057	RE1,	
847	01717	4147	TAD CARRTN	
848	01720	1056	JMS PRNTIR	
849	01721	4147	TAD LNFEED	
850	01722	5021	JMS PRNTIR	
851	01723	4543	JMP CONTIN	
852	01724	1131	JMS I ORGPT	
853	01725	7640	TAD CLOCK1	
854	01726	5336	S2A CLA	
855	01727	1132	JMP EN1	
856	01730	7640	TAD CLOCK2	
857	01731	5336	S2A CLA	
858	01732	1743	JMP EN1	
859	01733	3131	TAD I CLC1	
860	01734	1744	DCA CLOCK1	
861	01735	3132	TAD I CLC2	
862	01736	1166	DCA CLOCK2	
863	01737	6332	TAD ENBWRD	
864	01740	6344	EN1,	
865	01741	7200	STAR	
866	01742	5544	ATC	
867	01743	2300	CLA	
868	01744	2301	JMP I RETURN	
869	01745	0000	CLCON1	
870	01746	3360	CLCON2	
871	01747	1061	DPOINT,	
872	01750	1360	0	
873	01751	6054	DCA SAVE	/DISPLAY DATA POINT
874	01752	6052	TAD OFFSET	/ADD IN OFFSET
875	01753	5152	TAD SAVE	
876	01754	6055	DYS	
877	01755	7200	DISD	/WAIT TILL COMPLETION
878	01756	1360	JMP -1	
879	01757	5745	DIKY	/INTENSIFY
880	01760	0000	CLA	
881	02000	0000	TAD SAVE	/RESTORE AC
882	02001	6211	JMP I DPOINT	
883	02002	1521	0	
884	02003	6201	SAVE,	
885	02004	6201	*2000	
			SLM,	
			0	
			6211	
			TAD I PRODUCT	
			6201	

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886 02004 3222 DCA CN1
887 02005 1156 TAD SWIT
888 02006 0332 AND MK0007
889 02007 3224 DCA TEMAD
890 02010 1224 TAD TEMAD
891 02011 1235 TAD MINUS7
892 02012 7700 SMA CLA
893 02013 5625 JMP I BEF
894 02014 1224 TAD TEMAD
895 02015 1223 TAD CONAD
896 02016 3224 DCA TEMAD
897 02017 1624 TAD I TEMAD
898 02020 3224 DCA TEMAD
899 02021 5624 JMP I TEMAD
900 02022 0000 CN1, 0
901 02023 2025 CONAD, BEF
902 02024 0000 TEMAD, 0
903 02025 2036 BEF, SLML0 /64 COUNTS FULL SCALE
904 02026 2050 SLML1 /128 COUNTS FULL SCALE
905 02027 2062 SLML2 /256 COUNTS FULL SCALE
906 02030 2073 SLML3 /512 COUNTS FULL SCALE
907 02031 2104 SLML4 /1024 COUNTS FULL SCALE
908 02032 2114 SLML5 /2048 COUNTS FULL SCALE
909 02033 2125 SLM0 /4096 COUNTS FULL SCALE AND SO ON
910 02034 1777 MK1777, 1777
911 02035 7771 MINUS7, 7771
912 / IN SSLJ ABOVE, THE RIGHT MOST 3 BITS OF THE SWITCH REGISTER ARE
913 / READ. THE VALUE (SWIT) DETERMINES WHICH Y EXPANSION PROGRAM TO
914 / EXECUTE. ALL SWITCHES DOWN=64 COUNTS, 1=128, 2=256, 3=512,
915 / 4=1024, 5=2048, 6=4096
916 /
917 / DECIMAL OCTAL OCTAL RANGE SCALING FACTOR
918 / 0 64 100 0-77 *16
919 / 1 128 200 0-177 * 8
920 / 2 256 400 0-377 * 4
921 / 3 512 1000 0-777 * 2
922 / 4 1024 2000 0-1777 NO SCALING
923 / 5 2048 4000 0-3777 / 2
924 / 6 4096 10000 0-7777 / 4
925 /
926 / BASED ON SCREEN RESOLUTION OF 1024 POINTS
927 SLML0, TAD CN1 /64 COUNTS FULL SCALE
928 02037 0173 AND M7700 /MASK OFF BITS 6-11, A ZERO AC MEANS
929 02040 7650 SNA CLA / THAT CN1 IS WITHIN RANGE
930 02041 5244 JMP .+3
931 02042 1333 TAD C0077 /CN1 IS OUTSIDE RANGE, DISPLAY MAXIMUM
932 02043 7410 SKP
933 02044 1222 TAD CN1
934 02045 7106 CLL RTL /MULTIPLY BY 16
935 02046 7006 RTL
936 02047 5327 JMP SLMEND
937 /
938 02050 1222 SLML1, TAD CN1 /128 COUNTS FULL SCALE
939 02051 0331 AND M7600 /MASK OFF BITS 5-11
940 02052 7650 SNA CLA
941 02053 5256 JMP .+3
942 02054 1334 TAD C0177
943 02055 7410 SKP
944 02056 1222 TAD CN1
945 02057 7106 CLL RTL /MULTIPLY BY 8
946 02060 7004 RPL
947 02061 5327 JMP SLMEND
948 /
949 02062 1222 SLML2, TAD CN1 /256 COUNTS FULL SCALE
950 02063 0060 AND M4HUN /MASK OFF BITS 4-11 (M4HUN=7400)
951 02064 7650 SNA CLA
952 02065 5270 JMP .+3
953 02066 1335 TAD C0377
954 02067 7410 SKP
955 02070 1222 TAD CN1
956 02071 7106 CLL RTL /MULTIPLY BY 4
957 02072 5327 JMP SLMEND
958 /
959 02073 1222 SLML3, TAD CN1 /512 COUNTS FULL SCALE

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960	02074	0061	AND	M1THOU	/MASK OFF BITS 3-11 (M1THOU=7000)
961	02075	7650	SNA	CLA	
962	02076	5301	JMP	+3	
963	02077	1336	TAD	C0777	
964	02100	7410	SKP		
965	02101	1222	TAD	CN1	/MULTIPLY BY 2
966	02102	7104	CLL	RAL	
967	02103	5327	JMP	SLMEND	
968			/		
969	02104	1222	SLML4,	TAD CN1	/1024 COUNTS FULL SCALE
970	02105	0062	AND	M2THOU	/MASK OFF BITS 2-11 (M2THOU=6000)
971	02106	7650	SNA	CLA	
972	02107	5312	JMP	+3	
973	02110	1337	TAD	C1777	
974	02111	7410	SKP		
975	02112	1222	TAD	CN1	/NO SCFLING
976	02113	5327	JMP	SLMEND	
977			/		
978	02114	1222	SLML5,	TAD CN1	/2048 COUNTS FULL SCALE
979	02115	0157	AND	M4THOU	/MASK OFF BITS 1-11 (M4THOU=4000)
980	02116	7650	SNA	CLA	
981	02117	5322	JMP	+3	
982	02120	1777	TAD	C3777	
983	02121	7410	SKP		
984	02122	1222	TAD	CN1	/DIVIDE BY 2
985	02123	7110	CLL	RAR	
986	02124	5327	JMP	SLMEND	
987			/		
988	02125	1222	SLM0,	TAD CN1	/4096 COUNTS FULL SCALE
989	02126	7112	CLL	RTR	/DIVIDE BY 4
990			/		
991	02127	4741	SLMEND,	JMS I DPOINT	/DEPOSIT POINT
992	02130	5600	JMP	I SLM	/RETURN TO CALLING PROGRAM
993			/		
994	02131	7600	M7600,	7600	
995	02132	0007	MK0007,	0007	
996	02132	0077	C0077,	0077	
997	02134	0177	C0177,	0177	
998	02135	0377	C0377,	0377	
999	02136	0777	C0777,	0777	
1000	02137	1777	C1777,	1777	
1001	02140	3777	K3777,	3777	
1002	02141	1745	DPOINT,	DPOINT	
1003	02177	2727	*2200		
1004			/LOAD THE LIVE TIME CLOCK		
1005	02230	7200	CLKLD,	CLA	
1006	02201	3171	DCA	CLOCK1	
1007	02202	3172	DCA	CLOCK2	
1008	02203	3272	DCA	LL1	
1009	02204	3273	DCA	HH1	
1010	02205	4032	CLKL2,	JMS READ	
1011	02206	1100	TAD	HOLD1	
1012	02207	1171	TAD	M240	
1013	02210	7650	SNA	CLA	
1014	02211	5205	JMP	CLKL2	
1015	02212	1100	TAD	HOLD1	
1016	02213	1170	TAD	M215	
1017	02214	7450	SNA		
1018	02215	5263	JMP	CLKL3	
1019	02216	7300	CLA	CLL	
1020	02217	1272	TAD	LL1	
1021	02220	7004	RAL		
1022	02221	3274	DCA	TM1	
1023	02222	1273	TAD	HH1	
1024	02223	7004	RAL		
1025	02224	3277	DCA	TH1	
1026	02225	7100	CLL		
1027	02226	1274	TAD	TM1	
1028	02227	7004	RAL		
1029	02230	3275	DCA	TM2	
1030	02231	1277	TAD	TH1	
1031	02232	7004	RAL		
1032	02233	3273	DCA	HH1	
1033	02234	7100	CLL		

1034	02235	1275	TAD	TM2
1035	02236	7004	RAL	
1036	02237	3276	DCA	TM3
1037	02240	1273	TAD	HH1
1038	02241	7004	RAL	
1039	02242	3273	DCA	HH1
1040	02243	7100	CLL	
1041	02244	1274	TAD	TM1
1042	02245	1276	TAD	TM3
1043	02246	3272	DCA	LL1
1044	02247	7004	RAL	
1045	02250	1277	TAD	TM1
1046	02251	1273	TAD	HH1
1047	02252	3273	DCA	HH1
1048	02253	1100	TAD	HOLD1
1049	02254	1167	TAD	M260
1050	02255	7100	CLL	
1051	02256	1272	TAD	LL1
1052	02257	3272	DCA	LL1
1053	02260	7430	ISZ	HH1
1054	02261	2273	JMP	CLKL2
1055	02262	5205	TAD	HH1
1056	02263	1273	CLKL3,	
1057	02264	7040	CMA	
1058	02265	3301	DCA	CLCON2
1059	02266	1272	TAD	LL1
1060	02267	7041	CIA	
1061	02270	3300	DCA	CLCON1
1062	02271	5544	JMP	I RETURN
1063	02272	0000	LL1,	0
1064	02273	0000	HH1,	0
1065	02274	0000	TM1,	0
1066	02275	0000	TM2,	0
1067	02276	0000	TM3,	0
1068	02277	0000	TH1,	0
1069	02300	0000	CLCON1,	0
1070	02301	0000	CLCON2,	0
1071	02302	6001	DISFL,	ION
1072	02303	7604	CLA	OSR
1073	02304	3156	DCA	SWIT
1074	02305	7100	CLL	
1075	02306	3347	DCA	LOC
1076	02307	1066	TAD	MINUS4
1077	02310	3121	DCA	PRODC
1078	02311	1062	TAD	M2THOU
1079	02312	3350	DCA	LOK
1080	02313	1347	DF1,	TAD LOC
1081	02314	1061	TAD	OFFSET
1082	02315	6053	DXL	
1083	02316	7200	CLA	
1084	02317	1347	TAD	LOC
1085	02320	0346	AND	MAKS
1086	02321	7650	SNA	CLA
1087	02322	5334	JMP	VERMK
1088	02323	1121	TAD	PRODC
1089	02324	1070	TAD	PLUS4
1090	02325	3121	DCA	PRODC
1091	02326	4555	JMS	I TE1
1092	02327	2347	DF2,	ISZ LOC
1093	02330	7200	CLA	
1094	02331	2350	ISZ	LOK
1095	02332	5313	JMP	DF1
1096	02333	5302	JMP	DISFL
1097	02334	1070	VERMK,	TAD PLUS4
1098	02335	1121	TAD	PRODC
1099	02336	3121	DCA	PRODC
1100	02337	1064	TAD	P2THOU
1101	02340	7100	VERM,	CLL
1102	02341	1054	TAD	MIN20
1103	02342	7420	SNL	
1104	02343	5327	JMP	DF2
1105	02344	4766	JMS	I DPINT
1106	02345	5340	JMP	VERM
1107	02346	0377	MAKS,	0377

1108	02347	0000	LOC.	0	
1109	02350	0000	LOK.	0	
1110	02351	0000	NUMB.	0	
1111	02352	1167		TAD M260	
1112	02353	7510		SPA	
1113	02354	5362		JMP OTT	
1114	02355	1364		TAD M12	
1115	02356	7500		SMA	
1116	02357	5362		JMP OTT	
1117	02360	1365		TAD P12	
1118	02361	5751		JMP I NUMB	
1119	02362	2351	OTT.	ISZ NUMB	
1120	02363	5751		JMP I NUMB	
1121	02364	7766	M12.	-12	
1122	02365	0012	P12.	12	
1123	02366	1745	DPINT.	DPOINT	
1124			*2400		
1125					/ DECTAPE I/O ROUTINE FOR SINGSP
1126	02400	7700	DECAD.	CLA CLL	/NUMBERS INPUT ARE OCTAL
1127	02401	1000		TAD 0	
1128	02402	3352		DCA ZPC	/SAVE PC
1129	02403	1127		TAD SAVEAC	
1130	02404	3350		DCA ZAC	/SAVE AC
1131	02405	1170		TAD SAVLNK	
1132	02406	3351		DCA ZLNK	/SAVE LINK
1133	02407	6332		STAA	/TURN OFF DATA ACQUISITION
1134	02410	3311		DCA TSTOR	
1135	02411	1160		TAD M2	
1136	02412	3313		DCA DGENT	/NUMBER OF DIGITS
1137	02413	1220		TAD MODE1	
1138	02414	3325		DCA MODE2	
1139	02415	7700	SPCHK.	CLA CLL	/FILTER OUT SPACES
1140	02416	4032		JMS READ	
1141	02417	1100		TAD HOLD1	
1142	02420	1171		TAD M240	
1143	02421	7640		SZA CLA	
1144	02422	7410		SKP	
1145	02423	5215		JMP SPCHK	
1146	02424	1100	RETN1.	TAD HOLD1	
1147	02425	1170		TAD M215	/CHECK CR
1148	02426	7640		SZA CLA	
1149	02427	7410		SKP	
1150	02430	5706		JMP I ERR	/CR HERE IS AN ERROR
1151	02431	1100		TAD HOLD1	/CHECK FOR NUMBER
1152	02432	1167		TAD M260	
1153	02433	7510		SPA	
1154	02434	5215		JMP SPCHK	/SPACE?
1155	02435	7200		CLA	
1156	02436	1100		TAD HOLD1	
1157	02437	1715		TAD M267	
1158	02440	7540		SMA SZA	
1159	02441	5215		JMP SPCHK	
1160	02442	7300		CLA CLL	/NUMBER
1161	02443	1100		TAD HOLD1	
1162	02444	1167		TAD M260	/STRIP ASCII
1163	02445	2313		ISZ DGENT	/ONLY 2 DIGITS ALLOWED
1164	02446	7410		SKP	
1165	02447	5262		JMP DOCONV	/AFTER 2 DIGITS
1166	02450	3307		DCA TE3	/STORE DIGIT
1167	02451	4032		JMS READ	
1168	02452	1100		TAD HOLD1	
1169	02453	1171		TAD M240	
1170	02454	7640		SZA CLA	/SPACE TERMINATES, OTHERWISE CHECK NUMBER
1171	02455	5224		JMP RETN1	
1172	02456	1307		TAD TE3	
1173	02457	3310		DCA TE4	/LOW ORDER
1174	02460	3307		DCA TE3	/ZERO HIGH ORDER
1175	02461	7410		SKP	
1176	02462	3310	DOCONV.	DCA TE4	/STORE LAST NUMBER
1177	02463	3310		TAD TE4	
1178	02464	7300		CLA CLL	/NO. FORM BINARY NUMBER
1179	02465	1307		TAD TE3	
1180	02466	7004		RAL	
1181	02467	3307		DCA TE3	

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1182 02470 1307 TAD TE3
1183 02471 7006 RTL
1184 02472 1307 TAD TE3
1185 02473 1310 TAD TE4 /AC=OCTAL EQUIVALENT OF THE BLOCK NUMBER READ
1186 02474 7106 DECAD2, CIL RTL /MULTIPLY THE BLOCK NUMBER BY 40(OCT)
1187 02475 7006 RTL
1188 02476 7004 RAL
1189 02477 3322 DCA BLKN1 /BLKN1=STARTING BLOCK NUMBER
1190 02500 7430 SZL
1191 02501 5706 JMP I ERR
1192 02502 1322 TAD BLKN1
1193 02503 1316 TAD C20
1194 02504 3327 DCA BLKN2
1195 02505 5317 JMP DECADB
1196 02506 1457 ERR, DECODE+11
1197 02507 0000 TE3, 0
1198 02510 0000 TE4, 0
1199 02511 0000 TSTOR, 0
1200 02512 7777 M1, -1
1201 02513 0000 DGCNT, 0
1202 02514 0000 NMCNT, 0
1203 02515 7511 M267, -267
1204 02516 0020 C20, 20
1205 02517 4753 DECADB, JMS I DTA /TRANSFER 4000 WORDS (20 PAGES)
1206 02520 6011 MODE1, 6011 /16 BLOCKS, 129 WORDS/BLOCK, START
/ FORWARD, FIELD 1.
1207 02521 0000 0000 /CORE START ADDRESS
1208 02522 0000 BLKN1, 0000 /STARTING BLOCK NUMBER
1209 02523 5536 JMP I ERROR /EXIT ON ERROR
1210 02524 4753 JMS I DTA /2 CALLS ARE REQUIRED BECAUSE OF
/ NUMBER OF BLOCKS IS SO LARGE.
1211
1212
1213 02525 6011 MODE2, 6011
1214 02526 4000 4000
1215 02527 0000 BLKN2, 0000
1216 02530 5536 JMP I ERROR
1217 02531 5336 JMP RESTOR /JMP TO RESTORE INTERRUPT RETURN
1218 02532 7300 DECAD5, CLA CIL /HERE FOR READ OPERATION
1219 02533 1355 TAD RMODE
1220 02534 3320 DCA MODE1 /CHANGE ADDRESS
1221 02535 5200 JMP DECAD
1222 02536 7300 RESTOR, CLA CIL
1223 02537 1354 TAD WMODE /RESTORE
1224 02540 3320 DCA MODE1
1225 02541 1352 TAD ZPC
1226 02542 3000 DCA 0
1227 02543 1350 TAD ZAC
1228 02544 3127 DCA SAVEAC
1229 02545 1351 TAD ZLNK
1230 02546 3130 DCA SAVLNK
1231 02547 5544 JMP I RETURN
1232 02550 0000 ZAC, 0
1233 02551 0000 ZLNK, 0
1234 02552 0000 ZPC, 0
1235 02553 6204 DTA, DTA1
1236 02554 6011 WMODE, 6011
1237 02555 2011 RMODE, 2011
1238 02556 7767 NOTTEN, 7767
1239 *2600
1240 /
1241 /
1242 /THIS IS THE INTERRUPT HANDLER FOR THE ACOUSTIC EMISSION INTERFACE
1243 /INTRY LOCATION IS ACSTIC
1244 /TEST IS MADE FOR WHICH COUNTER IF ANY CAUSED THE INTERRUPT
1245 /THE ONE CAUSING THE INTERRUPT IS PROCESSED ALL ARE RETESTED
1246 /UNTIL ALL X,Y,Z THAT ARE READY HAVE BEEN READ
1247 /THE ENTIRE INTERFACE IS CLEARED WITH ARST AND THE INTERFACE IS READY
1248 /FOR A NEW INPUT WHEN A COUNTER IS READ IT CLEARS THE FLAG SO
1249 /ON RETEST IT IS CLEARED
1250 /THE COUNTING BUFFER IS DIVIDED INTO 3 1024(-512 TO 512) BUFFERS FOR
1251 /X,Y,Z. X=0 IS AT LOCATION 4096 +512, Y=0 AT LOCATION 4096+1536
1252 /AND Z=0 AT LOCATION 4096 +2560
1253 02600 7000 ACSTIC, NOP
1254 02601 6143 AXF /IS X COUNTER READY
1255 02602 5204 JMP .+2 /NO

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1256 02603 5224 JMP XSUBR /YES?
1257 02604 6145 AZF /NO IS Y COUNTER READY
1258 02605 5207 JMP +2 /NO
1259 02606 5250 JMP YSUBR /YES
1260 02607 6144 AYF /NO IS Z COUNTER READY
1261 02610 5212 JMP +2 /NO
1262 02611 5236 JMP ZSUBR /YES
1263 02612 7200 CLA
1264 02613 1330 TAD FLAG1
1265 02614 7510 SPA /IS FLAG RESET SET=7777, RESET=0 SET MEANS NO X,Y,Z CONTR READY
1266 02615 5222 JMP FINISH+1
1267 02616 6146 ARST /FLAG IS RESET CLEAR ACOUSTIC INTERFACE
1268 02617 7240 CLA CMA /PUT 7777 IN AC
1269 02620 3330 DCA FLAG1 /SET FLAG1 SO NO RESET UNTIL SOME COUNTER FLAG SET
1270 02621 5021 FINISH, JMP CONTIN /RETURN TO PROGRAM THAT WAS INTERRUPTED
1271 02622 7200 CLA /CLEAR AC AND GO TO CHECK
1272 02623 5005 JMP INTRTY /TELETYPE FOR INTERRUPT
1273 02624 7200 XSUBR, CLA
1274 02625 3330 DCA FLAG1 /RESET FLAG1
1275 02626 1323 TAD CS1000 /GET 512=1024 OCTAL
1276 02627 3326 DCA CONST /STORE IN CONST FOR LATER
1277 02630 1331 TAD ADX /GET BEGINNING ADS FOR 4TH QUADRANT
1278 02631 3317 DCA CONST4
1279 02632 1332 TAD RX
1280 02633 3340 DCA SPAN
1281 02634 6140 AXR /READ X COUNTER
1282 02635 5262 JMP SIGN
1283 02636 7200 ZSUBR, CLA
1284 02637 3330 DCA FLAG1 /RESET FLAG1
1285 02640 1324 TAD C3000 /GET 1536=3000 OCTAL
1286 02641 3326 DCA CONST /STORE IN CONST FOR LATER
1287 02642 1333 TAD ADZ
1288 02643 3317 DCA CONST4
1289 02644 1334 TAD RZ
1290 02645 3340 DCA SPAN
1291 02646 6142 AZR /READ Z COUNTER
1292 02647 5202 JMP SIGN
1293 02650 7200 YSUBR, CLA
1294 02651 3330 DCA FLAG1 /RESET FLAG1
1295 02652 1325 TAD C5000 /GET 2560=5000 OCTAL
1296 02653 3326 DCA CONST /STORE IN CONST FOR LATER
1297 02654 1335 TAD ADY
1298 02655 3337 DCA CONST4
1299 02656 1336 TAD RY
1300 02657 3340 DCA SPAN
1301 02660 6141 AYR /READ Y COUNTER
1302 02661 5262 JMP SIGN
1303 /THE NUMBER READ FROM THE ACOUSTIC INTERFACE BY THE ABOVE ROUTINES
1304 /COMES INTO THE AC AS A SIGN MAGNITUDE NUMBER THE SIGN FOR POSITIVE
1305 /NUMBERS IS A 0 IN THE LEFT MOST BIT 1 IN THE LEFT MOST BIT
1306 /IS A NEGATIVE NUMBER THE FOLLOWING SIGN ROUTINE CONVERTS THE
1307 /SIGN MAGNITUDE NUMBER TO A TWO'S COMPLEMENT NUMBER
1308 /THIS NUMBER RANGES BETWEEN -512 TO +512 A CONSTANT IS ADDED TO
1309 /THIS NUMBER TO FORM THE ADDRESS TO INCREMENT
1310 /THE CONSTANT IS 512 FOR AND X INPUT A 1536 FOR Z INPUT AND 2560 FOR Y INPUT
1311 02662 3342 SIGN, DCA VALUE /SAVE READING
1312 02663 1342 TAD VALUE
1313 02664 7500 SMA /IS COUNTER NEGATIVE NUMBER A0=1
1314 02665 5270 JMP +3 /NO, ITS POSITIVE
1315 02666 0327 AND C3777 /YES, MASK OUT NEGATIVE SIGN BIT
1316 02667 7041 CIA /NEGATIVE NUMBER, GET 2'S COMPLEMENT
1317 02670 3161 DCA TEM1 /SAVE
1318 02671 1341 TAD FLAG4
1319 02672 7650 SNA CLA
1320 02673 5307 JMP NQUAD /4TH QUADRANT IS DISABLED, FLAG4=0
1321 02674 1342 TAD VALUE
1322 02675 0327 AND C3777 /ADD THE RANGE TO THE 2'S COMPLEMENT
1323 02676 7041 CIA /OF THE READING, A NUMBER WITHIN RANGE
1324 02677 7100 CLL /WILL SET THE LINK
1325 02700 1340 TAD SPAN
1326 02701 7430 SNL
1327 02702 5307 JMP NQUAD /READING IS OUT OF RANGE
1328 /INCREMENT POPER CELL IN THE 4TH QUADRANT
1329 02703 7300 CLA CLL

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1330 02704 1337 TAD CONST4 /GET ADDRESS CONSTANT SET BY INPUT ROUTINE
1331 02705 4313 JMS ADDCST
1332 02706 6201 CDF0
1333 /INCREMENT PROPER QUADRANT
1334 02707 1126 NQUAD, TAD CONST
1335 02710 4313 JMS ADDCST
1336 02711 6201 CDF0
1337 02712 5200 JMP ACSTIC /CHECK LOOP AGAIN
1338
1339 02713 0000 ADDCST, 0
1340 02714 1161 TAD TEM1
1341 02715 3102 DCA HOLD3 /STORE ADDRESS TO DEPOSIT IN CORE
1342 02716 6211 CDF1 /INCREMENT LEAST SIGNIFICANT 12 BITS
1343 02717 2502 ISZ I HOLD3 /SKIP IF OVERFLOW
1344 02720 5713 JMP I ADDCST
1345 02721 6201 CDF0
1346 02722 5540 JMP I FULL /OVERFLOW, PRINT MESSAGE
1347
1348 02723 1000 CS1000, 1000
1349 02724 3000 CS000, 3000
1350 02725 5000 CS000, 5000
1351 02726 0000 CONST, 0
1352 02727 3777 C3777, 3777
1353 02730 7777 FLAG1, 7777
1354 02731 0000 ADX, 0
1355 02732 0000 RX, 0
1356 02733 0000 ADZ, 0
1357 02734 0000 RZ, 0
1358 02735 0000 ADY, 0
1359 02736 0000 RY, 0
1360 02737 0000 CONST4, 0
1361 02740 0000 SPAN, 0
1362 02741 0000 FLAG4, 0
1363 02742 0000 VALUE, 0
1364
1365
1366 /TD83 DECTAPE ROUTINE
1367 /JULY 2 1971 GB/RL/EF
1368 /COPYRIGHT 1971 DIGITAL EQUIPMENT CORP.
1369 / MAYNARD, MASS.
1370
1371 /ABSTRACT--
1372 / THE ROUTINE DESCRIBED AND LISTED HERE IS A GENERAL
1373 /DATA HANDLER FOR THE TD8E DECTAPE SYSTEM. THE ROUTINE
1374 /CONTAINS SEARCH, READ, AND WRITE FUNCTIONS IN A FORMAT
1375 /WHICH IS COMPATIBLE WITH PS/8 DEVICE HANDLER CALLING
1376 /SEQUENCES.
1377 /THIS ROUTINE CAN BE RE-EDITED AND ASSEMBLED TO PRODUCE
1378 /VARIANTS ON THE BASIC TD8E SYSTEM ASSEMBLY PARAMETERS
1379 /CONTROL
1380 /A) WHAT DRIVES (UNITS 0-7) WILL BE USED
1381 /B) THE ORIGIN OF THE TWO PAGE ROUTINE
1382 /C) WHAT MEMORY FIELD THE ROUTINE WILL RUN IN
1383 /D) THE SIZE OF THE DECTAPE BLOCK TO BE READ/Written
1384 /FOLLOWING ARE THE PARAMETERS SET UP FOR THE STANDARD
1385 /DEC VERSION OF THIS ROUTINE
1386 DRIVE=10 /UNITS 0 AND 1 SELECTED
1387 ORIG=6200 /ENTRIES AT 7200 AND 7204
1388 AFIELD=0 /INITIAL FIELD SETTING
1389 MFIELD=00 /AFIELD*10=MFIELD
1390 WDSBLK=201 /129 WORDS PER BLOCK
1391
1392 /THE USE OF THE PARAMETERS IS AS FOLLOWS:
1393 / DRIVE: DRIVE DETERMINES WHICH UNITS WILL BE SELECTED
1394 / DRIVE=10 IMPLIES UNITS 0 & 1
1395 / DRIVE=20 IMPLIES UNITS 2 & 3
1396 / DRIVE=30 IMPLIES UNITS 4 & 5
1397 / DRIVE=40 IMPLIES UNITS 6 & 7
1398 /ORIG: ALTERING ORIG CAUSES ASSEMBLY IN A DIFFERENT
1399 / MEMORY LOCATION. WHEN CHANGING ORIG KEEP IN MIND
1400 /THAT THIS IS A TWO PAGE ROUTINE
1401 /AFIELD: AFIELD DETERMINES THE INITIAL FIELD SETTING FOR THE
1402 / LOADER. PERMISSIBLE VALUES FOR AFIELD ARE 0 TO 7.
1403 /MFIELD: MFIELD IS USED IN A CIF CDF MFIELD INSTRUCTION
1404 / THE VALUE INSERTED FOR MFIELD SHOULD BE 10(8) TIMES
1405 / THE VALUE FOR AFIELD. THE PERMISSIBLE VALUES ARE 00-70.

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1404 /WDSBLK: WDSBLK GOVERNS HOW MANY WORDS THE ROUTINE THINKS ARE
1405 / IN A DECTAPE BLOCK THE STANDARD VALUE IS 201(8) OR
1406 / 128 DECIMAL NOTE THAT THE FUNCTION WORD BIT 10 CAN
1407 / BE USED TO SUBTRACT ONE FROM WDSBLK THE VALUE USED
1408 / FOR WDSBLK SHOULD BE THE NUMBER OF WORDS THE TAPE WAS
1409 / FORMATTED TO CONTAIN.
1410 /IF WE WANT A HANDLER FOR UNITS 2&3 TO RESIDE IN
1411 /FIELD 2 AT LOCATION 3000 AND READ/WRITE 256(10) WORDS
1412 /PER BLOCK, THE PARAMETERS WOULD BE:
1413 / DRIVE=20
1414 / ORIG=3000
1415 / AFIELD=2
1416 / MFIELD=20
1417 / WDSBLK=400
1418 /THE CALL TO THE SUBROUTINE FOLLOWS BASICALLY THE
1419 /CALLING SEQUENCE FOR PS/8 DEVICE HANDLERS
1420 /THE CALLING SEQUENCE IS.
1421 / CDF CURRENT
1422 / CDF MFIELD /MFIELD=FIELD ASSEMBLED IN
1423 / JMS ENTRY /ENTRY=ORIG (EVEN NUMBERED DRIVE
1424 / /AND ORIG+4 FOR ODD NUMBERED DRIVE.
1425 / ARG1
1426 / ARG2
1427 / ARG3
1428 / ERROR RETURN
1429 / NORMAL RETURN
1430 /THE ARGUMENTS ARE
1431 /ARG1: FUNCTION WORD BIT0 0=READ, 1=WRITE
1432 / BITS 1-5: # BLOCKS IN OPERATION
1433 / BITS 6-8: FIELD OF BUFFER AREA
1434 / BIT 9: UNUSED
1435 / BIT 10: # OF WORDS/BLOCK.
1436 / 0= WDSBLK, 1=WDSBLK-1
1437 / BIT 11: 1=START FORWARD, 0=REVERSE
1438 /ARG2: BUFFER ADDRESS FOR OPERATION
1439 /ARG3: STARTING BLOCK FOR OPERATION
1440 /ERRORS: THE HANDLER DETECTS TWO TYPES OF ERRORS:
1441 /A) FATAL ERRORS- PARITY ERROR, TIMING ERROR,
1442 / TOO GREAT A BLOCK NUMBER
1443 / FATAL ERRORS TAKE ERROR RETURN WITH THE
1444 / AC=4000
1445 /B) NON-FATAL- SELECT ERROR.
1446 / IF NO PROPER UNIT IS SELECTED, THE ERROR
1447 / RETURN IS TAKEN WITH CLEAR AC.
1448 /FATAL ERRORS TRY THREE TIMES BEFORE TAKING ERROR RETURN.
1449 /THE NORMAL RETURN IS TAKEN AFTER ALL INDICATED
1450 /BLOCKS HAVE BEEN TRANSFERRED. THE AC IS CLEAR.
1451 /THE TDS8 IOT'S ARE
1452 /SD55=7001-DRIVE /SKIP ON SINGLE LINE FLAG
1453 /SD5T=7002-DRIVE /SKIP ON TIMING ERROR
1454 /SD50=7003-DRIVE /SKIP ON QUAD LINE FLAG
1455 /SDLC=7004-DRIVE /LOAD COMMAND REGISTER
1456 /SDLD=7005-DRIVE /LOAD DATA REGISTER
1457 /SDRC=7006-DRIVE /READ COMMAND REGISTER
1458 /SDRD=7007-DRIVE /READ DATA REGISTER
1459 /THE IOT'S IN GENERAL ARE 677X, 676X, 675X, AND 674X.
1460 /THE OTHERS CONTROL UNITS 2-7.
1461 /BLOCK=DTA1
1462 /FIELD AFIELD
1463 /*ORIG
1464 06200 0000 DTA0, 0 /ENTRY POINT FROM UNIT 0
1465 06201 7300 CLA CLL /0 TO LINK
1466 06202 5210 JMP DTA1X
1467 06203 1000 C1000, 1000
1468 06204 0000 DTA1, 0 /UNIT 2 ENTRY
1469 06205 7320 CLA CLL CML /1 TO LINK
1470 06206 1204 TAD DTA1
1471 06207 3200 DCA DTA0 /PICK UP ARGS AT DTA0
1472 06210 7010 DTA1X, PAR
1473 06211 3361 DCA UNIT /LINK TO UNIT POSITION
1474 06212 6214 RDP /GET DATA FIELD AND SETUP RETURN
1475 06213 1354 TAD C6203
1476 06214 3352 DCA LEAVE
1477 06215 1600 TAD I DTA0 /GET FUNCTION WORD

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1478	06216	6775	SDLD	/PUT FUNCTION INTO DATA REGISTER
1479	06217	7112	CLL RTR	/AC STILL HAS FUNCTION PUT # WORDS PER
1480				/BLOCK INTO LINK
1481	06220	7670	SZL CLA	/KNOCK ONE OFF WDSBLK?
1482	06221	7001	IAC	/YES
1483	06222	1360	TAD MWORDS	
1484	06223	3356	DCA WCOUNT	/STORE MASTER WORD COUNT
1485	06224	2200	ISZ DTA0	/TO BUFFER
1486	06225	1600	TAD I DTA0	
1487	06226	3357	DCA BUFF	
1488	06227	2200	ISZ DTA0	/TO BLOCK NUMBER
1489	06230	1600	TAD I DTA0	
1490	06231	3204	DCA BLCK	
1491	06232	2200	ISZ DTA0	/POINT TO ERROR EXIT
1492	06233	6203	CIF CDF MFIELD	/TO ROUTINES DATA FIELD
1493	06234	6777	SDRD	/GET FUNCTION INTO AC
1494	06235	7104	CLL RAL	
1495	06236	0307	AND CM200	/GET # PAGES TO XFER
1496	06237	3364	DCA PGCT	
1497	06240	6777	SDRD	
1498	06241	0374	AND C70	/GET FIELD FOR XFER
1499	06242	1354	TAD C6203	/FORM CDF N
1500	06243	3377	DCA XFIELD	/IF=0 AND DF=N AT XFER.
1501	06244	7346	CLA CLL CMA RTL	
1502	06245	3367	DCA TRYCNT	/3 ERROR TRIES
1503	06246	1361	TAD UNIT	/TEST FOR SELECT ERROR
1504	06247	6774	SDLC	
1505	06250	6776	SDRC	
1506	06251	0366	AND C100	
1507	06252	7640	SZA CLA	
1508	06253	5346	JMP FATAL-1	
1509	06254	6777	SDRD	/PUT FUNCT INTO XFUNCT IN SECOND PG.
1510	06255	3762	DCA I CXFUN	
1511	06256	1356	TAD WCOUNT	
1512	06257	3765	DCA I CXWCT	
1513	06260	6777	SDRD	/GET MOTION BIT TO LINK
1514	06261	7110	CLL RAR	
1515	06262	5301	JMP GOES	/AND START THE MOTION.
1516	06263	6772	SDST	/ANY CHECKSUM ERRORS?
1517	06264	7640	SZA CLA	/OR CHECKSUM ERRORS?
1518	06265	5341	JMP TRY3	/PLEASE NOTE THAT THE LINK IS ALWAYS
1519				/SET AT RWCOM. GETCHK SETS IT.
1520	06266	1364	TAD PGCT	/NO ERROR . FINISHED XFER?
1521	06267	1307	TAD CM200	
1522	06270	7450	SNA	
1523	06271	5345	JMP EXIT	/ALL DONE. GET OUT
1524	06272	3364	DCA PGCT	/NEW PAGE COUNT
1525	06273	2204	ISZ BLCK	/NEXT BLOCK TO XFER
1526	06274	1356	TAD WCOUNT	/FORM NEXT BUFFER ADDRESS
1527	06275	7041	CIA	
1528	06276	1357	TAD BUFF	
1529	06277	3357	DCA BUFF	
1530	06300	7120	CLL CML	/FORCES MOTION FORWARD
1531	06301	7232	CLA CML RTR	/LINK BECOMES MOTION BIT
1532	06302	1203	TAD C1000	
1533	06303	1361	TAD UNIT	/PUT IN 'GO' AND UNIT #
1534	06304	6774	SDLC	/LOOK FOR BLOCK NO.
1535	06305	4755	JMS I CRDQUD	/WAIT AT LEAST 6 LINES TO LOOK
1536	06306	4755	JMS I CRDQUD	
1537	06307	7600	7600	/COULD HAVE SAVED A LOC. HERE
1538	06310	6771	SDSS	
1539	06311	5310	JMP .-1	/WAIT FOR SINGLE LINE FLAG
1540	06312	6776	SDRC	
1541	06313	7106	CLL RTL	/DIRECTION TO LINK. INFO BITS
1542				/ARE SHIFTED.
1543	06314	0241	AND C374	/ISOLATE MARK TRACK BITS
1544	06315	1333	TAD M110	/IS IT END ZONE?
1545	06316	7450	SNA	/THE LINK STAYS SAME THRU THIS
1546	06317	5335	JMP ENDZ	
1547	06320	1363	TAD M20	/CHECK FOR BLOCK MARK
1548	06321	7640	SZA CLA	
1549	06322	5310	JMP SRCH	
1550	06323	6777	SDRD	/GET THE BLOCK NUMBER
1551	06324	7430	SZL	/IF WE ARE IN REVERSE, LOOK FOR 3

1552				/BLOCKS BEFORE TARGET BLOCK. THIS
1553				/ALLOWS TURNAROUND AND UP TO SPEED.
1554	06325	1375	TAD C3	/REVERSE
1555	06326	7040	CMA	
1556	06327	1204	TAD BLCK	
1557	06330	7040	CMA	/IS IT RIGHT BLCK?
1558	06331	7450	SNA	
1559	06332	5370	JMP FOUND	/YES. HOORAY!
1560	06333	7670	M110, SZL SNA CLA	/NO, BUT ARE WE HEADED FOR IT?
1561				/ABOVE SNA IS SUPERFLUOUS.
1562	06334	5310	JMP SRCH	/YES
1563	06335	6776	ENDZ, SDRG	/WE ARE IN THE END ZONE
1564	06336	7106	CLL RTL	/DIRECTION TO LINK
1565	06337	7630	SZL CLA	/ARE WE IN REVERSE?
1566	06340	5301	JMP GOES	/YES. TURN US AROUND
1567			/IF WE ARE IN THE END ZONE GOING FORWARD, IT IS AN ERROR	
1568	06341	2367	TRY3, ISZ TRYCNT	
1569	06342	5301	JMP GOES	/TRY 3 TIMES
1570	06343	7100	CLL CLA	
1571	06344	5347	JMP FATAL	/LINK OFF MEANS AC=4000 ON RETURN
1572	06345	2200	EXIT, ISZ DTA0	
1573	06346	7120	CLL CML	/AC=0 ON NORMAL RETURN
1574	06347	1361	FATAL, TAD UNIT	
1575	06350	6774	SDLC	/STOP THE UNIT
1576	06351	7220	CLA CML RAR	
1577	06352	7402	LEAVE, HLT	
1578	06353	5600	JMP I DTA0	
1579	06354	6203	06203, 6203	
1580	06355	6513	CRDQUAD, RDQUAD	
1581	06356	0000	WCOUNT, 0	
1582	06357	0000	EUFF, 0	
1583	06360	7577	MWORDS, -WDSBLK	
1584	06361	0000	UNIT, 0	
1585	06362	6553	CXFUN, XFUNCT	
1586	06363	7760	M20, -20	
1587	06364	0000	PGCT, 0	
1588	06365	6561	CXWCT, XWCT	
1589	06366	0100	C100, 100	
1590	06367	7775	TRYCNT, -3	
1591			*ORIG+170	
1592	06370	7630	FOUND, SZL CLA	/RIGHT BLOCK. HOW ABOUT DIRECTION?
1593	06371	5301	JMP GOES	/WRONG TURN AROUND
1594	06372	1361	TAD UNIT	/PUT UNIT INTO LINK
1595	06373	7104	CLL RAL	/AC IS NOW 0
1596	06374	0070	C70, 70	/*****DON'T MOVE THIS!!!!****
1597	06375	0003	C3, 3	
1598	06376	1357	TAD BUFF	/GET BUFFER ADDRESS
1599	06377	7402	XFIELD, HLT	/INTO NEXT PAGE
1600			*ORIG+200	
1601			XUNIT=EQUFUN	
1602	06400	6202	CIF MFIELD	
1603	06401	3360	DCA XBUFF	/SAVE ADDRESS
1604	06402	7010	RAR	/NOW GET UNIT #
1605	06403	3320	DCA XUNIT	
1606	06404	1361	TAD XWCT	
1607	06405	3357	DCA WORDS	/WORD COUNTER
1608	06406	6771	REVGRD, SDSS	
1609	06407	5206	JMP, -1	/LOOK FOR REVERSE GUARD
1610	06410	6776	SDRG	
1611	06411	0241	AND K77	
1612	06412	1354	TAD CM32	/IS IT REVERSE GUARD?
1613	06413	7640	SZA CLA	
1614	06414	5206	JMP REVGRD	/NO KEEP LOOKING
1615	06415	1353	TAD XFUNCT	/GET FUNCTION READ OR WRITE
1616	06416	7700	K7700, SMA CLA	
1617	06417	5254	JMP READS	/NEG. IS WRITE
1618	06420	6776	WRITES, SDRG	
1619	06421	0266	AND C300	/CHECK FOR WRITE LOCK AND SELECT ERROR
1620	06422	7120	CLL CML	/LOCK OUT AND SELECT ARE AC 0 ERRORS
1621	06423	7640	SZA CLA	
1622	06424	5751	JMP I CFATAL	/FATAL ERROR. LINK MUST BE ON
1623	06425	4313	JMS RDQUAD	/NO ONE EVER USES THIS WORD!

1624	06426	7600	C7600,	7600	
1625	06427	1355		TAD C1400	
1626	06430	1320		TAD XUNIT	/INITIATE WRITE MODE
1627	06431	6774		SDLC	
1628	06432	7240		CLA CMA	
1629	06433	4304		JMS WRQUAD	/PUT 77 IN REVERSE CHECKSUM
1630	06434	7240		CLA CMA	
1631	06435	3356		DCA CHKSUM	
1632	06436	1760	WRLP,	TAD I XBUFF	/GLORY BE! THE ACTUAL WRITE!
1633	06437	4304		JMS WRQUAD	
1634	06440	2360		ISZ XBUFF	/BUMP CORE POINTER
1635	06441	0077	K77,	77	/ABOVE MAY SKIP
1636	06442	2357		ISZ WORDS	/DONE THIS BLOCK?
1637	06443	5236		JMP WRLP	/NOT YET. LOOP A WHILE
1638	06444	1353		TAD XFUNCT	/IS THE OPERATION FOR WDSBLK PER BLOCK?
1639	06445	7112		CLL RTR	/IF NO, WRITE A 0 WORD
1640	06446	7630		SZL CLA	
1641	06447	4304		JMS WRQUAD	/WRITE A WORD OF 0
1642	06450	4335		JMS GETCHK	/DO THE CHECK SUM
1643	06451	4304		JMS WRQUAD	/WRITE FORWARD CHECKSUM
1644	06452	4304		JMS WRQUAD	/ALLOW CHECKSUM TO BE WRITTEN
1645	06453	5752		JMP I CRWCOM	
1646	06454	4313	READS,	JMS RDQUAD	
1647	06455	4313		JMS RDQUAD	
1648	06456	4313		JMS RDQUAD	/SKIP CONTROL WORDS
1649	06457	0241		AND K77	
1650	06460	1216		TAD K7700	/TACK 7700 ONTO CHECKSUM
1651	06461	3356		DCA CHKSUM	/CHECKSUM ONLY LOW 6 BITS ANYWAY
1652	06462	4313	RDLP,	JMS RDQUAD	
1653	06463	4320		JMS EQUFUN	/COMPUT CHECKSUM AS WE GO
1654	06464	3760		DCA I XBUFF	/IT GETS CONDENSED LATER
1655	06465	2360		ISZ XBUFF	
1656	06466	0300	C300,	300	/PROTECTION
1657	06467	2357		ISZ WORDS	/DONE THIS OP?
1658	06470	5262		JMP RDLP	/NO SUCH LUCK
1659	06471	1353		TAD XFUNCT	/IF OP WAS FOR WDSBLK-1, READ AND
1660	06472	7112		CLL RTR	/CHECKSUM THE LAST TAPE WORD
1661	06473	7620		SNL CLA	
1662	06474	5277		JMP RDLP2	
1663	06475	4313		JMS RDQUAD	/NOT NEEDED FOR WDSBLK/BLOCK
1664	06476	4320		JMS EQUFUN	/CHECKSUM IT
1665	06477	4313	RDLP2,	JMS RDQUAD	/READ CHECKSUM
1666	06500	0216		AND K7700	
1667	06501	4320		JMS EQUFUN	
1668	06502	4335		JMS GETCHK	/GET SIX BIT CHECKSUM
1669	06503	5752		JMP I CRWCOM	
1670	06504	0000	WRQUAD,	0	/WRITE OUT A 12 BIT WORD
1671	06505	4320		JMS EQUFUN	/ADD THIS TO CHECKSUM
1672	06506	6773		SDSQ	/SKIP ON QUADLINE FLAG
1673	06507	5306		JMP -1	
1674	06510	6775		SDLD	/LOAD DATA ONTO BUS
1675	06511	7200		CLA	/SDLD DOESN'T CLEAR AC
1676	06512	5704		JMP I WRQUAD	
1677	06513	0000	RDQUAD,	0	/READ A 12 BIT WORD
1678	06514	6773		SDSQ	
1679	06515	5314		JMP -1	
1680	06516	6777		SDRD	/READ DATA
1681	06517	5713		JMP I RDQUAD	
1682	06520	0000	EQUFUN,	0	/COMPUTE EQUIVALENCE CHECKSUM
1683	06521	7040		CMA	
1684	06522	3362		DCA EQUIMP	/ACTUALLY CHECKSUMS ON DECTAPE ARE
1685	06523	1362		TAD EQUIMP	/EQUIVALENCE OF ALL WORDS IN A RECORD
1686	06524	0356		AND CHKSUM	/SIX BITS AT A TIME. BUT SINCE EQUIVALENCE
1687	06525	7041		CIA	/IS ASSOCIATIVE, WE CAN DO IT 12
1688	06526	7104		CLL RAL	/BITS AT A TIME AND CONDENSE LATER.
1689	06527	1362		TAD EQUIMP	/THIS ROUTINE USES THESE IDENTITIES:
1690	06530	1356		TAD CHKSUM	/A+B=(A XOR 3)+2*(A AND B)
1691	06531	3356		DCA CHKSUM	/A EQU B= NOT. (A XOR B)=A XOR (. NOT. B)
1692	06532	1362		TAD EQUIMP	/A EQU B=(A+(. NOT. B))-2*(A AND (. NOT. B))
1693	06533	7040		CMA	
1694	06534	5720		JMP I EQUFUN	
1695	06535	0000	GETCHK,	0	/FORM 6 BIT CHECKSUM
1696	06536	7200		CLA	
1697	06537	1356		TAD CHKSUM	

1698	06540	7040	CMA	
1699	06541	7106	CLL RTL	
1700	06542	7006	RTL	
1701	06543	7006	RTL	
1702	06544	4320	JMS EQUFLN	
1703	06545	7320	CLA CLL CML	/FORCES LINK ON AT RWCOM
1704	06546	1356	TAD CHKSUM	
1705	06547	0216	AND K7700	
1706	06550	5735	JMP I GETCHK	
1707	06551	6347	CFATAL, FATAL	
1708	06552	6263	CRWCOM, RWCOM	
1709	06553	0000	XFUNCT, 0	
1710	06554	7746	CM12, -32	
1711	06555	1400	CL400, 1400	
1712	06556	0000	CHKSUM, 0	
1713	06557	0000	WORDS, 0	
1714	06560	0000	XBUFF, 0	
1715	06561	0000	XWCT, 0	
1716	06562	0000	EQUIMP, 0	
1717				
1718			*7203	
1719			/READS THE RANGES INPUT AND CALCULATES ADDRESS CONSTANTS	
1720			/FOR GATHERING DATA INTO THE FOURTH QUADRANT	
1721	07200	1121	RANGE, TAD PRODC	/SAVE PRODC WHICH WILL BE CHANGED
1722	07201	3272	DCA PRODSV	/SUBROUTINE INPUT4
1723	07202	1674	DCA I FLAG41	/DISABLE 4TH QUADRANT
1724	07203	1304	TAD VARAD1	/SET VARADS=A(RANALL)
1725	07204	3303	DCA VARADS	
1726	07205	5214	JMP RAN1	
1727				
1728	07206	4673	RANRD, JMS I INPUT	/JMS INPUT4, READ 4 NUMBERS FROM BUFFER
1729	07207	3307	DCA RNRD	
1730	07210	1307	TAD RNRD	
1731	07211	7110	CLL RAR	/DIVIDE THE NUMBER READ BY 2
1732	07212	3310	DCA RRGDV2	
1733	07213	4703	JMS I VARADS	/CALCULATE THE ADS CONSTANT
1734				
1735	07214	4032	RAN1, JMS READ	/READ 1 CHARACTER FROM BUFFER INTO HOLD1
1736	07215	1100	TAD HOLD1	
1737	07216	1170	TAD M215	/IS IT A CARRIAGE RETURN
1738	07217	7650	SNA CLA	
1739	07220	5261	JMP ZERO4	/YES
1740	07221	5206	JMP RANRD	/NO ASSUME SPACE
1741				
1742	07222	0000	RANALL, 0	/ROUTINE SETS RANGE AND ADS CONSTANT FOR ALL
1743	07223	1062	TAD M2THOU	/THREE CHANNELS EQUAL, BEGINNING ADS=5000 (FIELD 1)
1744	07224	1310	TAD RRGDV2	
1745	07225	3675	DCA I ADCONX	
1746	07226	1310	TAD RRGDV2	
1747	07227	3676	DCA I RANGX	
1748	07230	4237	JMS RANZ	
1749	07231	4251	JMS RANY	
1750	07232	7201	CLA IAC	/AC=1, SIGNAL AOSTIC PROGRAM TO GATHER
1751	07233	3674	DCA I FLAG41	/DATA INTO 4TH QUADRANT
1752	07234	1305	TAD VARAD2	/SET VARADS=A(RANZ)
1753	07235	3303	DCA VARADS	
1754	07236	5622	JMP I RANALL	
1755				
1756	07237	0000	RANZ, 0	/SET UP CONSTANTS FOR CHANNEL 2
1757	07240	1675	TAD I ADCONX	
1758	07241	1675	TAD I RANGX	
1759	07242	1310	TAD RRGDV2	
1760	07243	3677	DCA I ADCONZ	
1761	07244	1310	TAD RRGDV2	
1762	07245	3700	DCA I RANGZ	
1763	07246	1306	TAD VARAD3	/SET VARADS=A(RANY)
1764	07247	3303	DCA VARADS	
1765	07250	5637	JMP I RANZ	
1766				
1767	07251	0000	RANY, 0	/SET UP CONSTANTS FOR CHANNEL Y
1768	07252	1677	TAD I ADCONZ	
1769	07253	1700	TAD I RANGZ	
1770	07254	1310	TAD RRGDV2	
1771	07255	3701	DCA I ADCONY	

1772	07256	1310	TAD RNGDV2	
1773	07257	3702	DCA I RANGY	/FINISHED
1774	07260	5651	JMP I RANY	
1775				
1776	07261	1272	ZERO4, TAD PRODSV	/RESTOR PRODC
1777	07262	3121	DCA PRODC	
1778	07263	1312	TAD P5777	/SET UP CONSTANTS FOR CLEARING LOCATIONS
1779	07264	3015	DCA INDEX1	/6000-7777 OF FIELD 1
1780	07265	1062	TAD M2THOU	
1781	07266	3161	DCA TEM1	
1782	07267	1056	TAD LNFEED	
1783	07270	4147	JMS PRNTIR	/PRINT LINE FEED
1784	07271	5711	JMP I CLD	
1785				
1786	07272	0000	PRODSV, 0	
1787	07273	1062	INPUT, INPUT4	
1788	07274	2741	FLAG41, FLAG4	
1789	07275	2731	ADCONX, ADX	
1790	07276	2732	RANGX, RX	
1791	07277	2733	ADCONZ, ADZ	
1792	07300	2734	RANGZ, RZ	
1793	07301	2735	ADCONY, ADY	
1794	07302	2736	RANGY, RY	
1795	07303	0000	VARADS, 0	
1796	07304	7222	VARAD1, RANALL	
1797	07305	7237	VARAD2, RANZ	
1798	07306	7251	VARAD3, RANY	
1799	07307	0000	RNGRD, 0	
1800	07310	0000	RNGDV2, 0	
1801	07311	0254	CLD, CLD0	
1802	07312	5777	P5777, 5777	
1803				
1804			*7400	
1805	07400	7474	TABLE2, 7474	/COMMAND DECODING TABLE (D)
1806	07401	7766	7766	/N
1807	07402	7764	7764	/Z
1808	07403	0003	0003	/W
1809	07404	0007	0007	/P
1810	07405	0013	0013	/E
1811	07406	7762	7762	/S
1812	07407	0012	0012	/I
1813	07410	7761	7761	/X
1814	07411	0013	0013	/M (NOT USED)
1815	07412	7770	7770	/U
1816	07413	0011	0011	/L
1817	07414	0011	0011	/C
1818	07415	7764	7764	/O
1819	07416	7775	7775	/R
1820	07417	0117	0117	
1821	07420	1000	TABLE1, DSPLAY	/ADDRESS TABLE (D)
1822	07421	1167	DSABLE	/N
1823	07422	0251	CLDATA	/Z
1824	07423	1632	WRITE	/W
1825	07424	1400	PUNCH	/P
1826	07425	1200	EXPAND	/E
1827	07426	7200	RANGE	/S
1828	07427	0700	INTEG	/I
1829	07430	1723	ENABLE	/X
1830	07431	1457	DECODE+11	/M-NOT VALID CURRENTLY
1831	07432	0512	UPPER	/U
1832	07433	0503	LOWER	/L
1833	07434	2200	CLKLD	/C
1834	07435	2400	DECAD	/O
1835	07436	2532	DECAD5	/R
1836	07437	7400	7400	
1837				

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